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Schedule

of

RECOMMENDED PRACTICES FOR METALLIZING SHAFTS
OR SIMILAR OBJECTS

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CANADIAN GOVERNMENT SPECIFICATIONS BOARD

SCHEDULE

OF

RECOMMENDED PRACTICES FOR METALLIZING SHAFTS OR SIMILAR OBJECTS

23-GP-3

16 MARCH 1951

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16 March 1951

CANADIAN GOVERNMENT SPECIFICATIONS BOARD

SCHEDULE
OF
RECOMMENDED PRACTICES FOR
METALLIZING SHAFTS OR SIMILAR OBJECTS

This SCHEDULE is based on Part IA of Recommended Practices for Metallizing, No. C2.1-50T, as prepared by the American Welding Society Committee on Metallizing, revised to include minor changes recommended by the C.G.S.B. Committee on Specifications for Metallizing.

The preparation of this Schedule has been made possible through a reciprocal arrangement between the American Welding Society and the Canadian Government Specifications Board. The kind permission of the Society to use their Standard as a basis for the Schedule is gratefully acknowledged.

CANADIAN GOVERNMENT SPECIFICATIONS BOARD

Schedule
of
RECOMMENDED PRACTICES FOR
METALLIZING SHAFTS OR SIMILAR OBJECTS

1. GENERAL

1.1 Scope - This schedule describes the procedures employed in metallizing the outside cylindrical surface of a metal shaft or other similar object to size or to provide specific surface characteristics, by the application of metal in wire form by gas metallizing only, and presents the various practices and methods currently used in industry.

1.2 Equipment Requirements - It is assumed that the spraying will be done with metallizing guns and auxiliary equipment complying with specification 23-GP-1: Metallizing Gun Sets - Wire Gas, that the machine tools specified are available and that a lathe or similar device will be used in performing the machining and finishing operations indicated.

2. SURFACE PREPARATION2.1 Cleaning Prior to Surface Preparation

2.1.1 Purpose - Cleaning prior to surface preparation is necessary to remove grease, paint, etc., from the area to be metallized as well as from adjacent surfaces where such materials will impair the bond and coating.

2.1.2 Methods - A suitable chemical solvent or heat should be used to thoroughly clean the surface to be metallized. Cast iron or other porous metals should be preheated sufficiently (500 to 800°F.) to drive out oil or other foreign matter. In some cases chemical cleaning may be necessary before preheating. Excessive carbon resulting from preheating may be removed by sandblasting.

2.2 Undercutting

2.2.1 Purpose - As part of the preparation for metallizing shafts or similar objects, it is almost always necessary to undercut the surface to be built up. This is done in order to obtain a satisfactory thickness of metallized deposit on the finished job. (See Para. 2.2.3). The undercutting is accomplished on a lathe or similar device by either machining or grinding to the required dimensions, care being exercised to see that the undercut section is concentric with the original axis of the shaft.

2.2.2 Length of Undercut - The length of the undercut section should generally extend beyond both ends of the sleeve, bearing, packing gland or stuffing box in which the shaft will operate.

2.2.3 Depth of Undercut - The depth to which the shaft should be undercut is determined by a number of factors such as the diameter of the shaft, the severity of service and the amount of wear to be expected in service. The factor of wear to be expected in service is taken into consideration in deciding the depth of undercut. The wear allowance must be determined for each individual job and may vary from 0.001 to 0.250 in. or more. Table 1 may be used as a guide in determining the depth of undercut to be provided for specific service applications. Additional allowances should be made, if necessary, for more severe wear.

Table 1 - Recommended Depths of Undercut

Diameter of Shaft, In.	Depth of Undercut Measured on Radius for Various Types of Service in		
	Class A Service*	Class B Service /	Class C Service **
Under 1		0.020	0.010
1-2	0.040	0.030	0.010
2-4	0.050	0.040	0.020
4-6	0.060	0.050	0.020
Over 6	0.070	0.060	0.020

* Class A Service: For shafts or journals operating under a heavy bearing load such as Diesel crankshafts or rolling mill journals; for pump sleeves, piston rods and hydraulic rams subject to severe service and high pressure; where a maximum safety factor is required.

