REGULATIONS

FOR

ARMY ORDNANCE SERVICES

PART II

PAMPHLET No. 14

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INSTRUCTIONS FOR EXAMINING AND CONDITIONING ORDNANCE

1938

By Command of the Army Council,

THE WAR OFFICE,
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INSTRUCTIONS FOR EXAMINING AND CONDITIONING ORDNANCE

1. The procedure relating to the examination of ordnance is given in R.A.O.S., Part II, Pamphlet No. 13.

2. The tools and gauges used in the examination of ordnance are given in detail for all natures of guns and howitzers in R.A.O.S., Part II, Pamphlet No. 19.

The following is a list of those most generally used. The suffix number refers to the paragraph of this pamphlet in which the description of the gauge will be found :—

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3. **Gauge, measuring, bore.**—All gauges, measuring, bore, are made and graduated in a similar manner, but differ in size to suit the various calibres of ordnance in the service. They are identified by numbers, and a complete list showing the maximum and minimum readings with each is given in Appendix I.

Each gauge consists of a steel plate frame provided on one side with a broad dovetailed recess in which works a sliding plate. One end of the plate is rounded to a slightly smaller radius than that of the minimum bore for which it is intended; the sliding plate, the opposite end of which is similarly rounded, projects from the other end. A clamping screw passing through a slot in the sliding plate is attached to the frame and, in conjunction with a spring washer, clamps the plate in any required position. A thumb piece is attached to the plate to enable it to be easily moved.

The sliding plate is engraved on one side with a scale of inches divided into tenths (·1 inch) and fiftieths (·02 inch). A vernier is fitted to the side of the plate frame and has 20 divisions equal to 19 divisions of ·02 inch on the scale. The

difference therefore, between one division on the vernier and one division on the scale is 1/20th of ·02 inch, thereby allowing measurements to be taken to thousandths of an inch (·001 inch).

Two connections are hinged to the rear face of the frame to which rods are screwed. These rods are generally of wood or duralumin, and are made in short lengths with metal screw connections, for convenience in taking measurements and for ease in packing and transport. The lower rod is graduated in inches. In taking a measurement a steel straight-edge or rule must be held at the distance on the graduated rod at which the measurement is to be taken.

To steady the rods in measuring at a long distance from the muzzle, guide discs are supplied, which are clamped on the graduated rod at convenient intervals (one should be about 12 inches from the gauge). The disc has an elongated hole through which the plain rod can move freely.

In order to take a measurement the gauge should be set to a slightly larger reading than the anticipated diameter, and the clamping screw screwed down so that the sliding plate can only move with difficulty. Push the plain rod at the upper end of the gauge fully forward and pass the gauge up the bore to the position at which the measurement is required. By pulling the plain rod evenly to the rear the sliding plate will be pushed in by its contact with the surface of the lands, and thus the diameter of the bore at the desired point can be read off on the vernier scale with the aid of a magnifying glass.

Precautions in using the gauge.—See that the spring washer is bearing evenly; if it does not do so, the plate may slip and low readings will be recorded.

The gauge should be checked periodically. If its accuracy is suspected, it should be returned to the Chief Inspector of Armaments, through the Chief Ordnance Officer, Royal Arsenal, Woolwich, for any necessary adjustment.

4. **Mirror, examining bore.**—The mirror, examining bore, consists of a brass cylinder with part of its frame removed to expose a mirror set at 45° to the axis of the bore. In front of the mirror, at the bottom of the cylinder, is fitted an electric lamp which illuminates the bore opposite. One end of the cylinder has a screwed socket, to take rods for pushing the cylinder up and down the bore, and is fitted with terminals for the leads from the battery. The cylinder is placed in the bore and moved slowly along. An observer at the breech or muzzle facing the mirror is able to see the condition of the bore as reflected in the mirror. By using binoculars any defects, such as cracks or scoring, can be detected.

5. Gauge, plug bore, low limit for provisional condemnation.—This gauge is a plain steel cylinder, varying in length according to the nature of gun for which it is designed and of such a diameter as to ensure that, if it passes through the bore, the shell with which the gun or howitzer is equipped can safely be fired without chance of being obstructed by the surface of the bore. It has a handle at one end, with a hole for the attachment of a cord to pull the gauge through the bore.

For full particulars concerning the use of the gauge, *see* R.A.O.S., Part II, Pamphlet No. 15.

6. Gauge, plug bore, acceptance after lapping.—This is a similar gauge to the gauge, plug bore, low limit for provisional condemnation, but is of larger diameter. It is for use after a gun has been lapped, to ascertain whether the lapping has been sufficient; the bore must be lapped until this gauge passes. (*See* R.A.O.S., Part II, Pamphlet No. 15.)

7. Gauge, plug, rifling.—This gauge resembles the gauge, plug bore, low limit for provisional condemnation, except that it is provided with a number of projections round the exterior of the cylindrical portion, corresponding with the rifling grooves in the gun with which it is intended to be used. The depth of the projections is slightly less than the minimum depth of the grooves.

The gauge is for use after the lands of a gun have been lapped. If this gauge will not pass after lapping, this indicates that the grooves are choked and need milling, and conversely, if it will pass, no milling is necessary. (*See* R.A.O.S., Part II, Pamphlet No. 15.)

8. Instrument taking impressions of bore.—Each instrument consists of a base plate to the upper surface of which is fitted a spindle having a right-hand thread at one end and a left-hand thread at the other. Fitted to the spindle and base plate are two carrier nuts which are furnished with hinged levers, supporting a surface plate to which the bore (or chamber) plates are attached by fixing screws or bolts. To the head of the instrument is fitted a handle made in lengths suitable for the various guns, the pieces being secured together by couplings and locking nuts. Fitted to the interior of the handle is a rod, gearing with the spindle in such a manner that, when the rod is turned with a wrench, the carrier nuts are made to approach or recede, according to the direction in which the spindle is rotated, and thus raise or lower the surface plate through the medium of the hinged levers. A clamp is attached to the handle to enable the instrument to be turned to the desired position when in the bore.

For certain of the smaller natures of guns and howitzers

wooden instruments are supplied for impression taking purposes. These are in two parts shaped to suit the diameter of the bore and provided with suitable wedges.

9. **Gauge, testing, seat of obturator.**—This gauge consists of a steel disc, the contour and thickness of which practically represents a complete obturator.

To gauge the seat of the obturator, remove the obturator from the breech screw and substitute the gauge ; apply a very thin film of marking, composed of lamp black, or red lead, and oil, to the periphery of the gauge, and carefully close the breech ; on opening the breech, the condition of the seat of obturator will be seen by the marks caused by contact with the gauge.

If the marks show that the gauge is not bearing regularly over the seating, the latter must be scraped where marked, and the above process repeated until the marking is regularly distributed round the seating.

Where necessary, the spare adjusting discs belonging to the gun will be placed behind the gauge on the breech screw to ensure contact between the gauge and the seat of the obturator. The limit for disc thickness in the case of B.L. 6-in. Mks. VII and VIIv guns is 0·045-in. (*See* R.A.O.S., Part II, Pamphlet No. 17.)

10. **Apparatus, testing, clinometer plane with axis of bore.**—The apparatus consists of a steel straight-edge, 4 feet long, with two steel sectors to suit the bore of the particular gun with which it is intended to be used.

The straight-edge is prepared on the underside with tapped holes in positions suitable for the sectors as indicated thereon. The sectors are shaped on the lower side to suit the bore of the gun and are prepared on the upper side with a recess for the reception of the straight-edge, which is secured thereto by means of fixing screws. The sectors should be placed on the straight-edge at :—

18 inches apart, for guns less than 4 inches.
24 inches apart, for guns 4 inches and less than 6 inches.
36 inches apart, for guns 6 inches and above.

The apparatus is used to test the angle between the axis of the bore at the muzzle and the clinometer plane at the breech end of the gun.

To ascertain this angle, the gun is brought to an approximately horizontal position ; the straight-edge with sectors is inserted in the muzzle and clinometer readings are taken both on the straight-edge and clinometer plane. The difference of these readings is the angle required. It is recorded as " down " or " up " in minutes according to whether

.he muzzle is inclined downwards or upwards in relation to the clinometer plane.

In the case of guns having clinometer planes at both the breech and muzzle, the difference of the clinometer readings taken on these planes will be the angle to be recorded.

11. **Straight-edge, with feelers for testing guide ribs.**—The straight-edge is 7 feet long and is used with a set of feelers to ascertain the amount the guide ribs of Q.F. 18-pr. I–II* guns are bent.

The following procedure will be followed in testing the straightness of the guide ribs :—

(1) Remove the gun from the cradle and place it on supports with the concave side of the ribs upwards ; in most cases this will be with the gun upside down.

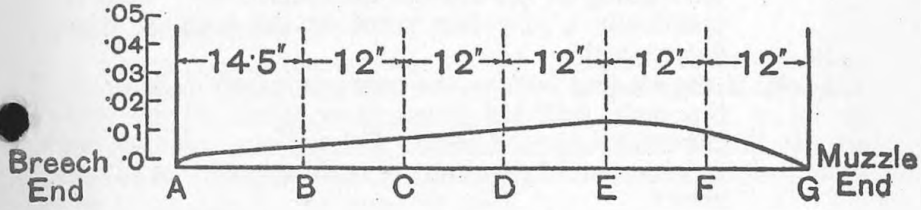
(2) Along the ribs from the muzzle end mark off five measurements of 12 inches, leaving a space of 14·5 inches at the breech end of the gun.

