Chapter Thirty-two

MISCELLANEOUS
RENEWALS, RECONDITIONING, REPAIR AND SALVAGE

Contents

Illustrations

THIS CHAPTER contains instructions for reconditioning and repairing worn or damaged components which do not form part of the assemblies covered by chapter 28 to 31. Instructions for dismantling and reassembling these components are not given unless they are an essential part of the repair instructions; reference should be made to chapter 23, 24, 33, and 34 as appropriate for information on dismantling or reassembling individual components before, or after, reconditioning or repair.

This chapter also contains instructions for carrying out processes, such as enamelling and plating, where it is thought necessary to provide specific information for such treatment of de Havilland engine components; where, however, such processes are peculiar to a few engine components only, for example vapour blasting and re-anodising of impellers, the process will be described in chapter 28, 29, 39, or 31 as appropriate. Where such instructions are not given standard aircraft-engineering practice should be followed. Most of the information contained in this chapter is based on the manufacturer's turbine repair (T.R.) schemes and process specifications, and, in each instance, the relevant drawing (T.R.) number and issue number, or specification number, is quoted; turbine repair schemes are introduced under the cover of a modification and this modification number is quoted also. After any repair has been completed, an entry should be made in the appropriate record book of the engine in accordance with British Air Registration Board Inspection Procedure, Section ML, Leaflet 1-1; refer also to page 3 of this chapter.

It must be appreciated, of course, that these repairs can be carried out only under the supervision of an Inspection Organisation approved for such repair work by the British Air Registration Board, or an equivalent authority, or under the supervision of an appropriately licensed aircraft engineer. It is assumed also that personnel having the requisite skill and experience will be employed and that the necessary tools and equipment will be available.

Where special tools and equipment are available for carying out repairs described in this chapter, they are listed, under the relevant T.R. number, in Part II Section G of "de Havilland Gas Turbines, Tools and Equipment for Servicing and Overhaul" which is issued as a separate publication.

"CROSS" HELICAL THREAD WIRE INSERTS

These wire inserts are screw thread bushings hot coiled from diamond shaped cross-sectioned steel wire manufactured in accordance with British Specification D.T.D.239. To ensure a positive and even seating when inserted into the tapped hole, the inserts are produced incorporating a controlled degree of oversize on the thread diameters whilst in the "free" position.

Assembly is effected by screwing the insert into the tapped hole by means of a diametral tang which may be notched or un-notched, as required for respective application to "through" or "blind" holes. When inserts with a notched tang are fitted, the tang is broken off and removed after insertion.

The dimensions and limits specified in the appropriate repair scheme must be rigidly adhered to, and the correct wire insert used. Due to the size and nature of these inserts, individual part numbering is not possible, therefore, different inserts should be segregated into clearly marked containers.

It is absolutely essential that the tapped hole is free from swarf, etc., before fitting the insert. The insert being flexible, may tend to ride over any particles of foreign matter, where a normal bolt or stud would clear the hole.

Surface treatment when specified, must be completed before preparing a tapped hole to take an insert. The top of an insert when screwed into a tapped hole, should be below the surface an amount equal to the depth of the counterbore, thus ensuring that the existing 'stand out' length of the stud is maintained.

The two types of inserts—notched and un-notched—and the tool that is used to insert either type are illustrated in Fig. 1. The integral tang provided on the inner end of the insert to facilitate fitting, should be broken off in all instances where a foul of the bolt or screw would otherwise occur;

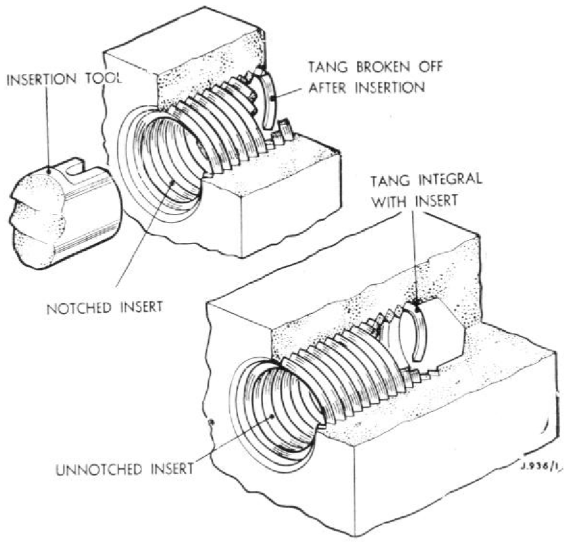

Fig. 1. Example of notched and un-notched inserts fitted to "through" and "blind" holes by means of insertion tool shown.

in this instance a notched insert will be required. In all other applications, the tang will be un-notched and may remain integral with the fitted insert.

If it is necessary to remove a fitted insert for any reason, the top end of the wire should be bent towards the centre of the hole; engaged by the slotted tool; removed, and then discarded. A new insert must be used as a replacement.

The following table lists the tools required to fit each size of insert and also the gauges used to check the insert after it is fitted. The part number of the inserts required will be specified in the appropriate repair schemes.

Insert Size	*Drill Size*	*Taper Tap Part No.*	*Plug Tap Part No.*	*Screw Gauge (Effective Dia.) Part No.*	*Inserting Tool Part No.*	*John Bull Mandrel (Intercheck)*	*John Bull Small Bore Gauge (Intercheck)*
2 BA	No. 10	T.77331	T.77343	Not required	T.77345	Not required	Use with appropriate mandrel and ring gauge to check insert when fitted.
$\frac{1}{4}$ BSF	Letter F	T.77320	T.77332	T.77362	T.77346	$\frac{1}{4}$ BSF (effective)	
$\frac{5}{16}$ BSF	Letter P	T.77321	T.77333	T.77363	T.77347	$\frac{5}{16}$ BSF (effective)	
$\frac{3}{8}$ BSF	Letter W	T.77322	T.77334	T.77364	T.77347	$\frac{3}{8}$ BSF (effective)	
$\frac{7}{16}$ BSF	$\frac{29}{64}$ in. dia.	T.77323	T.77335	T.77365	T.77349	$\frac{7}{16}$ BSF (effective)	
$\frac{1}{2}$ BSF	$\frac{33}{64}$ in. dia.	T.77324	T.77336	T.76794	T.77349	$\frac{1}{2}$ BSF (effective)	
$\frac{9}{16}$ BSF	$\frac{37}{64}$ in. dia.	T.78332	T.78333	T.78447	T.77349	$\frac{9}{16}$ BSF (effective)	
$\frac{1}{8}$ BSP	$\frac{25}{64}$ in. dia.	T.77325	T.77337	T.77366	T.77346	$\frac{1}{8}$ BSP (effective)	
$\frac{1}{4}$ BSP	$\frac{17}{32}$ in. dia.	T.77326	T.77338	T.77367	T.77348	$\frac{1}{4}$ BSP (effective)	
$\frac{3}{8}$ BSP	$\frac{43}{64}$ in. dia.	T.77327	T.77339	T.77368	T.77348	$\frac{3}{8}$ BSP (effective)	
$\frac{1}{2}$ BSP	$\frac{27}{32}$ in. dia.	T.77328	T.77340	T.77369	T.77350	$\frac{1}{2}$ BSP (effective)	
$\frac{5}{8}$ BSP	$\frac{29}{32}$ in. dia.	T.77329	T.77341	T.77370	T.77350	$\frac{5}{8}$ BSP (effective)	
$\frac{3}{4}$ BSP	$1\frac{3}{64}$ in. dia.	T.77330	T.77342	T.77371	T.77350	$\frac{3}{4}$ BSP (effective)	

INTERPRETATION OF MACHINING SYMBOLS


Denotes a datum surface.


Indicates the degree of accuracy of a surface in relationship to a datum surface in the same letter group. The figure expresses the permitted tolerance in units of 0·001 inch.


Triangle denotes a machined surface. Figures indicate surface finish in micro-inches to British Standard 1134. Letter/s indicate type of machining to British Standard 308.

G = Grind. H = Hone. LP = Lap.

PO = Polish. SP = Spot Face.

REPAIR IDENTIFICATION

When a component has been repaired, during overhaul, in accordance with an approved repair scheme, it is normal practice to stamp or etch, as appropriate, the 'TR' number, adjacent to the part number, on the repaired component. Where there are a number of oversizes, or undersizes, which are covered by a single 'TR' number, a suffix is added to indicate the actual oversize. Therefore, when a subsequent repair to a larger oversize is made, it is necessary only to add the appropriate suffix to the existing 'TR' and suffix number. This method of identification should avoid any wasted time which could arise from attempts to repair components which had been repaired already to the greatest permissible oversize.

In the case of certain components, such as the impeller, where one or more stud or dowel holes may be repaired individually, it is not possible to record the history of all the oversize studs and dowels likely to be fitted during the life of the component, on the component itself.