/ Class B Service: For normal duty lubricated bearing service; for standard pressure pump rods and sleeves; where a normal safety factor is required.

** Class C Service: For restoring a shaft to size where a gear, flange, wheel or other part will be pressed on and the sprayed surface will not act as a bearing. The values given above do not apply where the metallic spray bonding method is used for this class of service. (See Para. 2.3.2.3).

2.2.4 Ends of Undercut - The sprayed metal should be mechanically anchored into the base metal at the ends of the undercut section. This is done by providing suitable shoulders or other positive anchorages at each end of the undercut section. The dovetail shoulder at an angle of 15 to 20 deg. and with a radius at the bottom (as illustrated in the left-hand sketch of Fig. 1) provides a satisfactory anchorage. An equally effective method (as illustrated in the right-hand sketch of Fig. 1) is to machine a straight cut at right angles to the shaft with a radius at the bottom, in which case it is necessary to roughen or otherwise prepare the sidewalls of the undercut.

When the section to be metallized extends to the end of the shaft, it may be necessary to employ a special method of securing the degree of anchorage required. Several suitable methods are illustrated in Fig. 2.

Where a heavy coating is to be applied the undercut section may be stepped down to reduce the danger of cracking. (See Fig. 3.)

Note: The effective cross section of the part to be metallized will be reduced by undercutting. Sharp grooves and re-entrant angles may produce stress raisers. Therefore all parts subjected in service to high stresses, shock loads or critical applications should be examined carefully from a design standpoint to determine that adequate strength is maintained in the structure as prepared for metallizing. Metal spray deposits should not be depended upon to restore any qualities such as tensile strength or resistance to fatigue stress.

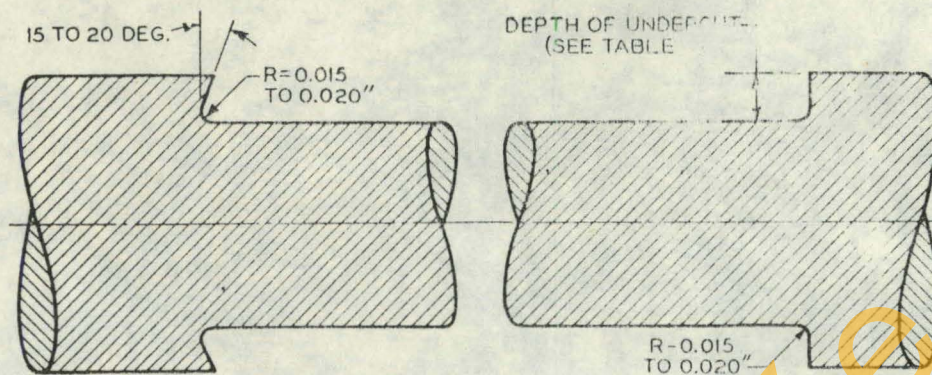
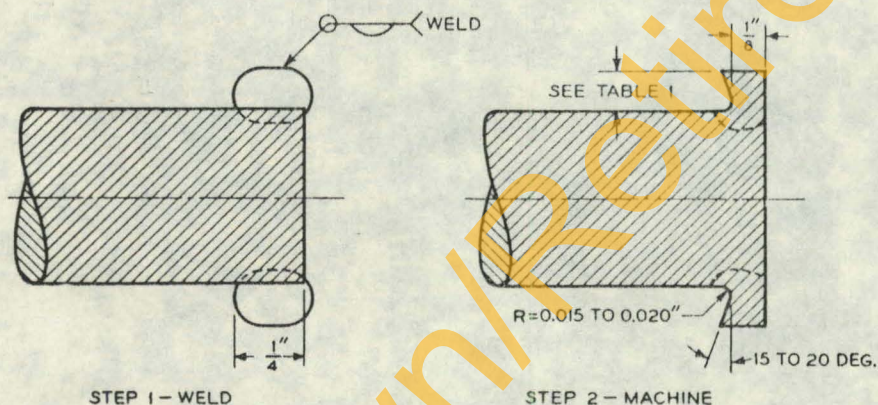
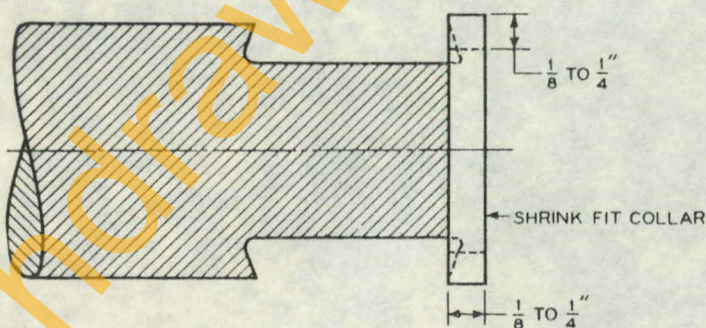