(3) Place the straight-edge on the rib, so as to butt against the breech ring. The straight-edge will generally be found to bear on each end of the rib.

By the use of feelers, ascertain the amount of clearance (if any) at each end of the points marked off.

Note :—When a 7-foot straight-edge is not available for the above test, a 6-foot one will be used. In such cases one end of the straight-edge will be set flush with the muzzle end of the guide rib. A note to the effect that a 6-foot straight edge was used must, when applicable, be inserted in the record of measurements.

Typical diagram showing bend of ribs



12. **Clinometer, inspector's.**—This consists of :—

Metal frame or body.
Main screw.
Drum.
Bubble arm.

The frame has two truly surfaced faces at right angles to each other. The sides of the frame are connected by a

platform on which is engraved the reader for the drum. The drum consists of a sleeve, tube, nut and cap, and is fitted to the main screw which is rigidly attached to the frame of the clinometer. The brass sleeve of the drum is engraved with a spiral graduated scale reading from $-30'$ to $+25°$. The bubble arm has a cased spirit bubble mounted on it.

These clinometers are used in conjunction with the apparatus, testing, clinometer plane with axis of bore, for taking readings of the breech and muzzle axis of a gun to ascertain the amount of droop of the muzzle.

To keep the clinometer in efficient working order it is necessary to keep the working parts free from grit or dust as much as possible. On no account should the instrument be taken to pieces.

To ascertain whether the clinometer is in adjustment :—

(*a*) Carefully clean the clinometer plane.

(*b*) Turn the drum to zero.

(*c*) Place the instrument on the clinometer plane, drum towards the breech, and elevate or depress the gun until the bubble is in the centre of its run.

(*d*) Turn the clinometer end for end.

(*e*) Should the bubble not return to the centre, the instrument is out of adjustment.

(*f*) As the amount of error will generally be small, it is advisable to add or subtract the error, as the case may be, rather than correct the adjustment.

(*g*) To ascertain the error after complying with (*d*) (drum towards muzzle), turn the drum until the bubble is again in the centre of its run ; one-half of the reading on the drum is the index error ; what is practically a new zero point on the scale is thus determined.

(*h*) If the reading falls on the part graduated in *black* on the scale, *add* the index error when setting the clinometer for any required elevation ; *subtract* the index error when taking a reading with the clinometer.

(*i*) If the reading falls on the portion graduated in *red* on the drum, *subtract* the index error when setting the clinometer for any required elevation ; *add* it when taking a reading.

If it is required to adjust the clinometer to have no index error, set the drum to the ascertained index error and bring the bubble to the centre of its run by elevating or depressing the gun. Then, placing the drum at zero, manipulate the

capstan-headed nuts (using a tempered steel wire just fitting the holes in the nuts) until the bubble is in the centre.

Reversing the instrument end for end should not alter the central position of the bubble; should it do so, proceed as before until there is no change.

13. **Method of examination.**—Before an examination is made the liner or barrel of a loose liner or loose barrel gun should be removed. The bore should be thoroughly cleaned by washing and brushing with fresh water: hot water should be used if available. If the bore is very dirty, it should be cleaned with paraffin oil. Soda must on no account be used.

A full examination consists of :—

(*a*) Visual examination.
(*b*) Taking impressions.
(*c*) Measuring.
(*d*) Gauging, testing, etc.

(*a*) *Visual examination*

After the bore has been cleaned it should be slightly oiled to facilitate the detection of cracks, etc. The mirror, examining bore, used in conjunction with binoculars, if necessary, should disclose the existence of any cracks, abrasions, scoring, etc. The exterior should be searched for cracks, movements of parts, etc. In the case of loose liner or loose barrel guns, the inside of the jacket and the interrupted threads of the jacket, breech ring and/or breech bush should also be examined for cracks and rust. The stamping on the gun should be compared with the description shown on the Memorandum of Examination as regards Nature, Mark and Regd. No., and any differences reported to the Chief Inspector of Armaments, Royal Arsenal, Woolwich.

(*b*) *Taking impressions*

Gutta-percha impressions should be taken of the chamber (including the obturator seating of B.L. guns), and all round the bore, from the commencement of the rifling to as far up the bore as scoring may extend. Impressions should also be taken of any defect in the bore such as may have been caused by a premature explosion of shell, etc.

If the mirror, examining bore, is not available, full length impressions of the chamber and bore must be taken, as otherwise defects such as cracks cannot be detected.

To prepare the gutta-percha for taking impressions, it should be placed in hot water and allowed to remain until sufficiently soft, care being taken to prevent the water from boiling, as this would render the gutta-percha useless for taking impressions. It should then be removed from the water and carefully

kneaded to expel all air and water, and finally placed on the plate of the impression instrument in the form of a roll, covering about one-third of the plate circumferentially for the whole length. The surface of the gutta-percha must be quite smooth and free from bubbles, creases and specks. The instrument, after being carefully inserted in the bore, should be screwed up and allowed to remain for 10 to 20 minutes until the gutta-percha is sufficiently hard. If a little oil or grease be applied to the plate of the instrument, and if the bore be very slightly oiled, the impression can easily be detached from both without damage; a sharper impression, however, can be obtained if the bore is not oiled. Too much pressure must not be applied in screwing up the instrument; otherwise the impression will be too thin and, should the defect be deep, it will be found difficult to withdraw the impression.

(*c*) *Measuring*

The bores of guns should be measured horizontally and vertically with the gauge, measuring bore, described in para. 3.

It will only be necessary to measure guns throughout when a suitable gauge, plug bore, is not available, or for some special reason.

When guns are measured throughout the bore, the positions in the bore should be determined from the muzzle. The points of measurement should be at 1 inch from the commencement of the rifling, and at every 12 inches from that point in the case of guns not liable to steel choke. For guns liable to steel choke additional measurements should be taken at the steps on the inner " A " tube and at every inch for a distance of 12 inches on either side of the steps. (*See* R.A.O.S., Part II, Pamphlet No. 15.)

In the case of Q.F. 18-pr. guns, Marks I to II*, IV, IVA and IVB, and B.L. 6-inch guns, Mark VII, VIIV, XIX and XXI, measurements should be taken at each examination as follows, at 10 inches from the commencement of the rifling in Q.F. 18-pr. guns and at 5 inches from the muzzle in B.L. 6-inch guns.

In the case of ordnance having a Range Table M.V. of 2,300 f.s. and over, measurements will be taken at one inch and at each succeeding inch up to three calibres from the beginning of the rifling.

At each complete examination of a gun, measurements should invariably be taken to ascertain the wear at one inch and at one calibre from the commencement of the rifling. These measurements should always be taken at the plan distance from the breech face given for each nature of gun in Appendix III. Should this distance vary in any particular gun, it will be indicated in the Memo. of Examination when the gun is issued to the service.

It is very seldom that measurements are required to be taken of the chamber, but, when this is necessary, the distances should be determined in inches from the breech face.

All measurements will be reported to the C.I.A. on A.F.G901. It will be stated whether the gauge, plug, bore, low limit for provisional condemnation passes or not.

(d) Gauging, testing, etc.

At all examinations the gauges provided for each particular nature of gun should be applied before sentence is passed, and the results stated in the report of examination.

If the gun is fitted with its mechanism, the mechanism should be gauged and tested also and results recorded. (*See* R.A.O.S., Part II, Pamphlet No. 16.)

14. Method of recording defects

Bore.—In order to note in returns the position of any flaw or defect, the bore is divided circumferentially (with reference to an observer facing the muzzle) into four parts, Up, Right, Down and Left; any spot may be more particularly indicated as lying " Right (or Left) of Up ", " Right (or Left) of Down " as shown on the following diagram. For example, a crack in the bore might be reported as extending from 26 inches, R. of U. to 57 inches, L. of D.

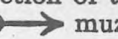
Distances down the bore are in all cases recorded in inches from the muzzle, except wear at 1 inch from the commencement of the rifling, which is recorded from the breech face when this is the only measurement taken in the bore.

Chamber.—The position of any flaw or defect in the chamber of a gun is reported in a similar manner, but with reference to an observer facing the breech, the distance in this case being measured and recorded in inches from the breech face.

Exterior.—With regard to exterior defects over bore or chamber, position is fixed with reference to an observer facing the muzzle and by means of the four cardinal and four intermediate points previously mentioned, and the distance is measured from the muzzle face. The exception to this rule is that any defects on the breech ring are described with reference to an observer facing the breech, the distance being measured from the breech face. When a defect extends to the jacket, this fact should be stated.

When an impression is forwarded with a report, a label

should be posted on the back of the impression showing the following information.

(*a*) Name of battery or fort.
(*b*) Nature, mark, factory initials and registered number of the piece.
(*c*) Number of equivalent full rounds fired.
(*d*) Nature, extent and position of the defect.
(*e*) Date of taking the impression.
(*f*) Direction of the muzzle, indicated by an arrow, thus  muzzle.