For manufacturer's new production salvage, therefore, the appropriate 'TR' number is marked adjacent to the component part number, and the degree of oversize for any stud is marked adjacent to the hole concerned, prefixed by 'S'—e.g., S.007. In the case of dowels, the degree of oversize is prefixed 'D'. This system, which has been applied to new components manufactured since mid-1952 only, ensures that the build history of such new components is readily available. Before this, the normal practice was to modify all the stud, or dowel, holes to the same oversize, and in such cases the 'TR' suffix contains the essential information. This has been explained, at some length, to enable operators to understand the markings which may be found on certain individual components.

When repair is carried out, subsequent to initial manufacture, the history of oversize studs and dowels is to be recorded in the engine log book, maintenance record book or folder, in accordance with the recognised procedure for the renewal and re-validation of Certificates of Airworthiness, and not marked on the component unless specified; refer to British Air Registration Board Inspection Procedures, Section ML, Leaflet 1-1. Where a production oversize hole is subsequently modified during overhaul, the existing degree of oversize suffix must be cancelled by a 'dash' stamped or etched over the figure. Where a repair is carried out on any individual component for the first time, that component should, of course, be marked with the appropriate 'TR' number.

ELECTRO-DEPOSITION OF HARD CHROMIUM

D.H. Process Specification No. 132/4, October, 1954

The process described in this specification may be used to reclaim steel components which have become worn or damaged, and where a hard surface is required, to a maximum thickness of 0·015 inch. This procedure conforms to the requirements of British Specification D.T.D.916.

The solutions used in this process must be under laboratory control.

Apparatus

The apparatus required for carrying out this process is as follows. A wax tank fitted with a steam heating coil is required and also a lead-lined tank to contain the sulphuric anodic etching solution. The lead coating of this tank is to be arranged to act as an electrode. The electrolyte for depositing the chromium must be contained also in a lead-lined tank, made of mild steel, fitted with reinforced glass side panels and a suitable fume extraction system. Steam heating and cooling equipment must be arranged to enable a working temperature to be thermostatically maintained. To ensure uniform deposition of the chromium, suitable jigs should be provided where necessary.

Preparation of work

The components to be plated must be cleaned from all grease and foreign matter by immersion in a trichlorethylene vapour degreaser until they have attained the temperature of the vapour. To clean the components it may be necessary to scour them with fine pumice powder.

Areas on which a chromium deposit is not required must be "stopped off" with a suitable stopping-off wax such as Akerin 4336 wax obtainable from Astor Boisillier and Lawrence. This wax does not require fume extraction and is used at a temperature of 195 to 205 deg. F. (90 to 96 deg. C.). The areas which are to be plated are given a thin coating of glycerine-chalk paste prior to the application of the stopping-off wax. The wax may easily be removed from the areas covered by the glycerine-chalk paste while the wax is still warm but care must be taken to ensure that the adhesion of the adjacent wax is not impaired. The areas to be plated must be cleaned from final traces of

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wax, by scouring with pumice powder, followed by a rinse in cold water.

Before plating, the components must be etched in a sulphuric acid solution at six volts and 200 to 300 amperes per square foot at room temperature. The sulphuric acid solution must contain 20 to 35 per cent by volume (30 to 40 per cent by weight or 58 to 100 ounces per gallon). The etching should produce a clean grey surface free from smut. The etching time must not exceed five minutes. As an alternative the components may, at laboratory discretion, be anodically etched for 30 seconds in the plating solution immediately prior to deposition.

Processing

The composition of the plating electrolyte is to be as follows:

Chromic acid, 40 to 45 ounces per gallon,
Sulphuric acid, 0·40 to 0·45 ounces per gallon.

The ratio of the Chromic acid to sulphuric acid is to be 90/110 to one and the specific gravity of a freshly prepared solution is approximately 1·16. The bath is to be worked at a temperature of 123 to 128 deg. F. (50 to 53 deg. C.).

The anodes should be made of antimonial lead for preference and must conform as closely as possible to the cathode contour to ensure a uniform deposition of the plating.

The operating conditions to be observed when plating is in progress must conform with those described. The components must be plated in the electrolyte at a current density of 260 to 280 amperes per square foot when the rate of deposition will be approximately 0·0005 inch per hour (i.e. 0·001 inch on diameter).

When the plating is completed the components must be thoroughly washed in cold running tap-water to remove all traces of the electrolyte, after which, they must be rinsed in hot water and air dried.

After plating, certain of the components will require de-embrittling; these are surface hardened steels and high tensile steels (i.e. of 65 tons tensile strength and above). The brittleness is removed by heating the components to a temperature of 150 to 200 degrees C. (300 to 390 deg. F.) for one hour after plating. Laboratory guidance in this matter should be sought if required. Materials which require this treatment after chromium plating include steels to the following specifications: S.28, S.65, S.98 (D.T.D.473) and S.99 (D.T.D.331).

In cases where no operation for the removal of brittleness has been carried out, it has been found beneficial to immerse the plated components in a de-watering oil immediately after washing in order to assist in surface protection. A suitable de-watering oil for this purpose is "Ilo" No. 5, which is supplied by W. B. Dick and Co., Ltd.

Flaw detection

High tensile or surface hardened components to which magnetic flaw detection is applicable and which are treated by this plating process, are to be examined by magnetic flaw detection after completion of the surface processing and any associated low temperature heat treatment.

CONTROL OF RESISTANCE WELDING AND HOT RIVETING PROCESSES

D.H. Process Specification No. 151/1, April, 1953

This process specification covers the materials, instructions and tests for electrical resistance spot welding, stitch welding, seam welding, projection welding, and hot riveting.

Electrical resistance welding is a process by which sheet metal, thin cast or wrought sections may be welded together if an electric current is passed by means of electrodes through two overlapping sections of metal, thus causing heating by the inherent resistance of the material which results in its fusion between the electrodes.

The welding machine consists of the following essential components. A transformer is required to supply the necessary high voltage welding current which is taken from the secondary windings. A means of applying mechanical pressure on the electrodes, such as pneumatically operated piston, with a suitable control valve, is also necessary, as to ensure a good weld the electrodes must firmly grip the material between them. Timing devices, a water circulating system for cooling the electrodes and voltage compensators are other requirements.

Spot welding is the term given to the type of welding where single spaced-out welds are made in the form of "spots" as shown in section in Fig. 3.

Stitch welding is similar to spot welding except that a series of overlapping spots are made. This is usually used as an alternative to seam welding at places where seam welding would be impracticable.

When carrying out seam welding, a machine equipped with circular disc or wheel-shaped rotating electrodes is necessary. This system produces a seam of overlapping spots with the assistance of a suitable thermionic timing device to control the speed of welding. One of the disc-shaped electrodes is driven at a fixed speed which automatically feeds the work between the electrodes. The speed of welding varies with the material but the values quoted in the accompanying table are typical.

Typical seam welding speeds

Material	*Speed in inches per minute*
Mild steel	36 to 90
Stainless steel	10 to 24
Nimonic 75	12 to 20

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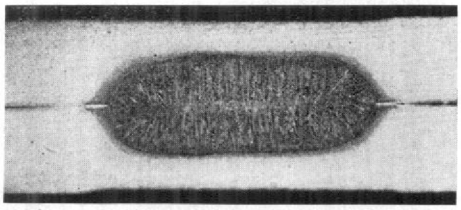

Fig. 3. Spot weld in heat resisting steel (Nimonic 75).

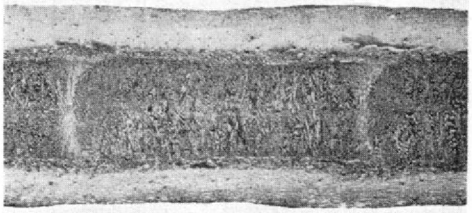

Fig. 6. Seam weld in heat resisting steel (Nimonic 75).

A section of a typical seam weld is shown in Fig. 6.

Projection welding is a process differing from those already mentioned, in that the size and shape of the fused spot is controlled, not by the electrodes but by suitable projections on one of the components to be welded. In this way a number of spots may be made simultaneously between two parts. The quality of the welding is dependent to a large extent on the size and position of the projection.

Hot riveting makes use of the electric welding machine which provides the current and pressure for heating and forging a rivet placed between the electrodes.

The materials that may be welded by electrical resistance welding cover quite a large field and though dissimilar metals may be satisfactorily welded certain precautions are necessary to ensure a good weld.

Mild steel used for normal resistance welding should have a carbon content below 0·25 per cent. However, it is quite common to use mild steel to

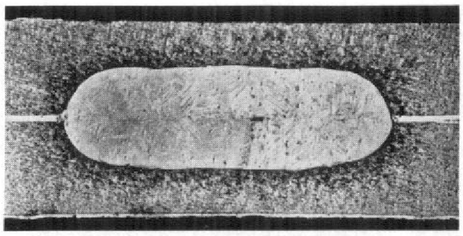

Fig. 7. Spot weld in nickel-plated low-carbon steel (S.84).

the specifications quoted in the accompanying table.