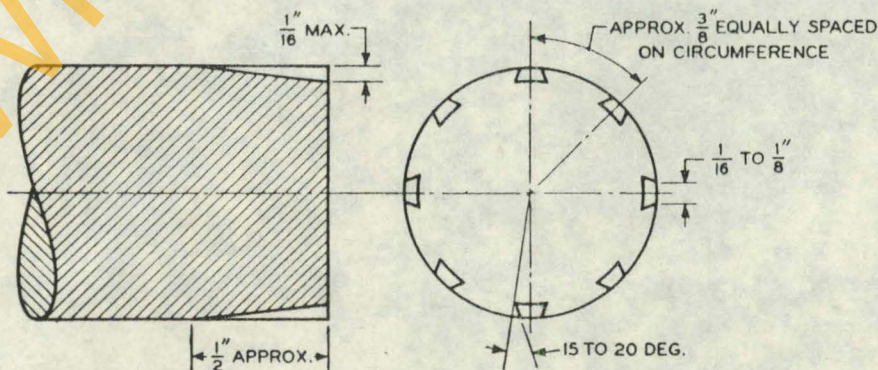
Fig. 1—Recommended Details for Shoulders of Undercut Section



(a) BEAD WELD METHOD



(b) COLLAR METHOD



(c) SLOT METHOD

Fig. 2—Suggested Methods of End Preparation When Metallizing Extends to End of Shaft

2.3 Surface Roughening

2.3.1 General Precautions - After undercutting the shaft, the next operation is the preparation of the undercut section to receive the metal spray. If undercut surfaces become contaminated with oil, grease or other foreign matter, they should be thoroughly cleaned and degreased. Cleanliness and roughness greatly affect the strength of the bond between the base metal and the sprayed metal and must be carefully controlled to insure adequate bond strength for the service to which the shaft will be later subjected.

2.3.2 Methods of Roughening - There are many different methods of surface preparation that may be employed. These include groove and rotary roughening tool, rough threading, metallic spray bonding, electric bonding and blasting methods as well as combinations of these methods. Of these, the most generally used is the groove and rotary roughening tool method, although the method selected will be dependent upon such factors as bond strength, base metal, service requirements, cost and availability of equipment.

2.3.2.1 Groove and Rotary Roughening Tool Method - The groove and rotary roughening tool method requires two separate operations. The first consists of cutting spiral or annular grooves in the undercut section. The second operation consists of spreading and roughening the lands or tops of ridges produced in the first operation. This method gives one of the strongest bonds possible on all machinable metals such as low-carbon steel, stainless steel, Monel, nickel, brass and bronze. Both operations are described below.

The cutting of the annular or spiral grooves as shown in Figs. 4(a) and (b), respectively, is accomplished with a round-nosed cutting tool ground to the shape and dimensions (right or left hand) shown in Fig. 5. Spiral grooves of the proper pitch may be obtained by setting the thread feed on the lathe at 16 threads per inch. In the case of annular grooves, the machining time can be reduced by using a gang cutting tool, which permits the making of several annular grooves at one time. Annular grooves should be cut, proceeding from both ends toward center, so that an outsize groove or land, if it occurs, will be in the center of the area to be sprayed. The depth of the groove should be approximately 0.025 in. on the radius (0.050 in. on the diameter), and may be cut in one or several passes. The grooves should be so spaced that the ridges or lands between the grooves are approximately 0.015 in. wide. The grooving should cover the entire length of the undercut section except for 0.025 to 0.035 in. at each end.