15. **Classification of defects.**—The defects which are likely to be found in the body of a gun or howitzer are classified under three distinct headings, viz. :—

Original defects.
Fair wear defects.
Accidental defects.

The following list gives details of the defects which may occur under the above headings :–

Original defects

Tool marks.
Specks or flaws in the steel.

Fair wear defects—

Erosion { (*a*) Wear. (*b*) Scoring.
Abrasion.
Flattening of lands.
Annular erosion.
Stripping of lands.
Choke due to steel contraction or copper deposit.
Expansion of bore or chamber.
Movement or stretching of tubes.
Cracking of inner tube, jacket or breech ring.
Openings between hoops or tubes ; twisting of tubes.
Excessive droop.
Overscrew of junction nut (Q.F. 3·7 inch howitzer).

Accidental defects—

Damage by explosion or break up of projectile in bore.
Injury by the projectile of a sub-calibre gun or aiming rifle.
Damage by hostile fire.
Injury caused by obstruction in bore.
Split cartridge cases (Q.F. guns).
Failure of obturator (B.L. guns).
Rust.

DESCRIPTION OF DEFECTS, GIVING CAUSES, APPEARANCES, LIMITS AND REMEDIES

16. Tool marks

Causes.—Tool marks are caused in the manufacture or repair of ordnance by the breaking or blunting of the machining tool, obstruction of metal turnings or carelessness on the part of the machinist.

Appearance.—Tool marks necessarily vary in extent and position. A description of tool marks in a gun is given on the front page of the Memorandum of Examination, to which reference should be made to ascertain whether the original defect as there recorded has altered as a result of firing.

Limits.—No limits for development can be given. Each defect will be dealt with on its merits by the Chief Inspector of Armaments, Royal Arsenal, Woolwich, on receipt of the particulars of examination.

17. Specks or flaws in the steel

Causes.—These marks are due to defects in the steel and are not caused by machining; often they are not visible until the final machining operation, or they may not develop until the ordnance is proved. If in the opinion of the inspecting officer they are not serious, the ordnance in which they appear is issued to the service.

Appearance.—The appearance of these defects differs; their extent, number and position, however, are recorded on the front page of the Memorandum of Examination, to which reference should be made to ascertain whether the defects originally recorded have developed in size and number.

Limits.—No limits for development can be given. Each defect will be dealt with on its merits by the Chief Inspector of Armaments, Royal Arsenal, Woolwich, on receipt of the particulars of examination.

18. **Erosion.**—(*a*) **Wear** (*b*) **Scoring.**—" Erosion " is a general term applied to the action produced on the bore by the rush of gas of exceedingly high temperature generated by the burning of the propellant.

It enlarges the bore at the breech end of the rifling and its action can be classified under two headings, viz.: " wear," and " scoring ". The nature of these defects and the limits of their action are fully dealt with below.

The enlargement of the bore thus produced results in a loss of muzzle velocity of the projectile. This is due to the projectile over-ramming and thereby increasing the capacity

of the chamber. Inaccurate shooting may also result from erosion owing to the rifling becoming worn and undefined, and thus failing to engrave the driving band sufficiently to effect the required rotation of the projectile. It should be noted, however, that, if the rifling towards the muzzle remains unworn and in good condition, accurate shooting will probably be maintained.

In the Memorandum of Examination of the gun is an appendix (*see* Appendix II), in which the mean wear at 1 inch from the commencement of the rifling, and also the maximum depth of scoring plus half wear, can be plotted against the number of equivalent full rounds fired. This appendix should be completed by the ordnance mechanical engineer at each examination of the gun, so that all concerned may see at a glance by reference to the Memorandum of Examination how the gun is wearing, and be able to ascertain readily the probable remaining life of the gun in equivalent full rounds. In the Memorandum of Examination for the later types of ordnance this appendix is incorporated in the body of the Memorandum.

(*a*) WEAR

Cause.—Wear is, primarily, the result of the action of propellent gas of very high temperature acting on the first few calibres of the bore from the commencement of the rifling. The nature of the steel of the rifled tube and its treatment during forging plays an important part in its resistance to wear, but is of secondary importance. On the other hand, the nature and weight of the charge has a very close relation to the rate of wear, e.g., cordite, Mark I, burns at a higher temperature than cordite, M.D., and causes more rapid wear; wear is greater with full than with reduced charges; guns of large calibre wear more quickly than those of small calibre. A number of rounds fired rapidly will wear a gun more quickly than an equal number of rounds fired slowly, because in the former case the gun becomes very hot.

Mechanical wear at the commencement of the rifling, due to the passage of the projectile, is negligible, except in the case of certain howitzers in which the action of the propellent gas is not so pronounced; in this case mechanical wear is probably a more important factor in causing enlargement.

Appearance.—Wear appears as a smooth wearing away or enlargement of the rifling. Both lands and grooves are affected, but the action is greater on the lands than on the grooves It begins in the first rounds fired from a gun, and is usually greater per round at first than subsequently. In the

early stages of wear the lands become rounded at the edges, and the grooves appear less deep than in a new gun. As wear develops, the lands at the commencement of the rifling scarcely stand up above the grooves, and wear extends further along the bore: when nearing the condemning limits, the lands often become obliterated and the surface of the bore becomes quite smooth for some two or three calibres at the breech end.

After repeated firing, the bore of a gun at the commencement of the rifling and the front end of the chamber becomes covered with a fine net-work of surface cracks, thought to be due to the variations of temperature to which the bore is subjected causing irregular expansions.

The maximum wear occurs at the commencement of the rifling, but is recorded at 1 inch from the commencement owing to the difficulty of taking measurement at the commencement itself. Guns do not wear uniformly, i.e., wear may be greater on the horizontal or on the vertical diameter. The wear of a gun is therefore always stated as the difference between half the sum of the horizontal and vertical diameters (i.e., the mean diameter) of the bore at 1 inch from the commencement of the rifling and the plan diameter of the bore at that point.

Limits.—The limit for wear is usually reached when the diameter at 1 inch from the commencement of the rifling (*see* Appendix III) is the same as the maximum diameter of the projectile, over the driving band. The following natures of guns are exceptions to this rule, viz. :—

B.L. 6-inch VII and VII^{V}.
B.L. 6-inch XIX.
Q.F. 18-pr. I to II*, IV, IV$_{A}$ and IV$_{B}$.
Q.F. 6 and 3-prs.

The limits for wear for these guns have been fixed from general experience of inaccurate shooting which, normally, is found to occur before the original wear limits laid down for them have been reached. (*See* also para. 19, " Abrasion ".)

The Q.F. 18-pr. gun has two limits for wear, one at 10 inches from the commencement of rifling in addition to that at 1-inch, and the gun is provisionally condemned on either limit being reached. When a gun reaches the limit at 10 inches, this is an indication of general enlargement throughout the bore.

The limits for wear laid down for Q.F. 6 and 3-pr. are usually reached when the rifling has become obliterated for 3 inches from the commencement.

The limits for wear for all guns and howitzers are given in

R.A.O.S., Part II, Pamphlet 25. They are also given in the Memorandum of Examination of each gun.

At each examination a gun will be measured at the point for which a limit is laid down, and the measurements recorded on A.F. G 875 and in the Memorandum of Examination.

Remedy.—There is no remedy for wear. Replacement of the worn tube, liner or barrel is necessary when the limit has been reached.

(*b*) SCORING

Cause.—Scoring is usually attributed to imperfect sealing of the bore by the driving band of the projectile when the gun is fired ; this allows the propellent gas to escape between the projectile and the bore.

Defects in the steel, or tool marks near the commencement of the rifling, may cause scoring to start, and a deepened groove may show earlier signs of scoring than undeepened grooves in the same gun, owing to the driving band offering less resistance to the gas pressure.

The stream velocity of the propellent gas causes the reticulated cracks on the surface of the steel, produced by the heated gas, to develop into slight longitudinal streaks. These streaks form narrow channels through which the gas under great pressure eats into the steel between the projectile and the bore.

Scoring, once it begins, develops at an increasing rate, and in this respect differs from wear.

Insufficient ramming of the projectile is probably an initial cause of scoring.

High temperature propellants cause more scoring than those burning at lower temperatures, and charges of small size cordite are liable to promote scoring sooner than those of large size, owing to the quicker combustion and more rapid development of the propellent gas.

Appearance.—The first indications of scoring are slight longitudinal streaks on the front end or slope of the chamber and in the grooves of the rifling. These streaks develop in depth and tend to form irregular gutterings and holes. The grooves of the rifling, mainly, become affected, development taking place on the non-driving edge of the land. It extends gradually over the groove and the adjacent land then becomes affected. Scoring is very irregular in its action and may affect only a few grooves. It most frequently develops on the upper surface of the bore, i.e., at or in the vicinity of UP. It develops at varying rates in guns of the same nature. No two guns score exactly alike, and the deepest scoring may be

at a different point in the same gun at two successive examinations. It develops always both longitudinally and in breadth, and in extreme cases may extend all round the bore for a depth of 4 to 6 calibres.

Limits.—The limit after which a gun which is scored should not be fired is calculated from the remaining thickness of the tube at the point of deepest scoring; the tube must remain intact if the gun is to be safe and repair is not to be prejudiced.