If it is necessary to weld mild steel of a higher carbon content than those quoted or containing alloying elements, special welding cycles are employed.

The mild steel quoted may normally be spot, stitch, or seam welded in all thicknesses up to a

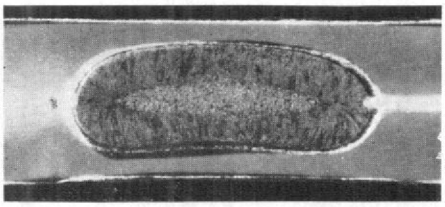

Fig. 4. Spot weld in aluminium alloy (Alclad, D.T.D.610).

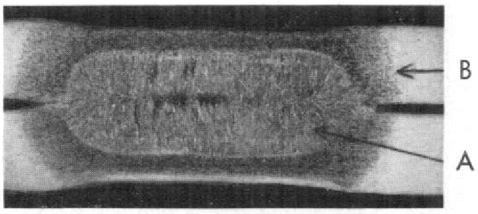

Fig. 8. Spot weld in low-carbon steel (S.84).

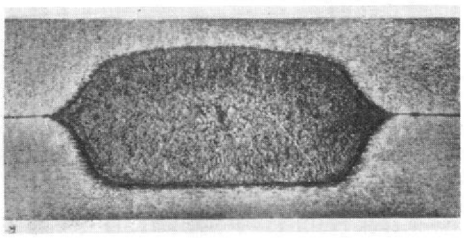

Fig. 5. Spot weld in stainless steel (D.T.D.171).

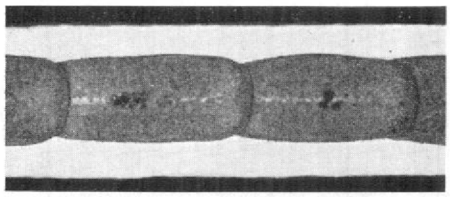

Fig. 9. Seam weld in stainless steel (D.T.D.171).

combined total thickness of 0·25 inch. It is possible to resistance weld sections thicker than this but the welding of such assemblies should only be carried out after each individual case has been considered.

Specifications of mild steel commonly used for resistance welding

Specification number	*Maximum percentage of carbon*
S.84	0·12
S.3	0·2
S.21	0·25

Stainless steel may be welded by this process though the Austenitic varieties are generally used as they are readily welded by all resistance processes. The stainless steels listed in the accompanying table may be spot, stitch, and seam welded in thicknesses up to a combined total of ⅜ inch.

Stainless steels used for electrical resistance welding

Specification Number	*Type Specification*
D.T.D. 171 D.T.D. 571	18 per cent chrome 20 per cent nickel
D.T.D. 493	25 per cent chrome 20 per cent nickel
Red Fox 33	20 per cent chrome 30 per cent nickel
D.H.E. 204 D.H.E. 223 D.H.E. 225	22 per cent chrome 12-15 per cent nickel (cast in the form of thin flanges and projections)

Heat resisting non-ferrous alloys of the nickel base type that are generally used have approximately the same welding characteristics as stainless steel. The nickel base alloys listed in the accompanying table may also be spot, stitch, and seam welded in thicknesses up to a combined total of ⅜ inch.

Nickel base alloys suitable for electrical resistance welding

British Specification Number	*Manufacturer's Reference Number*
D.T.D. 703	Nimonic 75
D.T.D. 714	Nimonic 75F
D.T.D. 725	Nimonic 80
D.T.D. 328	Inconel
D.T.D. 204	Monel (70 per cent nickel 30 per cent copper)

Resistance welding may be applied to materials which have been plated with cadmium or nickel for corrosion resistance purposes. However, the welding problems are in fact magnified by the presence of such electro-deposited films, but even so, it is considered preferable to plate the component parts before they are welded, as this will ensure adequate corrosion resistance at the contact faces of the weld. Parts intended for resistance

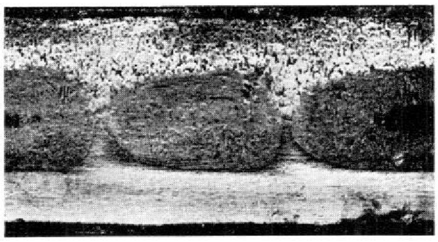

Fig. 10. Stitch weld between dissimilar materials (D.T.D.493 and H.R.C.M.).

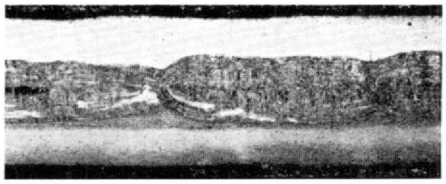

Fig. 11. Seam weld between dissimilar materials (D.T.D.171 and Nimonic 75).

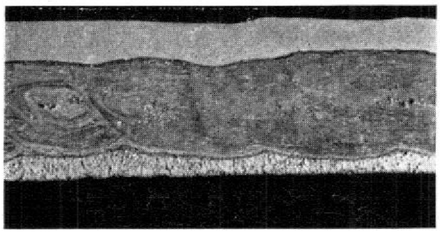

Fig. 12. Seam weld between dissimilar materials (S.84 and S.110).

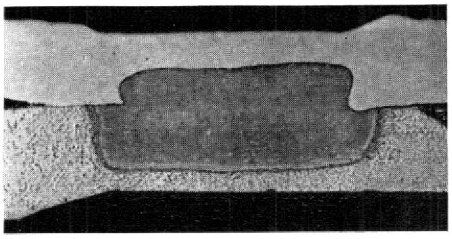

Fig. 13. Spot weld between dissimilar materials (S.84 and S.110).

welding after plating should have the following thickness tolerances stated on the drawings:—

Nickel	0·001 inch max.
Cadmium	0·0005 inch max.

When plated materials are welded, special conditions in the quality of the weld must be maintained. It is important that surface overheating should be reduced to a minimum to avoid serious damage to the plating. However, the nugget penetrations should be high to ensure that adequate mixing occurs in the fused area. A minimum penetration of 50 per cent is recommended. The

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different thermal properties of the materials in the weld increase the possibility of cracking and the welding sequence, therefore, requires more careful control than is normally the case. The welding of cadmium plated components is accompanied by contamination and rapid wear of the electrodes.

Dissimilar materials present a problem in resistance welding as it is difficult to obtain a uniform penetration of the individual sheets as the materials will have differing electrical resistances. The result of this is uneven heating and the weld nugget will tend to be offset at the welding face, and steps must therefore be taken to restore the uniform disposition of the nugget. Typical welds between dissimilar materials are shown in Fig. 10 to 13.

The accompanying table indicates the possibility of welding together various combinations of dissimilar materials.

Aluminium and its alloys may be resistance welded but is usually confined to spot welding. As these alloys are normally forged and heat treated it should be realised that there will be a loss of material strength at the weld. This will occur both as a result of the reversion to the cast condition in the weld nugget and overheating effects on the surrounding wrought structure.

Preparation for welding

The surfaces of any components to be welded must be free from scale, grease, oxide, paint and all other contaminating films. As a general procedure, the material should be degreased in trichlorethylene vapour and the surfaces prepared for welding by wire brushing.

When the material is badly scaled the use of a wire brush tends to burnish the scale rather than remove it. In such cases the components should

WELDING SUITABILITY TABLE

	Inconel	Nimonic 80	Nimonic 75, Nimonic 75F	Monel	25/12-15 cast stainless	25/20 stainless steel	18/8 stainless steel	Cadmium plated mild steel	Chromium plated mild steel	Nickel plated mild steel	Mild steel
Mild steel	2	3	3	3	2	2	2	2	1	1	1
Nickel plated mild steel	2	2	2	2	1	1	1	3	2	2	
Chromium plated mild steel	2	2	2	2	2	2	2	2	2		
Cadmium plated mild steel	2	2	2	2	2	2	2	2			
18/8 stainless steel	1	1	1	2	1	1	1				
25/20 stainless steel	1	1	1	2	1	1					
25/12-15 cast stainless	1	1	1	2	1						
Monel	2	2	2	1							
Nimonic 75 / Nimonic 75F	1	1	1								
Nimonic 80	2	2									
Inconel	1										

Aluminium alloys cannot be welded to other materials

Key to table numbers
1. Good production possibility
2. Requires careful control
3. Not recommended

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be chemically etched or acid pickled in the appropriate bath after degreasing. Acid pickling or chemical etching may only be carried out on components where the process is specified in the appropriate repair scheme.

It is essential that the mating parts of two components when assembled for welding should fit so that the two surfaces are in contact with each other or can be made to contact each other with light manual pressure prior to each weld being made.

Where the standard welding conditions cannot be used such as when welding more than two sheets of metal together, or when welding sheet to cast or plated components, the settings may be modified to suit those conditions. The quality of the weld will then be assessed by normal tests as far as possible. Where, however, a discrepancy exists, or there is doubt or dispute as to the results of these tests, laboratory advice should be sought to enable a decision to be made whether the method of test is satisfactory and advise the inspection department of the quality of the weld produced.