After the grooving operation is completed, the next step is the spreading and roughening operation, which is best accomplished with a special rotary roughening tool. The tool is set in the tool post of the lathe with the roughening wheel assembly of the tool perpendicular to the axis of the shaft. With the work turning at a surface speed of from 200 to 300 ft. per minute, the tool is fed into the work at 0.005 in. infeed per pass and is traversed over the lands of the grooves at a feed of about 0.020 in. per revolution. The roughening operation should be continued until the land is spread out and the land width and groove width are approximately the same (0.030 in.). This dimension may be checked with a feeler gauge. When this operation has been completed, the U-shaped grooves will have been converted into a series of dovetails. The surface of the lands will be spread and roughened.

2.3.2.2 Rough Threading Method - This method is generally recognized as a fast single operation. Its use is recommended only on low-carbon steels where the surface can be torn and roughened, as shown in Fig. 6.

The objective of the rough threading method is to obtain roughened threads with a sharp point at the top, with the sides torn and jagged, and with a radius of not more than 0.015 in. at the bottom. The desired type of thread can be obtained by using a 50 to 60 degree tool and cutting to a depth as indicated in Table 2 below:

Table 2

Pitch (threads/in.)	16	18	20	22	24
Recommended Depth(in.)	.041	.036	.033	.030	.027

The operator should examine the top of the thread to insure that the proper sharp edge is obtained. Care should be exercised to insure that no part of the thread is completely torn out. The cutting tool used may be ground in several different ways, but regardless of the shape, it should be ground in such a manner that it will produce the result described above. Figure 7 illustrates one of the many ways to grind the tool bit for rough threading. Another way is to grind the tool so that it will have a zero or slightly negative back rake and side rake.

The thread cutting tool should be set on or slightly below the center line of the work and fed to a greater depth than normal so as to obtain a sharp, pointed thread. The work should be rotated at a low speed and the thread feed should be not less than 14 threads per inch. The number of threads required normally is from 16 to 24 per inch depending upon the diameter of the work, the thickness of the deposit to be applied and the intended service.

The threading operation may be done in one or more passes or cuts. In any case the final cut should be such as to give the results described above, (See Fig. 6.) If burrs remain on the tops of the threads they should be removed by using a square-nosed tool so set as to barely miss the tops of the threads.

2.3.2.3 Metallic Spray Bonding Method - The metallic spray bonding method consists of spraying a suitable molybdenum wire directly onto a clean surface which does not necessarily have to be roughened as required for normal metallizing operations.

Molybdenum has a very high particle hardness, and in the sprayed form has a tensile strength higher than high-strength sprayed bronze, but somewhat lower than most sprayed steels. Its shrinkage on depositing is slightly greater than high-chromium, high-carbon stainless steel and considerably less than 0.40 carbon steels. It may safely be used as a bonding coat for most machine element work where corrosion is also a factor. It bonds equally well to steel either in the hardened or in the soft state. It bonds well to most white metals, such as zinc or aluminum, but will not bond to copper or copper alloys.

Molybdenum deteriorates at high temperatures in the range of 1000 to 1200°F. To provide an adequate factor of safety and avoid the possibility of deterioration of bond, it is recommended that it be used only on work which will not be subjected to temperatures over 600°F. unless special test work is carried out to determine that the bond will not deteriorate.