As wear occurs both before and also simultaneously with scoring, a limit cannot be fixed for scoring only, but wear at the point of deepest scoring has also to be taken into account.

A limit is laid down, therefore, for each nature of gun; this limit consists of the maximum permissible sum of the depth of scoring (whenever it may occur) and half the wear at the same point. In other words the difference between the plate gauge measurement and the plan diameter of the bore, at the deepest point of scoring, is halved and added to the depth of the scoring at this point; if the total so arrived at equals, or exceeds, the limit laid down, the gun will be provisionally condemned.

To ascertain the depth of the scoring, an impression taken of the bore, and the scoring, as shown on the impression, is measured at the deepest place. Pierce the impression with a stout needle through what is thought to be the highest protrusion, and scribe on the needle the thickness of the entire impression at this point, then pierce an adjoining land and again scribe the thickness of the impression. Then measure the two lengths scribed and the difference will be the depth of the scoring as measured from the land. To this, as stated above, must be added half the wear at this point in order to get the total amount of " scoring plus half wear ".

Several factors have to be considered in fixing a limit for scoring plus half wear, as for example :—

(*a*) Experience as to where scoring is likely to develop.
(*b*) The thickness of the inner tube in the probable area or zone of scoring.
(*c*) The calculated amount that the inner tube can be reduced in thickness without unduly weakening the gun or prejudicing repair.

The limit is stated for each gun in its Memorandum of Examination, and a complete table of limits for all guns is given in R.A.O.S., Part II, Pamphlet No. 25.

Remedy.—There is no remedy for this scoring. Replacement of the tube, or the fitting of an inner tube, are the only methods of repair. In the case of a loose liner or loose barrel

gun, the jacket, breech ring and/or breech bush should be fitted to a new liner or barrel.

19. **Abrasion**

Cause.—Abrasion, or mechanical wear, is caused by the passage of the projectile through the bore. Some of the conditions which favour this action, are :—

(*a*) Projectiles rotating untruly about their longer axis, whereby the shoulders at their front and rear bear heavily on the lands.
(*b*) Soft carbon " A " tubes.
(*c*) Improper ramming of projectiles, causing them to slip back at high elevations and find their own seating in the rifling when fired.
(*d*) Steel choke at the steps of inner " A " tubes.

Appearance.—Abrasion takes at times the form of spiral wear, due to the untrue rotation of the projectile, and follows the twist of the rifling. Its presence is indicated by measurement of the bore and sometimes shows on impressions. In some guns enlargement of the bore due to this cause increases very considerably towards the muzzle and to such an extent that the lands may become entirely obliterated there.

Some 18-pr. I–II* guns fitted with soft carbon " A " tubes were found to exhibit, after firing a few thousand rounds, an exceptionally smooth wearing away of the lands at the breech end of the rifling without the signs of gas action usually shown by guns of this nature having harder " A " tubes. This enlargement gradually extended throughout the bore.

Abrasion caused by improper ramming of the projectiles shows in the form of longitudinal grazing, severe at the commencement of the rifling and extending in a lesser degree throughout the bore.

Some natures of howitzers, after firing a very large number of rounds, show very few signs of gas action at the commencement of the rifling, but exhibit evidence of longitudinal grazing even when proper ramming is assured. The enlargement of the bore in this case is probably due mainly to abrasion by the projectiles.

Abrasion of a steel choke in the bore often appears as a bright circumferential ring.

In some 9·2 inch howitzers two or more lands have frequently been observed to be completely obliterated throughout the whole length of the rifling.

Limits.—It is not usual for this defect to affect shooting in a gun before it reaches the limit for wear at 1 inch from the commencement of the rifling.

In the case, however, of B.L. 6-inch VII, VII^{v}, XIX and XXI guns it has been found necessary to provide a limit for abrasion, viz. :—6·06 inches at 5 inches from the muzzle.

A limit for this defect has also been provided in Q.F. 18-pr. I to II*, IV, IVA and IVB guns, viz. :—3·315 inches at 10 inches from the commencement of the rifling.

Remedy.—Repair with a new tube. In the case of a loose liner or loose barrel gun, the jacket, breech ring and/or breech bush should be fitted to a new liner or barrel.

20. Flattening of lands

Cause.—Fair wear flattening is attributed to some of the causes that produce abrasion. (*See* " Accidental defects " for flattening by premature.) Imperfect centring of the projectile, when rammed, is thought to set up a hammering effect on the lands in its passage along the bore. Steel choke in a bore sometimes results in a local flattening of the lands, owing to the projectile forcing a passage over the obstruction.

Appearance.—Flattening is discernible by the lands of the rifling becoming wider and the adjoining grooves narrower than they were when the gun was new. It is generally associated with abrasion and contributes to the enlargement of the bore, but in a lesser degree than does abrasion.

Limits.—Excessive flattening is not usual, and it has not been necessary to fix any limits for this defect, except in the case of B.L. 6 inch VII, VII^{v}, XIX and XXI guns, in which it is so closely associated with abrasion that the limits for the latter defect apply also for flattening.

Remedy.—Repair with a new tube. In the case of a loose liner or loose barrel gun, the jacket, breech ring and/or breech bush should be fitted to a new liner or barrel

21. Annular erosion

Cause.—This defect is a form of gas erosion which is often found in the chambers of Q.F. guns, immediately in front of the cartridge case.

Appearance.—It takes the form of a ring of enlargement all round the chamber. Considerable roughness is sometimes associated with it, either in front or in rear of the ring, showing signs of incipient scoring. Usually, with guns or howitzers using short cartridge cases, the roughness develops at the rear of the ring by the gas acting on the chamber under the front edge of the cartridge case.

Limit.—Should difficulty of extraction be experienced with guns using long cartridge cases, owing to scoring under the

front end of the case, such guns should be sentenced for firing short cases only.

Long cases should not be used if scoring with short cases exceeds ·05 inch.

Remedy.—Repair by the electro-deposition of nickel (*see* para. 34). In the case of a loose liner or loose barrel gun, the jacket, breech ring and/or breech bush should be fitted to a new liner or barrel.

22. Stripping of lands of rifling

Cause.—Stripping of lands is a common defect in B.L. 6 inch 26-cwt. howitzers. It occasionally occurs also in other howitzers. It is attributed to the absence of, or insufficient, radius on the bottom corners of the grooves of the rifling, which reduces the strength of the lands to stand up against the force required to rotate the projectile.

Insufficient ramming, whereby projectiles slip back after loading and, on firing, come up against the rifling with more or less a blow, probably conduces to the cracking of the lands at the bottom corner of the driving edge at the commencement of the rifling, and to small portions of the lands breaking away at this point.

Isolated instances have occurred of lands being torn off in guns, due to flaws in the steel or to the effects of a premature.

Appearance.—Cracking of lands at the commencement of the rifling is generally to be seen in the bottom of the grooves on the edge. These cracks are not sharply defined and resemble a smooth streak of guttering on the side of each land. Stripping of the land soon follows the development of these gutterings and the latter may therefore be looked upon as the first signs of stripping. Stripping starts by small sections of the lands breaking away and is rapidly followed by more extensive stripping.

Limits.—Instances are known of projectiles becoming jammed in the bore owing to being wedged by pieces of stripped lands; in the case of B.L. 6 inch 26-cwt. howitzers, in which stripping of lands is a common defect, it is necessary, therefore, to provisionally condemn them when they show signs of stripping of lands.

If this defect is observed in other guns or howitzers, they should also be provisionally condemned and a special report of the defect should be forwarded to the Chief Inspector of Armaments, Royal Arsenal, Woolwich, on A.F. G 875 accompanied by gutta-percha impressions.

Remedy.—Care in loading to ensure that projectiles are properly rammed will reduce the possibility of lands stripping.

The liability of the lands to strip has been reduced by increasing the radius at the bottom of the grooves.

In cases of provisional condemnation for stripping of lands repair by fitting a new " A " tube is necessary.

23. Steel and copper choke

See R.A.O.S., Part II, Pamphlet No. 15.

24. Expansion of bore or chamber

Cause.—Expansion is due to the pressures in the bore being higher than that which a gun is built to withstand. If a gun is liable to expansion, it is usually revealed at proof. The use of an augmented charger other than one of those approved of may cause expansion. The inner " A " tube, if not properly supported, may even expand on firing approved service charges and this may occasionally happen after the issue of a gun.

Appearance.—Evidence of expansion is seen in the measurements of a bore. It can rarely be detected by visual examination, except in very pronounced cases of local expansion in the bore, when a dark ring is noticeable, due to the projectile passing the expanded portion of the bore without coming into contact with it. An impression of the bore will only reveal expansion when the bore is bulged. Expansion from the above causes will be unaccompanied by flattening of lands.

(For examples of expansion *see* Appendix IV.)

Limits.—An enlargement in the bore may allow the projectile to travel freely so that it will receive a check to its movement where the bore becomes again of normal size.

The maximum diameter at the enlarged portion of the bore will be considered in each case in relation to the mean diameter of the adjacent portion of the bore on either side of the enlargement. For natures 4·5 inch and above the condemning limit for local expansion is a diametrical enlargement of ·02 inch, while for natures below 4·5 inch it is ·01 inch.