There are various types of electrodes which can be used for the different types of resistance welding.

The following table gives a general guide to the type of electrode employed with the various metals when engaged in spot, stitch, or seam welding.

When engaged in projection welding, Elkonite grade 20.W.3 electrodes are suitable for all steels.

For electrical hot riveting, Elkonite electrodes are used, grades 20.W.3 or 100.M being satisfactory for this purpose.

The electrodes normally used in spot and stitch welding are in the form of a truncated cone with a 120 degrees included angle. For certain applications one of the electrodes may be domed or flat, provided that the use of such electrodes does not detract from the quality of the weld or cause it to deviate in size from that produced by normal electrodes. In seam welding both the sides of the wheel electrodes must be chamfered equally from the track of the seam weld, with a total included angle of 120 degrees. The correct electrode tip diameter and track width for the thickness of sheet to be welded is given in the table on page 26. When sheet metal of similar material but different thicknesses are being welded, a larger sized electrode tip or wheel should be used against the thicker sheets.

When materials of different composition are being welded the electrode sizes quoted may have to be modified to suit the material. The criteria on which the use of other sizes depend and on which their use is permissible are as follows:

1. Attainment of a satisfactory nugget size.

2. Correct heat balance. Where the design of

ELECTRODE TYPES FOR SPOT, STITCH, AND SEAM WELDING

	Aluminium Alloy	Stainless Steel Heat Resisting Non-Ferrous	Nickel & Chromium Plated Mild Steel	Mild Steel
Mild Steel	X	II / III	II / II	II / II
Nickel & Chromium Plated Mild Steel	X	II / III	II / II	
Stainless Steel Heat Resisting Non-Ferrous	X	III / III		
Aluminium Alloy	I / I			

Class of material

I. Hard drawn high conductivity copper
II. Mallory 3, CCS (Enfield rolling mills)
III. Mallory 100, 3A (Enfield rolling mills)

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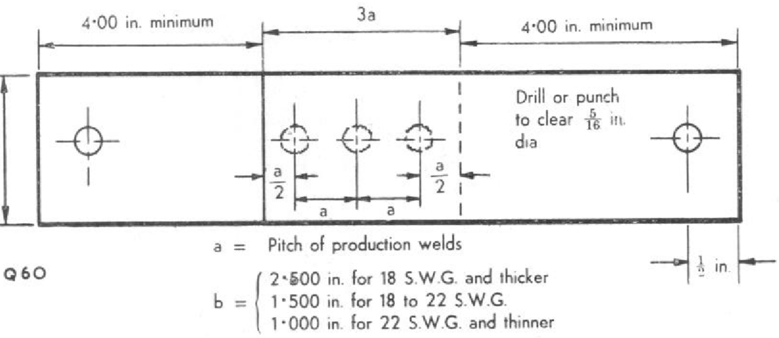

Fig. 14. Dimensions for spot welding a tension-shear test piece.

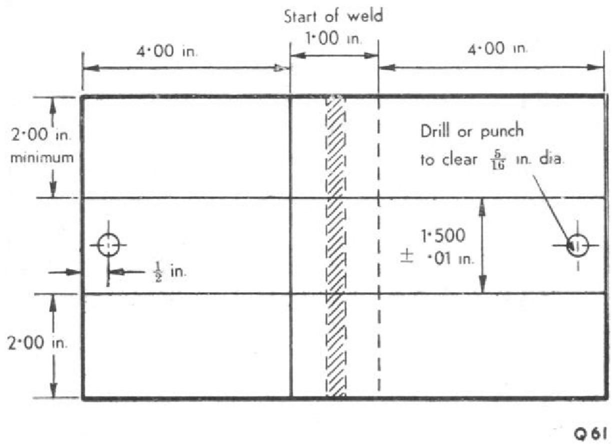

Fig. 15. Dimensions for stitch and seam welding a tension-shear test piece.

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the component prohibits the use of the correct size of electrode, a different size or shape may be used after consultation with the design authority or inspection department.

All electrode shanks used must conform to British Specification 807 in respect of design, and arrangements must be made for water cooling.

A hand file must on no account be used to reduce the tip diameter of the electrodes. When the nominal diameter of the electrodes is increased by 10 per cent they should be machined. The only permissible form of hand-trimming which can be allowed is the rotation of a finely shot-blasted plate between the electrode tips under pressure until a uniform copper impression is obtained. Emery cloth must not be used as the abrasive particles tend to become embedded in the electrode tip.

Control of processes

The welding procedure is controlled on the results of the examination of separately welded test pieces. The inspection department must verify that the welding procedure used to make the test piece is subsequently used on the component itself.

If the welding of the component introduces a large amount of magnetic material between the electrode arms, the standard of welding must be investigated by the macroscopic examination of the first component welded.

If the nugget characteristics of this sample are different from those found in a flat test piece, then the control of future welding must be on the basis of the examination of one component from each welding batch.

When the welding machine settings are being ascertained for any particular component then the test piece used for this purpose must be made of the same material specification and made up from the same number and thicknesses of pieces present in the component to be welded. The surface preparation of the test pieces must be the same as that to be given to the actual component. It is also important that the surface hardness of both test pieces and components shall be identical.

Tests that must be carried out on the test pieces are described below.

A tension-shear test consists of loading two overlapping resistance welded sheets in tension. The form of the test piece will vary with the type of welding and must be as follows:

Spot welding. In the test piece illustrated in Fig. 14 the welds must be made in the order shown, weld No. 1 must be removed by drilling before testing is carried out. The test results are to be recorded in pounds per spot, that is, failing load/2. The manner of the failure, whether in shear (S), pulling out the spot (P) or away from the weld (away) is to be recorded. When broken, the spot diameter should be measured and recorded.

Stitch and seam welding. In the test piece illustrated in Fig. 15 the results of the test must be recorded in pounds per line inch, that is, failing load/length of seam tested.

Macro test. This test is to establish acceptable welding machine settings for projection welded and hot riveted joints as well as for the normal resistance welding processes. The form of the test piece and the tests to be undertaken are as follows.

Spot weld. The dimensions for the test piece used to establish spot weld machine settings are as indicated in Fig. 16. The welds should be made in the order shown and the macro-section taken from No. 3, along the plane X-X. The specimen should be reserved and in cases of doubt a further section should be cut from No. 2.

Stitch and seam welds. The test piece to be used is illustrated in Fig. 17 and a transverse and longitudinal section is to be taken on the planes X-X and Y-Y as shown. These may be taken from the tension-shear test panel as illustrated in Fig. 15.

Projection welds. In this case, as it is usual to make only small components or assemblies by this process, an example of the actual component should be used as a test piece and a section taken so as to include at least two representation "spots". Where it is impracticable to use the component as a test piece, the nearest approach to the design of the component should be attained in the test piece.

When preparing for the acid etch test on electrical hot riveting, the material of the test piece to be riveted must be of the same composition, condition and thickness as in the component. The holes to receive the rivets must be the same size and tolerance as in the component. A transverse section should be taken in a plane including the longitudinal axis of the rivet.

The section should be prepared by filing, then by grinding on successively finer grades of emery paper to a suitable finish for low-power microscopical examination.

Composition of the electrolyte should be 10 per cent. oxalic acid at room temperature and sufficient current density can be obtained from a 12 volt accumulator which will etch specimens up to 0·500 in. square.

Copper wire 16 S.W.G. electrodes should be used. The positive lead will be connected to the specimen when immersed in the solution, and the negative lead dipped into the solution above the surface to be etched. Agitation of the cathode will improve the uniformity of the etch, but care must be taken to ensure that the cathode does not come into contact with the surface of the specimen otherwise burning will occur.

The time taken for etching will vary; Nimonic 75 and 80a will require about one second; whilst a longer period will be required for D.T.D.171, 493, and 571.

The specimen when etched, should be examined at low power magnification of × 16 and the

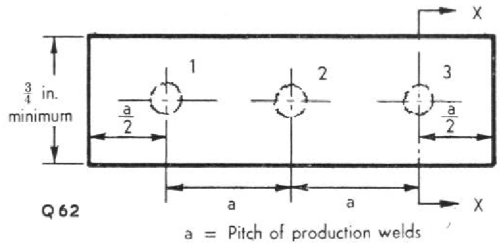

Fig. 16. Dimensions for spot welding a macro test piece.