Expansion in the chamber of Q.F. guns may cause the case to set out on firing with consequent difficulty of extraction. When difficulty is experienced from this defect, a gun should be provisionally condemned.

Remedy.—There is none that can be carried out on service.

25. Longitudinal movement and stretching of tubes

Cause.—The bodily forward movement of an inner " A " tube is due to it being insufficiently held by the outer tube, and to the shoulders, both at the rear and front, not being

brought in contact during building. Imperfect building may also cause the inner " A " tube to carry forward the outer " A " tube with it.

Forward stretching may be due also to the same reasons, as regards the forward shoulders and portion of the tube only, and to the natural tendency of the tube to move in a forward direction from the pull of the projectile in its passage along the bore. Rearward stretching is probably due to expansion and is possible only in guns designed with the breech bush not butting up against the rear face of the tubes.

Appearance.—A bodily forward movement of a tube will cause :—

(*a*) A gap in B.L. guns between the rear end of the tube and front face of breech bush, and in Q.F. guns a recess on the rear face of the tubes in the breech opening.

(*b*) Additional protrusion, at the muzzle, of the inner " A " tube beyond the " A " tube.

(*c*) Additional protrusion at the muzzle of the " A " tube beyond the " B " tube, jacket or muzzle stop ring.

Forward stretching will only result in (*b*) and (*c*). Rearward stretching may be visible on the rear face of the tubes in the breech opening. Rearward and forward movement of exterior tubes may be detected by the appearance of the paint at the joints.

(For examples of stretching *see* Appendix V.)

Limits.—There are no definite limits for the movement or stretching of tubes.

Bodily forward movement of the inner " A " tube in B.L. guns may become serious, as it removes the obturator seating from the obturator and so may cause an escape of gas over the obturator owing to the latter not seating properly. In Q.F. guns the movement may cause the cartridge case to be removed so far forward as to cause a missfire, or, if the gun fires, the cartridge, being insufficiently supported, may split. Otherwise forward movement and stretching are not serious, but may be regarded as indicating the possibility of the development of chokes or cracks in the bore of certain designs of guns.

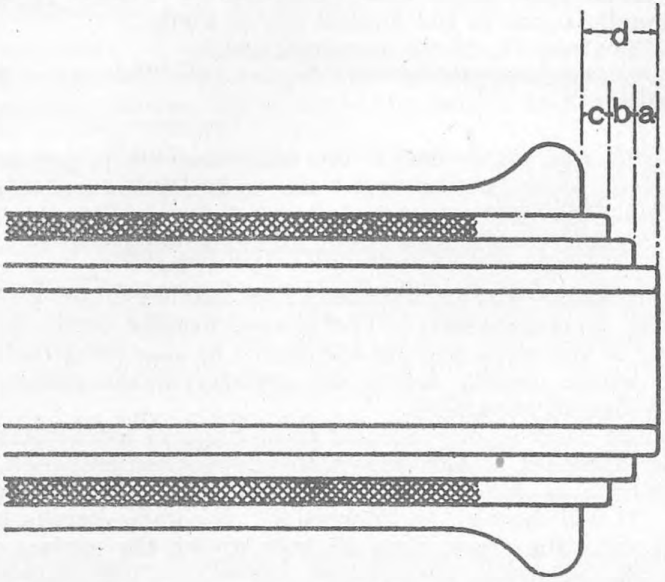
Rearward movement of an " A " tube in a Q.F. gun may interfere with the closing of the breech.

All movements of tubes should be recorded at each examination of a gun, and bodily forward movements should be specially reported to the Chief Inspector of Armaments, Royal Arsenal, Woolwich.

The amount of space in the breech opening between the rear

face of the inner " A " tube and the breech bush should be ascertained by the insertion of feeler gauges at " Up ", " Down ", " Left " and " Right ".

In reporting the protrusion of the inner " A " tube the amount of protrusion of the inner " A " tube beyond the " A " tube, and of the " A " tube beyond the next tube outside it, and so on, should be recorded. It is advisable to illustrate these movements by a sketch, thus :—



The increase in protrusion at (*a*), (*b*) and (*c*), respectively, should be recorded, and (*d*), the sum of (*a*), (*b*) and (*c*), will indicate the total stretch or movement of the inner " A " tube, provided that no bodily movement of the tube has occurred at the same time.

Remedy.—In B.L. guns the result of bodily forward movement of an inner tube may be temporarily remedied by the application of discs, adjusting obturator, to the mechanism, until the obturator is found to seat tightly in the cone seating ; but this remedy is limited to the number of discs it is possible for a mechanism to take.

In Q.F. guns the trouble in closing the breech owing to the rearward movement of the tube may in some guns be remedied by removing the surface of the tube on the rear face. Before this adjustment is carried out, however, the Chief Inspector of Armaments, Royal Arsenal, Woolwich, must be consulted.

Forward movement may increase the space between the firing hole bush and the base of the cartridge in the gun. If the limit is exceeded, the gun should be provisionally condemned.

26. Cracking of tubes, etc.

Cause.—Cracks in a tube, jacket or breech ring are due to failure of the steel to withstand the compression or extension imposed on them, and, although they are usually the result of a severe premature (*see* "Accidental defects"), they occasionally occur in the normal life of a gun.

Steel is always liable to develop a crack.

The principal causes of cracking of gun tubes have been due to :—

(*a*) Development of internal flaws in the steel.
(*b*) Stretching.
(*c*) Expansion.
(*d*) Tubes being too thin.
(*e*) Want of sufficient support by outer tube.

Appearance.—Cracks in inner tubes may be either circumferential or longitudinal. The former usually occur in the vicinity of the steps and are attributed to stretching, and the latter, which usually follow the grooves of the rifling, are usually due to expansion.

A small crack is very difficult to distinguish from a scratch, streak of scoring, or hair lines such as appear in nickel chrome steel, and may not be noticed at a visual examination of the bore. It will show on an impression ; the gutta-percha being forced into the crack rises slightly above the surface and, when the impression is examined, shows as a fine jagged line with rounded edges.

A large crack in the bore is seen at a visual examination as a dark line.

A crack on the exterior of a gun may be detected by the cracking of the paint ; if a gun is not painted, a small crack is difficult to see.

Cracks on the exterior are more likely to be found where any thrust takes place, such as in the rear of breech opening of jackets with sliding block mechanisms, or on the hinge lugs of breech rings for swinging breech screws.

An impression should always be taken of a crack, and in cases of doubt it is advisable to take one or more additional impressions to see that the same defect is noticeable on all.

Limit.—Any crack anywhere in the body of a gun entails provisional condemnation.

Remedy.—No remedy is possible on service.

27. Openings between hoops or tubes–Twisting of tubes

Cause.—In some guns of early manufacture hoops were shrunk on the tubes, over the chase. Stretching of the tubes occasionally caused openings to occur between the hoops.

Modern guns are built without hoops, but openings between the tubes sometimes occur on the muzzle and breech faces, owing to slight imperfections in building. Twisting of the inner tube sometimes occurs from the same cause.

Appearance.—Openings between the hoops on the exterior of a gun can easily be seen and need no special description.

Openings between the tubes on the muzzle and breech faces can be detected by feeler gauges.

Twisting of the inner tube can be seen by the axis line on the muzzle face being out of line with the remainder of the axis lines. It will always be clockwise owing to the driving force of the projectile on the right hand twist of the rifling.

Limit.—There are no limits for these defects. They should always be fully reported to the Chief Inspector of Armaments, Royal Arsenal, Woolwich, on A.F. G 875, when observed.

Remedy.—There is none.

28. Droop

Cause.—Excessive droop may be due to faults in original construction causing loss of girder strength, to misuse of a gun or to an accident.

Appearance.—Unless a gun is very much out of straightness, droop would not be noticeable at a visual examination, but it would be detected from the difference in clinometer readings taken on the clinometer planes at the muzzle and the breech, or by use of the " apparatus " referred to in para. 10.

Limit.—The amount of droop which will entail provisional condemnation cannot be definitely stated, except in Q.F. 18-pr. guns. If accuracy or recoil is affected, the gun must be provisionally condemned.

Q.F. 18-pr. guns I to IVB and Q.F. 25-pr. Mk. I guns should be provisionally condemned when the droop is 7 minutes or more.

Q.F. 18-pr. guns I to II* should also be condemned when bend of guide ribs amounts to ·05 inch or more.

Clinometer planes on the breech and muzzle ends of guns when issued to the service are adjusted to the axis of the bore at the breech and muzzle, respectively, and no further adjustments should be carried out on service without reference to the Chief Inspector of Armaments, Royal Arsenal, Woolwich.

The angle between the axis of the bore at the muzzle and the clinometer plane at the breech will be taken at each examination, and will be recorded in the memorandum when found to differ by two or more minutes from that taken at the previous examination.

Remedy.—Guns can only be straightened satisfactorily in an Ordnance Factory.

29. Overscrew of junction nut (Q.F. 3·7 inch howitzer)

When the arrow on the junction nut is coincident with, or beyond, the half arrow on the stop ring indicating the limit for wear, the howitzer should be provisionally condemned.

Repair for this defect is only possible in an Ordnance Factory.

30. Explosion or break up of projectile in bore

Cause.—The explosion or break up of a projectile in the bore may be due to :—

(*a*) Failure of the projectile itself, or its fuze.
(*b*) The presence of a steel choke or local enlargement in the bore.
(*c*) To some loose obstruction in the bore such as debris or stones, a fragment of a driving band left by the previous round, a piece of stripped rifling, etc.

Appearance.—The extent of the damage to the bore of a gun from a premature or break up will vary according to the nature or violence of the explosion or extent of the break up. The following damage may be anticipated :—

Denting.
Grazing.
Flattening of lands and enlargement.
Bulging.
Cracking.
Bursting.
Burring.

Limit.—The damage should be dealt with as laid down in this pamphlet for defects as found. Denting will be treated as for flattening, and grazing, if slight, will be governed by the limits for " scoring plus half wear ".

Before a gun is sentenced serviceable after a premature, care should be taken to ensure that all burrs have been removed.

Bulging, bursting or cracking entails, of course, provisional condemnation.

Remedy.—Liability to prematures may be reduced to a minimum by keeping the bore within limits, by keeping it clean and by careful visual searching for obstruction before firing.

31. Injury by the projectile of a sub-calibre gun or aiming rifle

Cause.—The break up of a projectile from a sub-calibre gun may damage the sub-calibre gun, the parent gun or both.

Damage to the parent gun may occur if the sub-calibre gun or aiming rifle is improperly assembled so that it is unsteady or its axis is not either parallel, or coincident, with that of the parent gun.

Appearance.—The break-up of a sub-calibre projectile will have the same effect as in the case of a projectile breaking up in a gun.

A bullet from an aiming rifle may cause a cavity near the muzzle of the parent gun.

Limit.—The limits are as already stated; the limit for a cavity is the same as for scoring plus half wear.

In all cases careful examination must be made to see that no obstruction exists in the bore before a gun is sentenced serviceable.

32. Damage to exterior by hostile fire

Cause.—Damage may be caused by a direct or ricochet hit, or by debris thrown up by an enemy shell bursting near the gun.

Appearance.—This differs in accordance with the nature and violence of the blow.

A gun may be only pitted by fragments, but even these may be sufficient to prevent free recoil of the gun in the cradle of its carriage.

In more serious cases the blow on the exterior may cause an indentation in the bore—a small mark on the exterior frequently has been observed to cause a serious contraction in the bore.

Limit.—Each case must be taken on its merits, but the gun must be examined to see that it will recoil correctly and the bore must be examined to see that there is no contraction.

A gun which has been badly hit is obviously unserviceable.

33. Injury caused by obstruction in bore

Cause.—Obstruction in the bore may be more definitely stated as a non-inherent obstruction to the free passage of the

projectile. Burrs, steel and copper chokes, etc., have already been mentioned. Other obstructions may be :—

(*a*) A ring of grease and dirt immediately in front of the projectile left by the sponge head if a gun is cleaned when loaded.

(*b*) A ring of fouling near the position occupied by the muzzle of a sub-calibre gun. If the parent gun is not cleaned after sub-calibre practice, this ring gets very hard.

(*c*) Water or ice in the bore.

(*d*) A muzzle tampeon
(*e*) A muzzle cover } left inadvertently in position.

(*f*) Stones, etc.

Appearance.—Firing a gun with an obstruction in the bore may seriously expand the gun or cause the muzzle to be blown off.

Limits.—Damage should be dealt with on its merits (*see* previous paras.).

To prevent damage.—Thorough cleaning and care of the gun are necessary.

34. Split cartridge cases

Cause.—A cartridge case may split from defects in the case, occurring independently or combined with a large chamber, or a defect in the chamber of the gun.

A large or defective chamber of a gun does not give proper support to the case and so may allow it to split.

If the inner " A " tube of the gun has moved forward, the case may set back on firing and, being improperly supported, may split.

Appearance.—If a case splits, the resulting gas escape may cause longitudinal scoring at the front end of the chamber, or circumferential scoring at the rear end of the chamber, depending on whether the case has split at its front end or near the flange at its base.

The face of the breech screw or block may also be scored.

Limit.—If neither opening of the breech nor extraction of the cases is affected, a slight score is not important, as succeeding cases cover the mark and further damage to the gun may not develop.

If the scoring mark is bad and difficulty in operation of the breech or extraction of the cases is experienced, the gun should be provisionally condemned.

Remedy.—Repair will be effected by copper or copper alloy filling as described in paras. 19188 and A.9858, List of Changes,

or, as an alternative method, electro-deposition of nickel. (*See* para. A.5429, List of Changes.)

Guns which have previously been repaired by bushing are unsuitable for repair by copper filling. Such guns, when damaged by scoring at the rear end of the chamber sufficient to affect extraction, will be repaired, where practicable, by the electro-deposition of nickel. (*See* para. A.6255, List of Changes.)

35. Failure of obturator

Cause.—An escape of gas between the obturator and its seating is due to incorrect seating of the pad. This may be due to hardness, incorrect adjustment or improper use of the pad (*see* R.A.O.S., Part II, Pamphlet No. 17), to movement of the tube or to a flaw in the obturator seating.

Appearance.—The seating for the obturator becomes scored, and obturator and breech fittings become damaged, by gas escape.

Limit.—A gun with its obturator seating badly scored across must be provisionally condemned and an impression of the defect submitted to the Chief Inspector of Armaments, Royal Arsenal, Woolwich.

Remedy.—If the scoring is slight, it is possible to rectify the seating by scraping and to make a good seating for the obturator by one or more adjusting discs.

If the scoring is too deep to adjust by scraping, the damage can be repaired by copper filling (*see* para. 19,188, List of Changes) but, before this repair is carried out, an impression of the defect should be submitted to the Chief Inspector of Armaments, Royal Arsenal, Woolwich.

36. Rust

Cause.—Exposure to damp or water, through want of preservation and neglect.

Appearance.—Roughening and pitting result from rusting. It is usually found in the grooves of the bore at " Down " or on the threads at the bottom of the breech opening.

Limit.—No limit can be stated ; accuracy may be affected when the bore is badly pitted. Badly pitted guns should be " provisionally condemned for rust " and impressions submitted to the Chief Inspector of Armaments, Royal Arsenal, Woolwich.

Remedy.—If guns are kept well oiled and properly preserved, they will not rust.

37. M.L. mortars

Before mortars are examined, they should be thoroughly cleaned in the same manner as for guns.

The defects likely to be found in mortars are few. They are not subject to erosion by gas action to the same degree as guns are. Limits for enlargement, however, have been published, after reaching which mortars should be provisionally condemned. (*See* R.A.O.S., Part II, Pamphlet No. 25.)

The bores of mortars should be measured both horizontally and vertically at each full examination at the following distances :—

Nature	Inches from muzzle
M.L. 3 inch	2, 4, 23, 29, 40, 42, 44

All measurements should be recorded on A.F. G 875A, and in the Memorandum of Examination which is provided for each mortar.

Owing to the comparative thinness of the barrel, mortars are very liable to become bent, and it has been necessary to provide a gauge, testing, straightness of bore, for use with 3-inch mortars. Mortars which will not accept this gauge up to 35 inches from the muzzle should be provisionally condemned.

The position of all defects in the bore and on the exterior, should be described in inches from the muzzle, in the same way as for guns. (*See* para. 14.)

APPENDIX I

Gauges, measuring, bore

(*Referred to in para.* 3)

No. of gauge	Readings		
	Zero	Maximum	Minimum
	(inches)	(inches)	(inches
1	12·0	12·63	11·9
3	9·2	9·83	9·1
4	8·0	8·63	7·9
6	6·0	6·62	5·9
7	4·7	4·97	4·62
8	4·0	4·28	3·9
9	3·3	3·63	3·2
10	3·0	3·3	2·9
11	5·0	5·25	4·9
12	1·85	2·0	1·77
13	2·244	2·394	2·154
16	14·0	14·6	13·9
17	4·5	4·75	4·4
19	18·0	18·6	17·9
23 Mk. I	3·7	4·2	3·6
23 Mk. II	3·7	4·6	3·6
27	3·45	4·35	3·35
28	4·45	5·45	4·35

APPENDIX III

Plan lengths of rifling

(*Referred to in para.* 18)