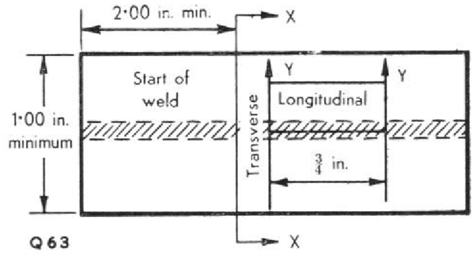

Fig. 17. Dimensions for stitch and seam welding a macro test piece

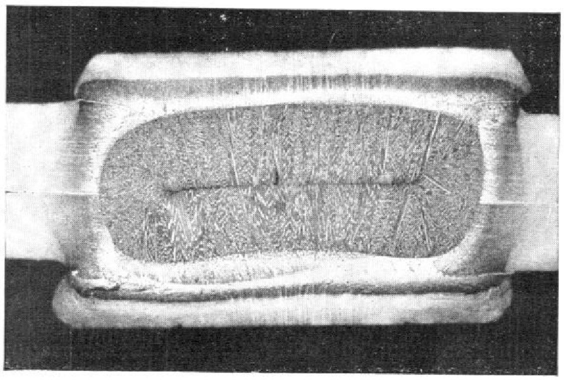

Fig. 18. Example of a hot-formed rivet showing the type of defects to avoid; enlarged.

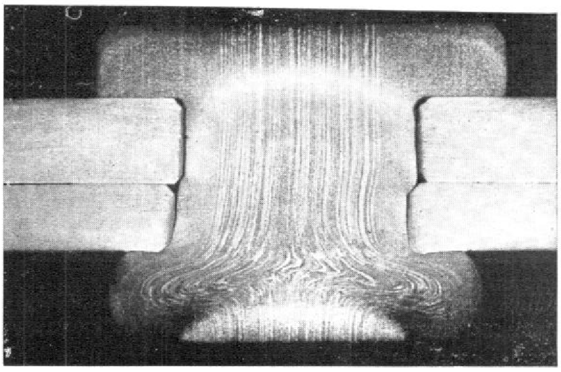

Fig. 19. Example of a well-formed rivet which conforms to the conditions specified in the text.

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following conditions must apply (see Fig. 18 and 19):—

(1) The grainflow of the rivet must be reasonably uniform and the rivet head not seriously offset from the stem.

(2) Large blowholes must not be present in the stem.

(3) The stem must not have melted and distorted the material around the hole.

(4) The formed head must be free from cracks or signs of 'bursting'.

Before commencing the acid etch test on a normal resistance weld, a similar preparation as that described for the hot riveting must be made to the test piece. The etching reagents for use with the various alloys are as described below.

The composition of the etching reagent for mild steel is 2 per cent Nitric acid in alcohol (2 per cent Nital). Under no circumstances must the quantity of Nitric acid be increased above the 2 per cent specified, as an explosive mixture may otherwise be produced.

This reagent is applied by immersing the test piece in the acid at room temperature for a period varying with the carbon content of the material. A typical immersion period is that for mild steel to specification S.84 which is 10 to 20 seconds.

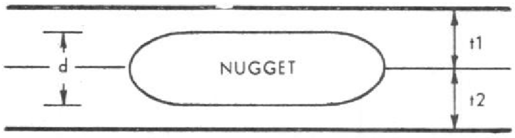
The electrolyte used for etching stainless and heat resisting steels is described in the paragraphs dealing with electrical hot riveting and acid etching. But in addition the following reagents may be used. A solution of Ferric Chloride, composed of 5 gm. Ferric Chloride, 50 c.c. Hydrochloric acid and 100 c.c. tap-water in which the test piece to be etched is immersed for approximately one minute.

Handforth's reagent may also be used. This is composed of solution A which is 10 per cent Chromic acid and solution B comprising concentrated Hydrochloric acid. This is used by mixing one part of A with five parts of B and eight parts of water. This should be made up when required. The etching is carried out by totally immersing the test piece in the solution for a period of fifteen seconds.

Penetration of a weld is defined as the thickness of the weld nugget, in a transverse direction, expressed as a percentage of the combined thickness of the two sheets welded together as shown in Fig. 20 where it can be seen that

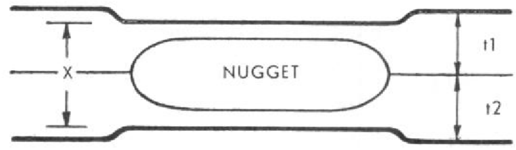
$$\text{Penetration} = \frac{d}{t_1 + t_2} \times 100 \text{ per cent.}$$

This method of measurement does not take into account any difference in the amount of penetration in the individual sheets, and judgment by eye or by separate calculations must be used to determine whether the nugget is central.



Q64

Fig. 20. Section through weld, giving dimensions for measuring weld penetration.



Q65

Fig. 21. Section through weld, giving dimensions for measuring indentation.

The indentation may be measured as shown in Fig. 21.

$$\text{Total indentation} = (t_1 + t_2) - X$$

$$\text{Therefore indentation} = \frac{(t_1 + t_2) - X}{t_1 + t_2} \times 100 \text{ per cent}$$

$$\text{When } t_1 = t_2 \text{ indentation} = \frac{(2t - X)}{2t} \times 100 \text{ per cent}$$

Where t = sheet thickness.

Manual tests may be carried out on selected test pieces to quickly ascertain the properties of suitability of the weld when setting up or adjusting a welding machine.

Twisting of a test piece is usually applied when setting up a welding machine for spot welding, to quickly determine the diameter of the nugget and adhesion of the weld. The test piece may be of any convenient size. The welded test piece is twisted until the nugget fails and the quality of the weld is estimated by the appearance of the fracture which should show an acceptable standard of adhesion.

A peel test for stitch and seam welds is carried out by holding the test piece in a vice and prising open the seam with a chisel. A weld in which the adhesion is poor or in which there is a large amount of cracking will tear easily along the centre line of the nuggets as shown in Fig. 35. For this test the test piece may be of any convenient size.

Approval tests for machine settings are carried out by making tests on the component concerned when a tentative setting will be established. The inspector will then verify that the conditions laid down under "preparation for welding" have been met and will permit the making of test pieces as described in this process specification. The test pieces will then be tested and if they meet the requirements that are described under "quality

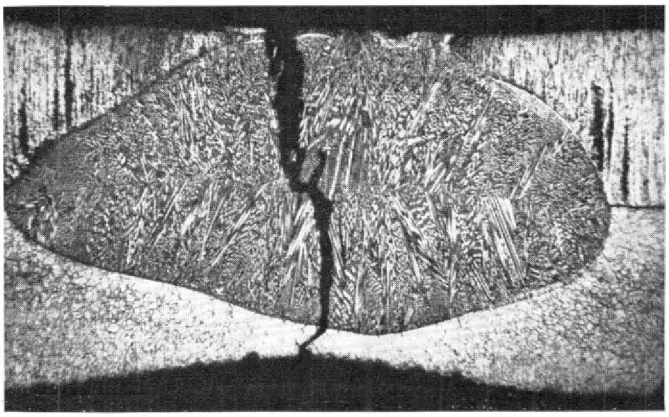


Fig. 22. Transverse cracking in weld.

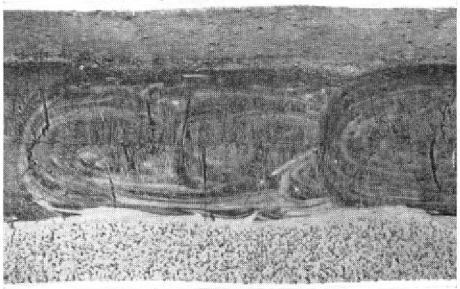


Fig. 24. Transverse cracking in weld.

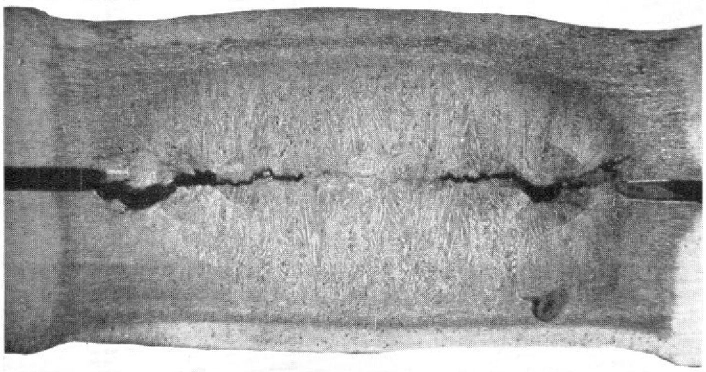


Fig. 23. Longitudinal (edge) cracking in weld.

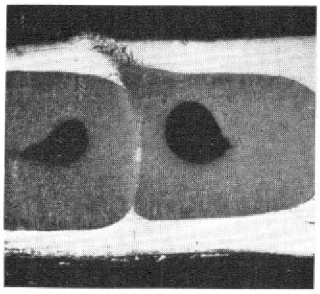


Fig. 25. Blowhole in weld.

standards" the results will be logged as described and work may proceed. The details to be logged are as set out below. They should be recorded in such a manner as to facilitate reference to the results:

Material and gauge ....

Date welded and time ....

Machine number ....

Machine location ....

Machine settings ....

1. Electrode pressure (gauge) ....
2. Transformer tapping ....
3. Current setting ....
4. Welding time cycle ....
5. Electrode sizes ....
6. Linear welding speed (for seam welding) ....

Three routine tension-shear and macro-tests must be made for each machine during the period of each working shift, one at the commencement of the shift, one half-way through and one at the end of the shift. These tests are irrespective of the initial approval tests, and for routine checking of seam welding the macro-test only will be required. The results from these tests are to be recorded as described in the preceding paragraph.

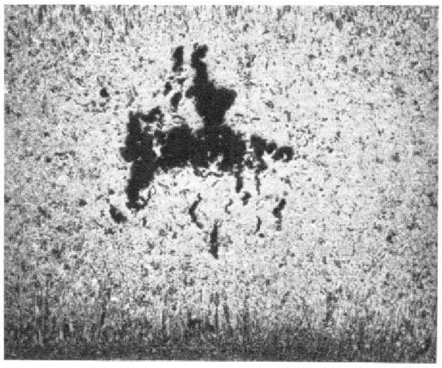


Fig. 26. Shrinkage porosity in weld.

Quality standards

Tension-shear test minimum failing loads for each material and gauge combination are set down in the Tables of Minimum Strength Requirements and Electrode Sizes on pages 26 and 27. In a joint between sections of unequal thicknesses of material of different strengths, the weld shear-strength requirement is to be determined by the thickness of the thinner sheet or the strength of the weaker sheet, whichever is the lower requirement.

The outer surfaces of all welds should be

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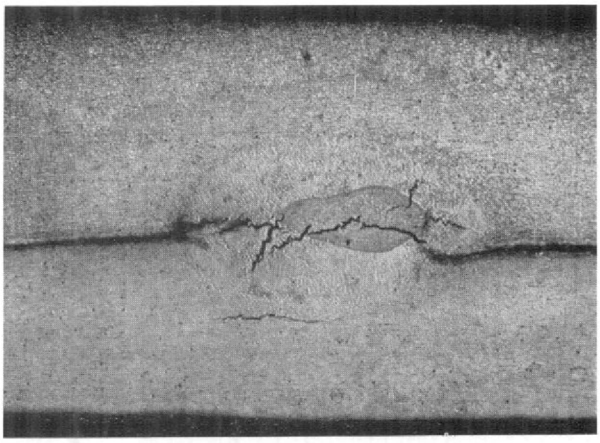

Fig. 27. Cracking of weld due to inadequate fusion.

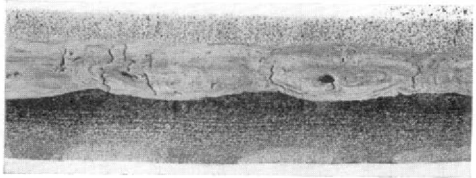

Fig. 30. Cracking in weld, due to inadequate mixing.

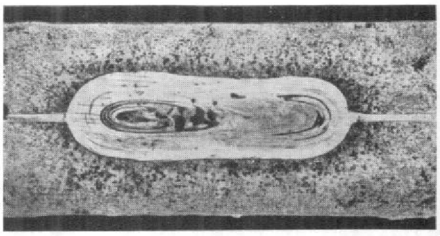

Fig. 28. Welded nickel-plated mild steel, showing inadequate mixing.

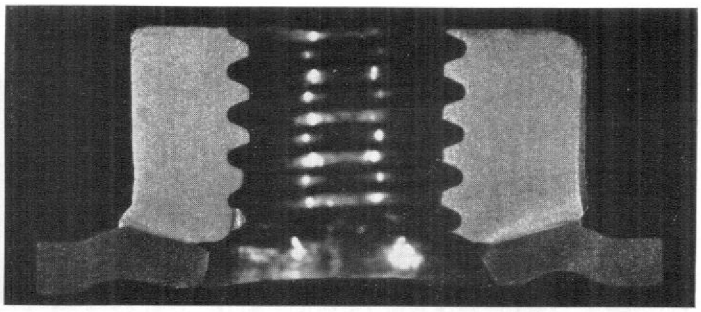

Fig. 31. Example of projection weld, showing inadequate fusion.

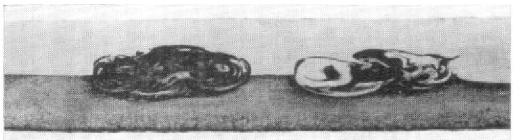

Fig. 29. Weld between stainless steel and Nimonic 75, showing inadequate mixing.

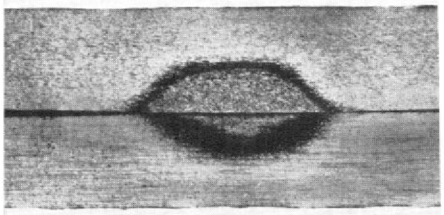

Fig. 32. Spot weld, showing inadequate fusion.

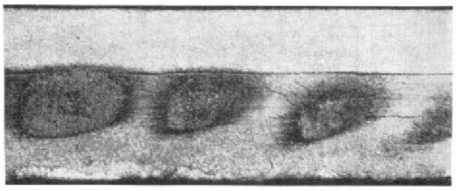

Fig. 33. Seam weld, showing inadequate fusion.

smooth, free from cracks, electrode tip pick-up, burning, and defects which indicate that the welds were made with a dirty electrode, improperly prepared surface, or incorrect machine setting. Every effort should be made to prevent "splashing" of the weld between the sheets. The indentation of the electrodes must not be more than 10 per cent.

The acceptance standards for macroscopic examination (macro-test) are as enumerated below.

Spot welding requires a penetration of 40 to 80 per cent overall, the ideal being 60 per cent with a minimum of 20 per cent in any one sheet and an indentation of less than 10 per cent. The nugget diameter should not be more than 10 per cent greater than the nominal tip diameter of the electrode and not less than the minimum specified in the table on pages 26 and 27. Any transverse cracking in the weld nugget must be less than 20 per cent of the nugget thickness while longitudinal cracking, a bad example of which is shown in Fig. 23, must be less than 25 per cent of the nugget diameter. If porosity is present in the weld in the form of blowholes, as shown in Fig. 25, shrinkage cavities, etc., then such porosity as shown in Fig. 26 must occupy less than 25 per cent of the volume of the nugget. Single small blowholes are not important as their occurrence does not indicate a significant deviation from standard technique.

Stitch welding is to measure up to the same standards as spot welding but as regards the amount of overlap of the spots, this is immaterial though it is advisable to arrange this at less than

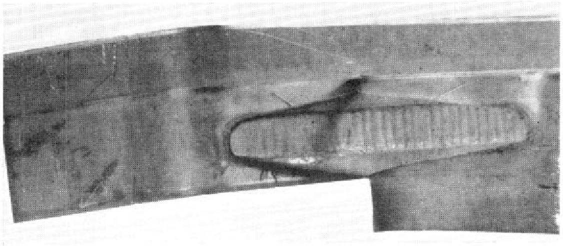

Fig. 34. Peeling test: satisfactory seam weld showing good adhesion.

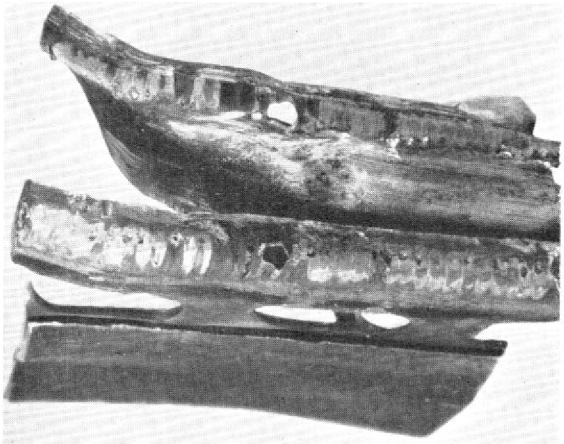

Fig. 35. Peeling test: unsatisfactory seam weld showing poor adhesion.

25 per cent of the diameter of the nugget.

In the case of seam welding the minimum overall penetration may be allowed to fall to 30 per cent. Except for the overlap which is the same as for stitch welding the other standards are the same as for spot welding.

Recommendations for the individual material groups are as follows:—

With the mild steel groups it is important when determining the penetration of the weld that the melted zone only is measured and not the area affected by heat surrounding the nugget. A spot weld in steel to specification S.84 is shown in Fig. 8. The nugget is indicated by the arrow A and the area affected by heat by arrow B. With nickel plated mild steel, the penetration should be of the order of 60 to 80 per cent, the ideal being 75 per cent.

When stitch and seam welding alloys of the non-ferrous heat resisting group the overlap should be kept to the minimum to avoid the effects of overheating.

There are no strict standards for nugget size, etc., when projection welding is undertaken. However, fusion must have taken place sufficiently to form at least a small melted nugget. A "pressure" projection weld will not be considered satisfactory except on unstressed or lightly stressed components.

The quality standard conditions for hot riveting are described on page 22.