Nature	Length of rifling in inches	1-inch from commencement of rifling	
		Inches from muzzle	Inches from breech face
Guns—			
B.L. 15-in., Mk. I	516·33	515·33	135·07
B.L. 14-in., Mk. VI	588·75	587·75	140·25
B.L. 9·2-in., Mk. IX and C. Mk. IX	354·435	353·435	91·815
B.L. 9·2-in., Mks. X, X^{v} and X*	353·8	352·8	89·55
B.L. 9·2-in., Mk. XIII	271·3	270·3	64·725
B.L. 6-in., Mks. VII and VII^{v} (original chamber)	234·783	233·783	45·445
B.L. 6-in., Mks. VII and VII^{v} (modified chamber)	233·602	232·602	46·626
B.L. 6-in., Mk. XIX	170·758	169·758	49·462
B.L. 6-in., Mk. XXI	259·053	258·053	52·372
Q.F. 6-in., Mk. II	214·16	213·16	36·09
B.L. 60-pr., Mks. I, I* and I**	135·968	134·968	33·082
B.L. 60-pr., Mks. II and II*	160·968	159·968	32·282
Q.F. 4·7-in., Mks. III to IV*	170·6	169·6	24·5
Q.F. 4·5-in. Mk. II	170·92	169·92	41·83
Q.F. 4-in., Mk. III	143·456	142·456	22·894
Q.F. 3·7-in. Mks. I, II and III	156·985	155·985	39·165
Q.F. 25-pr., Mk. I	74·225	73·225	23·50
Q.F. 25-pr., Mk. II	74·235	73·235	24·238
Q.F. 18-pr., Mks. I to IV and IVB	80·232	79·232	17·728
Q.F. 18-pr., Mk. IVA	79·997	78·997	17·728
Q.F. 13-pr. 6-cwt., Mks. I to III	55·832	54·832	18·428
Q.F. 12-pr. 12-cwt., Mks. I to II*	103·035	102·035	21·565
Q.F. 3-in. 20-cwt., Mks. I to I***, III, III* and IB	117·385	116·385	23·615
Q.F. 3-in. 20-cwt., Mks. IA and IIIA	117·185	116·185	23·615
Q.F. 6-pr. 10-cwt., Mk. I	86·55	85·55	24·17
Q.F. Hotchkiss, 6-pr. 6-cwt., Mk. II	39·167	38·167	21·833
Q.F. Hotchkiss, 6-pr. 8-cwt., Mks. I and II	76·807	75·807	21·823
Q.F. Nordenfelt, 6-pr., Mk. III	81·78	80·78	23·62
Sub-calibre, Q.F. 6-pr. (B.L. 9·2-in., Mks. X, X^{v} and X* guns), Mk. I	76·797	75·797	21·833
Sub-calibre, Q.F. 3-pr. (Hotchkiss)	58·347	57·347	23·283
Sub-calibre, Q.F. 3-pr. (Nordenfelt)	68·197	67·197	24·303
Q.F. 3-pr. 2-cwt., Mk. I	43·372	42·372	18·928
Q.F. 3-pr. 2-cwt., Mk. II	59·372	58·372	18·928
Q.F. 2-pr., Mks. IX and X	65·84	64·84	17·11

APPENDIX III—*continued*

Nature	Length of rifling in inches	1-inch from commencement of rifling	
		Inches from muzzle	Inches from breech face
Howitzers—			
B.L. 18-in., Mk. I	544·37	543·37	105·03
B.L. 12-in., Mk. IV	174·87	173·87	48·48
B.L. 12-in., Mks. III and V	174·85	173·85	51·45
B.L. 9·2-in., Mk. I	110·165	109·165	24·635
B.L. 9·2-in., Mk. II	121·24	120·24	50·27
B.L. 8-in., Mk. VIII	99·52	98·52	49·78
B.L. 6-in. 26-cwt., Mk. I	65·475	64·475	23·075
Q.F. 4·5-in., Mks. I and II	52·29	51·29	18·71
Q.F. 3·7-in., Mk. I	35·685	34·685	12·115
Mortars—			
Q.F. 3·7-in., Mk. I	50·975	49·975	8·725

APPENDIX IV

Examples of Expansion of Bore

(*Referred to in para.* 24)

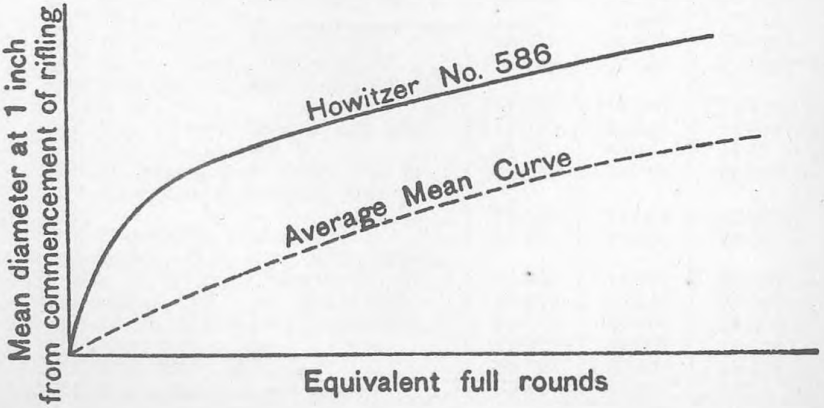
Example A.—Showing a large initial expansion at the commencement of rifling in a relined B.L. 6-inch howitzer, owing to the new "A" tube not being properly supported, followed by normal wear as the "A" tube received proper support by the surrounding wire.

B.L. 6 inch, 26 Cwt. Howitzer, V.S.M., Mk. I, Reg. No. 586; 2nd issue

Diameter at 1 inch from commencement of rifling			Total number of equivalent full rounds fired
Hor.	Vert.	Mean	
(inches)	(inches)	(inches)	
6·001	6·001	6·001	8
6·035	6·036	6·035	52·04
6·051	6·056	6·053	258·74
6·063	6·065	6·064	708·34
6·079	6·095	6·087	2818·54
6·116	6·140	6·128*	8821·29

* Howitzer provisionally condemned for wear.

Chart showing wear curve of howitzer No. 586 compared with average wear curve in B.L. 6 inch 26 cwt. howitzers.



Example B.—Showing local expansion of bore from 0 to 12 inches in a B.L. 60-pr. gun owing to a mild form of premature. Visual inspection showed nothing abnormal.

B.L. 60-pr. R.G.F., Mark I, No. 256 ; 3rd issue

Inches from muzzle	Bore measurements			Total number of equivalent full rounds
	Hor.	Vert.	Mean	
	(inches)	(inches)	(inches)	
·25	5·272	5·261	5·266	
2	5·237	5·221	5·229	
4	5·208	5·204	5·206	
5	5·134	5·128	5·131	1,707
8	5·050	5·048	5·049	
10	5·011	5·008	5·009	
12	5·004	5·000	5·002	
14	5·004	5·000	5·002	

Gun provisionally condemned.

APPENDIX V

Examples of progressive stretching of inner " A " tube, culminating in failure of the tube

(*Referred to in para.* 25)

Example A.

B.L. 60-pr. E.O.C., Mark I, No. 1069 ; 2nd issue fitted with inner " A " tube to design R.G.F./11050/130

Total equivalent full rounds fired	Muzzle protrusion of inner " A " tube
	inches
60	·31
211	·45
506	·525
625	·55
894	·575
974	·6
1,152	·625
1,373	·675
1,550	·69
1,770	·72
1,940	·74
2,046	·76
2,576	·89
2,634	·92
2,677	·925
2,893*	·98

* Inner " A " tube cracked all round at 1st step.
Gun provisionally condemned.

Example B.

B.L. 8 inch Howitzer, E.O.C., Mark VII*, E.O.C. No. 777 ; 1st issue

Inspection	Protrusion of inner " A " tube at muzzle	Forward movement of inner " A " tube at breech end
	inches	inches
1st	0·18	NIL
2nd	0·92	·057
3rd*	1·16	·060

* Wear at 1 inch from commencement of rifling :—
Hor. 8·042 inches, Vert. 8·044 inches.
Total equivalent full rounds fired :—412·02.
Chamber cracked circumferentially, at 34·7 inches from breech face to a maximum depth of 0·1 inch.
Howitzer provisionally condemned.

9/41 (3711) Wt. 28837/9219/29456. 2,000. 11/41. P.L.H. & CO. LTD. G.943.

Notified in A.C.Is. 30th July, 1941

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26 Regulations 2106

REGULATIONS FOR ARMY ORDNANCE SERVICES, PART II

PAMPHLET No. 14, 1938

AMENDMENTS (No. 1A)

1. Page 10. Para. 13 (*c*).

Below fourth sub-para. *insert* :—

26 Regulations 2106 — In the case of ordnance having a Range Table M.V. of 2,300 f.s. and over, measurements will be taken at one inch and at each succeeding inch up to three calibres from the beginning of the rifling. — Amdt. 1A July, 1941

After "one inch" in line 2 of existing fifth sub-para. *insert* "and at one calibre"

Below existing sixth sub-para. *insert* :—

26 Regulations 2106 — All measurements will be reported to the C.I.A. on A.F. G 901. It will be stated whether the gauge, plug, bore, low limit for provisional condemnation passes or not. — Amdt. 1A July, 1941

2. Page 26. *Delete* lines 1 to 7 and *substitute* :—

26 Regulations 2106 — The angle between the axis of the bore at the muzzle and the clinometer plane at the breech will be taken at each examination, and will be recorded in the memorandum when found to differ by two or more minutes from that taken at the previous examination. — Amdt. 1A July, 1941

By Command of the Army Council.

THE WAR OFFICE,
30*th July*, 1941.