When welding aluminium and its alloys the shear strength of spot welds will vary with the material composition. For the purpose of establishing the minimum design strength, the alloys have been arranged into three groups of materials having similar welding characteristics as shown in the accompanying table.

It is important to note that the following minimum shear strength figures will only be achieved if the other variables in the table are met. This is particularly so in the case of the minimum weld pitch.

The three groups of aluminium alloys are as follows:

Group A

High strength, heat treated alloys containing copper or zinc, e.g. British Specification D.T.D.687, 646, 610, 710, L.3, L.38, L.47, L.70, L.71, L.72, L.73.

Group B

Medium strength, corrosion resistant materials. Al-Mg (all tempers) or Mg_2Si heat treatable materials, e.g. D.T.D.606 and 346, L.46.

Group C

Pure aluminium and low strength corrosion resistant alloys (all tempers), e.g. D.T.D.213, L.16, L.17.

								Spot weld: lb. per spot		
SWG	Thickness in.	Flat Electrode Tip dia. in.	Domed Electrode Dome rad. in.	Min. Weld dia. in.	Min. Weld Area sq. in.	Min. Weld Pitch in.	Min. Edge Distance in.	Group A	Group B	Group C
28	0·0148	1/8	2	0·100	0·00785	5/16	5/32	150	90	50
27	0·0164	1/8	2	0·106	0·00882	3/8	3/16	180	100	65
26	0·018	1/8	2	0·113	0·00985	3/8	3/16	200	110	75
24	0·022	5/32	2	0·125	0·0123	3/8	7/32	250	140	100
22	0·028	5/32	2	0·133	0·0139	13/32	7/32	310	180	145
21	0·032	3/16	2	0·150	0·0177	13/32	7/32	400	220	175
20	0·036	3/16	2	0·159	0·0198	7/16	1/4	445	250	200
18	0·048	7/32	2	0·176	0·0243	1/2	5/16	545	380	240
16	0·064	1/4	4	0·200	0·0314	1/2	3/8	705	485	350
14	0·080	9/32	4	0·225	0·0398	5/8	3/8	890	780	445

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TABLES OF MINIMUM STRENGTH REQUIREMENTS AND ELECTRODE SIZES

MILD STEEL

SWG	Thickness in.	Electrode Tip dia. or Track Width in.	Min Weld dia. in.	Min. Weld Area sq. in.	* Min Weld Pitch in.	Min. Edge Distance in.	Min. Failing Load Spot Weld lb. per spot	Min. Failing Load Seam Weld lb. per in. S.84	Min. Failing Load Seam Weld lb. per in. S.3
28	0·0148	1/8	0·094	0·00694	5/16	3/16	235	660	930
27	0·0164	1/8	0·100	0·00785	5/16	3/16	265	735	1030
26	0·018	1/8	0·106	0·00882	3/8	7/32	295	805	1130
24	0·022	1/8	0·113	0·0100	3/8	7/32	335	985	1380
22	0·028	3/16	0·141	0·0156	1/2	7/32	525	1255	1755
21	0·032	3/16	0·155	0·0189	1/2	7/32	635	1435	2010
20	0·036	3/16	0·169	0·0224	3/4	1/4	755	1610	2260
18	0·048	1/4	0·188	0·0278	7/8	9/32	935	2150	3010
16	0·064	1/4	0·206	0·0333	1	5/16	1120	2865	4010
14	0·080	1/4	0·225	0·0398	1 1/4	11/32	1335	3585	5010

** For three pieces increase pitch by 30 per cent*

STAINLESS STEELS, ETC.

SWG	Thickness in.	Electrode Tip dia. or Track Width in.	Min. Weld dia. in.	Min. Weld Area sq. in.	* Min. Weld Pitch in.	Min. Edge Distance in.	Min. Failing Load Spot Weld lb. per spot	Min. Failing Load Seam Weld lb. per in.
28	0·0148	1/8	0·100	0·00785	1/4	1/8	390	1055
27	0·0164	1/8	0·106	0·00882	5/16	1/8	435	1280
26	0·018	1/8	0·112	0·00985	5/16	1/8	485	1410
24	0·022	1/8	0·119	0·0111	5/16	5/32	545	1720
22	0·028	3/16	0·150	0·0177	1/2	3/16	870	2195
21	0·032	3/16	0·164	0·0211	1/2	3/16	1040	2505
20	0·036	3/16	0·178	0·0249	9/16	7/32	1225	2820
18	0·048	1/4	0·200	0·0314	3/4	1/4	1545	3760
16	0·064	1/4	0·219	0·0377	1	5/16	1855	5010
14	0·080	1/4	0·238	0·0445	1 1/4	11/32	2190	6265

** For three pieces increase pitch by 30 per cent*

STRIPPING OF NICKEL PLATE FROM MILD STEEL COMPONENTS

D.H. Process Specification No. 186, November, 1954.

Nickel plating that is to be stripped from mild steel components may be removed by the application of this process. When using the method described there is relatively little danger of attack on the base metal. It is therefore particularly suited for treating stressed components such as outer combustion chambers, provided stainless steel fittings are masked.

This process consists of removing the plating by a sulphuric acid solution contained in a lead-lined tank into which the component undergoing treatment is immersed, and passing a controlled electrical current through the solution.

The lead-lined tank is arranged to act as a cathode and suitable anode bars must be provided. The anodes are placed in the same positions as those used for nickel plating the component. Depending on the shape of the component, it may be necessary to arrange the positioning of auxiliary cathodes in accordance with good plating practice.

A critical control of the stripping voltage is an essential feature of this process. This must not be permitted to rise above 2·10 volts, even under no-load conditions. The current supply must be capable of providing 40 amps per square foot of work to be treated. When switching on, a momentary surge of current will occur up to approximately twice the value quoted. The supply equipment should be capable of accommodating this without damage. It shoud be noted that the voltage may be permitted to fall somewhat below 2·10, a reduction in voltage serving merely to lengthen the process time.

Control of this voltage may be accomplished by the following alternative methods:—

1. By the use of an accumulator battery supplemented by a trickle charger.

2. Standard rectifier equipment may be employed in conjunction with a relay and inching motor to control the transformer tapping.

3. Alternatively, standard equipment may be supplied pre-set to an open circuit voltage of 2·10 at full mains voltage. In this case the overall regulation of the system should be better than 20 per cent from zero to full load.

The equipment should be provided with a suitable ammeter and a voltmeter having a full scale deflection of 2·5 volts.

To carry out this process, proceed as follows:

1. If necessary, degrease the component.

2. Apply stopping-off wax such as Okerin 4336 (Astor Boisellier and Lawrence) to the portions of the component it is necessary to protect, such as the following:—

   (a) Any portion from which it is not required to remove the nickel plating.

   (b) Associated stainless steel components which must be held to a high degree of dimensional accuracy. Losses from stainless steels are normally nil or of an extremely small amount (less than 0·0001 inch per two hour period) but occasionally loss rates of up to 0·0004 inch have been observed in the same period.

   (c) Where copper, brass, nickel base alloys, magnesium base alloys and cadmium plate must be preserved. Aluminium alloys will not be attacked if they are normally regarded as suitable for anodising.

3. Where necessary, the component may be placed in a jig.

4. Make the component anodic at 2·1 volts maximum in a cold solution of 35 per cent by volume concentrated sulphuric acid in tap-water, operated below 28 deg. C. Stripping of the nickel plate should be completed in approximately 1½ hours per 0·001 inch of nickel. Completion of stripping must be verified by visual inspection.

5. Drain components of excess acid and thoroughly rinse.

6. De-wax if applicable.

7. Dry the component by dipping in hot water and exposing to an air blast. If the component is not immediately required for plating dip it in dewatering oil. Unless protection is applied by dewatering oil, rusting will rapidly set in, especially in plating-shop atmospheres.

The concentration of sulphuric acid is not critical, satisfactory working limits being 30 to 50 per cent by volume. The higher concentrations normally absorb water from the atmosphere and settle at around 33 per cent. Regular analyses should be made to ensure that the concentration does not fall below 30 per cent by volume.

FLASH CHROMIUM PLATING

D.H. Process Specification No. 143/1, October, 1954

This process covers the deposition of chromium in thicknesses up to 0·0005 inch for the purpose of providing a hard, low-friction or heat-reflecting surface on steel. This method differs from D.H. Process Specification No. 132 as described on page 3, in the limiting thickness deposited and in the omission of the sulphuric acid electrolytic etch.

The testing and control of the solution must be under laboratory supervision.

Apparatus

The electrolyte used for the plating process must be contained in a lead-lined tank fitted internally with reinforced glass insulating panels, and provided with efficient fume extraction apparatus. The tanks must be provided with thermostatically controlled heating and cooling coils to maintain a steady working temperature. The anodes must be made of antimonial lead and in many cases suitable jigs may be necessary to hold the components to ensure uniform deposition of the chromium.

Preparation

The components to be plated must be degreased by immersion in a trichlorethylene vapour degreasing bath.

The areas of the component not required to be plated may be protected by dipping in " Fescol " F.2 stopping-off wax (Okerin 4336) at a temperature of 90 to 96 deg. C., to produce a uniform adherent layer. Removal of the wax from those areas to be plated is facilitated by a previous application of glycerine-chalk paste. The wax is removed from these areas whilst still warm, care being taken to ensure that the adhesion of the adjacent wax is not impaired.

Where glycerine-chalk paste has been applied and the wax subsequently removed, the area should be scoured with fine pumice powder and thoroughly rinsed in water. Where the masking of components is not required they must be chemically cleaned in an approved hot Alkaline solution to be followed by a thorough rinsing in tapwater.

Processing

The composition of the electrolyte contained in the plating bath is to be as follows:

Chromic acid, 40 to 45 ounces per gallon,
Sulphuric acid, 0·40 to 0·45 ounces per gallon.

The plating bath is to be worked at a temperature of 50 to 53 deg. C. (123 to 128 deg. F.).

While the component is still wet from being rinsed after cleaning off the wax, it should be transferred to the plating tank, allowed to reach solution temperature and then anodically etched for 15 seconds at 200 amps. per square foot.

After the anodic etching is completed the current is reversed and adjusted to 260 to 280 amps. per square foot when deposition of the chromium will occur. The maximum permissible time in the solution is 40 minutes.

When the requisite thickness of chromium has been deposited the component must be drained, rinsed in cold water, de-waxed if necessary in hot water and finally dried in a compressed air jet.

When high tensile steels have been plated it is necessary to remove hydrogen embrittlement by heating the parts to a temperature of 150 to 200 deg. C. for not less than one hour. Steels such as S.28, S.82, S.97, S.98, S.99, S.107, S.108, and spring steels fall into this category. When required, Laboratory guidance on this matter should be obtained. Where no operation for the removal of brittleness is carried out, it has been found beneficial, especially when areas of the parts have not been plated, to immerse them in a de-watering oil: " Ilo " No. 5 de-watering oil supplied by W. B. Dick & Co. has been found suitable.

Flaw detection

High tensile or surface hardened parts to which magnetic flaw detection is applicable and which are treated by this plating process are to be examined by magnetic flaw detection after completion of the surface processing and any associated low temperature heat treatment.

ELECTRO-DEPOSITION OF SOFT NICKEL

D.H. Process Specification No. 134/3, October, 1954.

Mild steel components may be protected against corrosion by this process. Where components have become worn or damaged by over machining they may be reclaimed by heavy deposition of soft nickel in accordance with this process specification.

This process consists of depositing soft nickel over the required areas of the component. Areas that do not require plating are protected by the application of stopping-off wax. A preliminary etching is carried out before the actual nickel deposition.

The composition of the deposition solution and of the etching tank must be under laboratory control.

Apparatus

The apparatus required to carry out this process is as follows:—

(a) A tank to contain the stopping-off wax is required. This is made of mild steel and must be fitted with a steam heating coil to provide the necessary heat to melt the wax.

(b) A lead-lined tank is required for the etching operation. The lining acts as one electrode. A means of reversing the current, such as a double pole knife switch must be provided.

(c) The deposition tanks must be lined with rubber, glass, hard P.V.C. or other suitable material. Provision must be made for thermostatically controlled heating of the solution. Agitation by means of air must be provided. Continuous pressure filtration of the electrolyte is strongly advocated.

(d) A stripping tank, made of mild steel, is required for the removal and recovery of the wax from the components after the process has been completed. A steam heating coil is also required for this tank.

(e) Suitable racks or fixtures should be provided where required to facilitate working and to ensure uniform deposition of nickel.

Preparation of work

(a) Degreasing. The components to be plated must be cleaned from grease and foreign matter by immersion in a trichlorethylene vapour degreaser until they have attained the temperature of the vapour.

(b) Fixture. The component should be suspended in the deposition tank by means of a fixture or copper wire.

(c) Stopping-off. Areas on the component on which a nickel deposit is not required must be coated with Okerin wax 4336 supplied by Astor Boisellier. The components should be immersed in the wax, which is to be maintained at a temperature of 195 to 200 deg. F. (90 to 96 deg. C.) but areas to be plated should have been coated previously with a thin film of glycerine-chalk paste. The wax is removed from these areas whilst still warm, care being taken that the wax adjacent to these areas is not lifted during the process.

(d) Final cleaning. Areas to be plated must be cleaned from final traces of wax by scouring with pumice powder followed by rinsing the component in cold water.

(e) Etching. The component must be etched anodically immediately before plating for three minutes at 200 to 300 amperes per square foot of area to be plated. This is done in the etching tank containing 20 per cent by volume of sulphuric acid (96 per cent comm.) i.e. 57 ounces per gallon. The tank is to be worked at room temperature. The component must be rinsed thoroughly in cold running water after etching.

Method of processing

(a) Composition of electrolyte.

	Ounces per gallon	*Nominal*
Nickel sulphate	30·0 to 40·0	32·0
Sodium chloride	2·0 to 3·0	2·5
Boric acid	2·0 to 5·0	3·0
pH	4·8 to 5·6	

The bath must be operated in the temperature range 30 to 35 degrees C. (86 to 95 deg. F.).

(b) Anodes. The anodes should preferably be depolarised and must be enclosed in bags of canvas or other suitable material. The anodes are to be disposed so as to obtain uniform deposition over the surface of the parts. Where necessary auxiliary anodes, non-conducting screens, or rubbers should be used.

(c) Operating conditions. The components must be plated in the electrolyte described at 6 to 25 amperes per square foot. Deposition is normally 0·0005 inch per hour at approximately 10 amperes per square foot.

(d) Removal of wax. The wax may be removed by immersion of the components in boiling water and the wax recovered.

(e) The components are to be finally degreased after wax removal.

(f) Removal of brittleness. The component must be de-embrittled unless otherwise stated by heating at a temperature of 210 to 390 deg. F. (100 to 200 deg. C.) for a period of not less than thirty minutes.

Maintenance

The pH of the deposition solution must be tested daily.

Flaw detection

High tensile or surface hardened parts to which magnetic flaw detection is applicable and which are treated by this plating process, are to be examined by magnetic flaw detection after completion of the surface processing and any associated low temperature heat treatment.

CHROMATE TREATMENT FOR MAGNESIUM BASE ALLOYS

D.H. Process Specification No. 167/1, June, 1952

This process is a modification of the R.A.E. half-hour boiling bath and is used for the treatment of magnesium base alloys to enhance corrosion resistance, and to provide a suitable surface for the subsequent application of organic coatings such as D.H. Process Specifications No. 101 and No. 115. The process is intended to supersede those described in D.H. Process Specifications No. 112 and No. 147, and is suitable for all magnesium alloys used in the Ghost engine.

Apparatus

An open mild steel tank, equipped with a fume extractor and heating coils, is required. The heating coils should enable the solution to be maintained at a brisk boil when necessary.

Preparation

The sequence of preparatory work carried out is as follows:

(a) All paint and marking out compounds must be removed from the areas to be chromated.

(b) If the component is heavily contaminated with grease or oil, it must be degreased in a trichlorethylene vapour bath, or other suitable equipment.

(c) Areas on which chromate treatment is not required must be suitably plugged or masked.

(d) The component must be degreased in Zonax, or other approved aqueous detergent solution, thoroughly rinsed in water—preferably warm—and transferred directly to the chromating solution. This rinse tank may, with advantage, also be used for washing the component after chromating.

Processing

(a) The component must be immersed for twenty minutes in a boiling solution, the initial composition of which is as follows:—

Ammonium dichromate .. 3 per cent by weight
Ammonium sulphate ..1·5 per cent by weight
Ammonia to increase pH to 5·3 (electrometric) (approximately $\frac{1}{4}$ fluid oz. of 0·880 Ammonia per 10 gallons).

(b) The component must be rinsed in warm water and dried with an air blast.

Maintenance

The volume of the solution must be maintained by the addition of water, preferably distilled. The pH of the solution must not be allowed to fall below 5·0 (electrometric), and, when satisfactory chromating is no longer obtained at a pH of 5·5 (electrometric), 0·5 per cent of ammonium sulphate may be added to reactivate the bath. The bath may be reactivated by further additions provided that the total added content of ammonium sulphate does not exceed 3·5 per cent. This is equivalent to four reactivations of 0·5 per cent of ammonium sulphate. The bath ratio of SO_4'' to $Cr\ 0_3$ must not exceed 2 to 1.

Repair of chromate films

Chromate films which have been damaged by local abrasion, or partly removed by a minor machining operation carried out subsequent to chromate treatment, may be repaired using a 10 per cent solution of selenious acid. The surface to be treated must be thoroughly degreased and the solution applied by swabbing until a permanent brown-black colour is obtained on the exposed metal. The treated surface must then be washed thoroughly in clean water and dried immediately.

The selenious acid is poisonous, and care must be taken to prevent any of the solution coming into contact with the skin.