Printed under the Authority of HIS MAJESTY'S STATIONERY OFFICE
by William Clowes & Sons, Ltd., London and Beccles.
(1685) Wt. 15172—8450. 9,000 7/41. W. C. & S., Ltd. **Gp. 395.**

APPENDIX III—*continued*

Nature	Length of rifling in inches (full depth)	1-inch from commencement of rifling		
		Inches from muzzle	Inches from breech face of gun	Inches from breech face of loose liner or barrel
Guns—*continued*				
Q.F. 2-pr., Mks. IX to XA (1·575)	65·84	64·84	17·11	13·91
Sub-calibre, Q.F. 2-pr., H.A. (1·575)	34·388	33·388	—	5·952
Sub-calibre, Q.F. 2-pr., L.A. (1·575)	54·84	53·84	—	8·242
Q.F. 2-pr., Mk. VIII (1·575) ..	54·84	53·84	—	8·16
Q.F. 40-mm., Mks. I and III (1·575)	75·850 (1926·6-mm.)	74·850 (1901·2-mm.)	19·638 (498·8-mm.)	13·732 (348·8-mm.)
Howitzers—				
B.L. 18-in., Mks. I to II ..	544·37	543·37	105·03	—
B.L. 12-in., Mks. III and V ..	174·85	173·85	51·45	—
B.L. 12-in., Mks. IIIA and VA	174·87	173·87	48·48	37·93
B.L. 12-in., Mk. VI	174·87	173·87	48·48	—
B.L. 9·2-in., Mk. I	110·165	109·165	24·635	—
B.L. 9·2-in., Mk. II	121·24	120·24	50·27	—
B.L. 9·2-in., Mk. IIA	121·24	120·24	50·27	42·27
B.L. 8-in., Mk. VIII	99·52	98·52	49·78	—
B.L. 7·2-in., Mks. I to I*, II, III and IV	128·68	127·68	43·32	—
B.L. 6-in., 26-cwt., Mk. I ..	65·475	64·475	23·075	—
Q.F. 4·5-in., Mks. I to II ..	52·29	51·29	18·71	—
Q.F. 3·7-in., Mks. I and III ..	35·685	34·685	12·115	—
Q.F. 3-in., Mks. I to IA ..	69·06	68·06	10·14	6·940
Mortars—				
Q.F. 3·7-in., Mk. I	50·975	49·975	8·725	—

By Command of the Army Council,

THE WAR OFFICE,
4th February, 1942.

(1833) Wt. 40247—9781. 9,000. 1/42. W. C. & S., Ltd. **Gp. 395.**

Notified in A.C.Is. 4th February, 1942

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26 Regulations 2106

REGULATIONS FOR ARMY ORDNANCE SERVICES, PART II

PAMPHLET No. 14, 1938

(AMENDMENTS No. 2A)

Pages 34 and 35. *Delete* Appendix III and *substitute*:—

Amdt. 2A Feb., 1942

APPENDIX III

Plan lengths of rifling

(*Referred to in para.* 18)

26 Regulations 2106

Note.—The plan diameter of 1-in. from C. of R., where it differs from that disclosed by the nomenclature of the ordnance, is inserted in brackets.

Nature	Length of rifling in inches (full depth)	1-inch from commencement of rifling		
		Inches from muzzle	Inches from breech face of gun	Inches from breech face of loose liner or barrel
Guns—				
B.L. 15-in., Mk. I	516·33	515·33	135·07	—
B.L. 14-in., Mk. VI	588·75	587·75	140·25	—
B.L. 9·2-in., Mks. X, Xv, X* and XV	353·8	352·8	89·55	—
B.L. 9·2-in., Mk. XIII	271·3	270·3	64·725	—
B.L. 9·2-in., Mk. XIII* ..	273·0	272·0	63·025	—
B.L. 9·2-in., Mk. XIIIA ..	273·0	272·0	63·025	54·4
B.L. 6-in., Mks. VII, VIIv (original chamber)	234·783	233·783	45·445	—
B.L. 6-in., Mks. VII, VIIv, VII*, VIIv* (modified chamber) ..	233·602	232·602	46·626	—

APPENDIX III—*continued*

Nature	Length of rifling in inches (full depth)	1-inch from commencement of rifling		
		Inches from muzzle	Inches from breech face of gun	Inches from breech face of loose liner or barrel
Guns—*contd.*				
B.L. 6-in., Mk. XIX	170·758	169·758	49·462	—
B.L. 6-in., Mk. XXI	259·053	258·053	52·372	—
B.L. 6-in., Mk. XXIV	233·302	232·302	46·998	40·298
Q.F. 6-in., Mk. II	214·16	213·16	36·09	—
B.L. 5·5-in., Mk. III	135·32	134·32	37·28	32·08
B.L. 4·5-in., Mk. II	156·825	155·825	36·925	31·725
B.L. 4·5-in., Mks. I to I* ..	156·435	155·435	36·565	31·465
B.L. 60-pr., Mk. I to I** (5·000)	135·968	134·968	33·082	—
Q.F. 4·7-in., Mks. III to IV* (4·724)	170·6	169·6	24·5	—
Q.F. 4·5-in., Mk. II (4·450) ..	170·92	169·92	41·83	30·33
Q.F. 3·7-in., Mks. I, II, III ..	156·985	155·985	39·165	29·015
Q.F. 25-pr., Mk. I (3·450) ..	74·225	73·225	23·50	19·375
Q.F. 25-pr., Mk. II (3·450) ..	74·235	73·235	24·238	19·275
Q.F. 18-pr., Mks. I to II* (3·300)	80·232	79·232	17·728	—
Q.F. 13-pr., Mks. I to III (3·000)	55·832	54·832	18·428	—
Q.F. 12-pr., 12-cwt., Mks. I to II* and IV (3·000)	103·035	102·035	21·565	—
Q.F. 3-in. 20-cwt., Mks. I to I***, III, III*, IB	117·385	116·385	23·615	18·615
Q.F. 3-in. 20-cwt., Mks. IA and IIIA	117·185	116·185	23·615	18·615
Q.F. 75-mm., Mk. IV (2·953) ..	97·745	96·745	29·675	21·375
Q.F. 75-mm., Mk. I (2·953) French	87·4683	86·4683	20·6577	—
Q.F. 75-mm., Mk. I (2·953) converted	78·238	77·238	19·722	—
Q.F. 6-pr. 10-cwt., Mk. I (2·244)	86·55	85·55	24·17	—
Q.F. 6-pr. 7-cwt., Mks. II to III (2·244)	78·18	77·18	23·77	19·02
Q.F. 6-pr. 6-cwt., Mks. I to II Hotchkiss (2·244)	39·167	38·167	21·833	—
Q.F. 6-pr. 8-cwt., Mks. I to II Hotchkiss (2·244)	76·797	75·797	21·833	—
Q.F. 6-pr., Mk. III (Nordenfelt) (2·244)	81·78	80·78	23·62	—
Sub-calibre, Q.F. 6-pr., guns (2·244)	76·797	75·797	21·833	—
Sub-calibre, Q.F. 3-pr., Mks. I, I*, III, V, VII (1·850) ..	58·347	57·347	23·283	—
Sub-calibre, Q.F. 3-pr., Mks. II, II*, IV (1·850)	68·197	67·197	24·303	—
Q.F. 3-pr. 2-cwt., Mk. I (1·850)	43·372	42·372	18·928	—
Q.F. 3-pr. 2-cwt., Mk. II (1·850)	59·372	58·372	18·928	—

Quarter of Life.	Fired since last examination.				Grand Total of equivalent full rounds fired.	Diameter at 1 inch from commencement of rifling.			Maximum depth of Scoring.	Max: depth of Scoring added to ½ wear at the same point.	Sentence and Date.	Probable remaining life of rifling in Full Rounds.	Probable Depth of Scoring in next series.
	Proof Charges	Full Charges	Three-quarter Charges	Half Charges		Hor.	Vert.	Mean.					

ROUNDS should be computed as follows:-

For all guns, except B.L. 9·2 inch, Mark XIII.

1 proof charge = 2 full charges.
1 full charge = 4 three-quarter charges.
1 full charge = 16 half charges.

Each round fired with paper shot is to be assessed as one equivalent full charge if the round is designed to produce a service length of recoil.

Any other reduced charge will be taken as equal to the charge (full, three quarter or half) next above it.

For all howitzers, and B.L. 9·2 inch Mark XIII guns.

The decimal value of each charge will be as shewn in the Memorandum of Examination.

APPENDIX II.

(Referred to in para. 18.)

INSTRUCTIONS FOR FILLING IN THIS FORM.

1. Examinations to be made after every equivalent full charges computed as on the last page, provided that the actual total number does not exceed
When scoring begins in these guns, the series for subsequent examinations will be half this number.

2. The table on the last page should be completed after each examination.

3. The mean wear, and scoring plus half wear, should be plotted separately on the inside page.

4. A gun or howitzer will be provisionally condemned when the mean diameter at 1" from the commencement of the rifling (inches from the breech face) reaches
(See R.A.O.S. Part II. Pamphlet No. 25.)

5. A gun or howitzer will also be P.C. if the maximum depth of scoring at any point in the bore, plus half wear at the same point, amounts to

NOTE:- This form to be kept with the Memorandum of Examination.

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Quarter of Life.	Fired since last examination.				Grand Total of equivalent full rounds fired.	Diameter at 1 inch from commencement of rifling.			Maximum depth of Scoring.	Max: depth of Scoring added to ½ wear at the same point.	Sentence and Date.	Probable remaining life of rifling in Full Rounds.	Probable Depth of Scoring in next series.
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