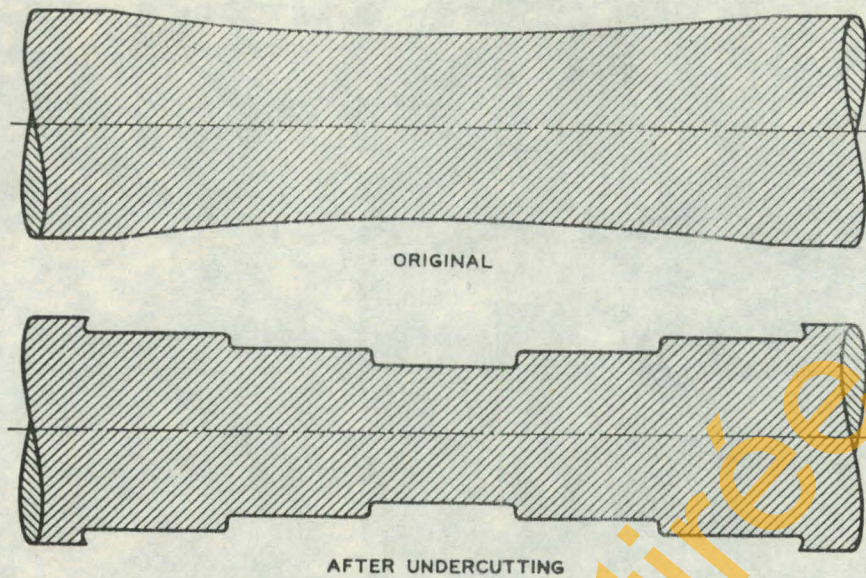
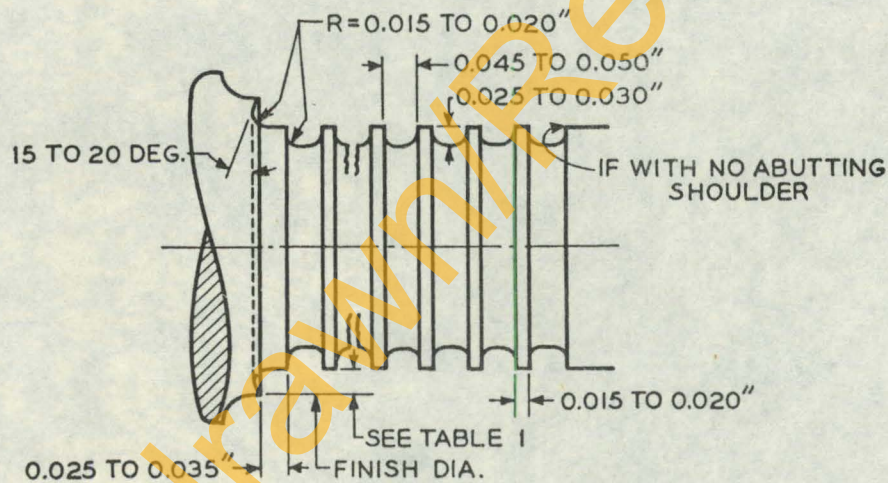
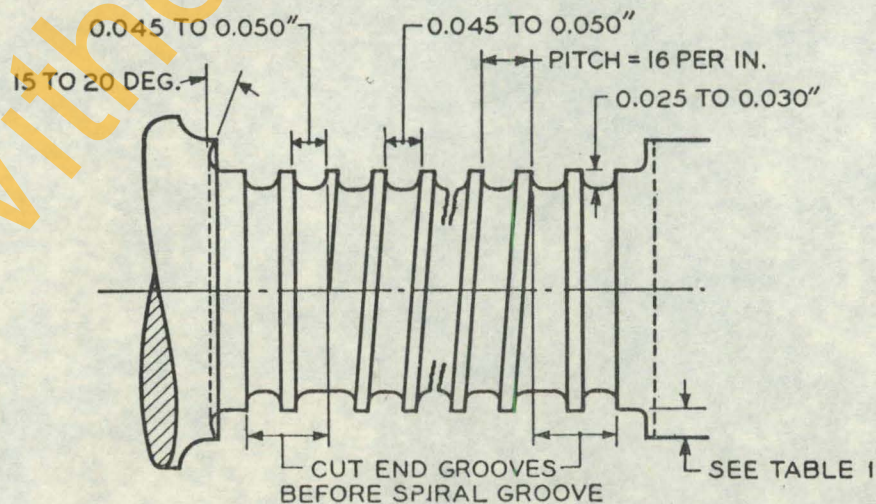


Fig. 3—Method of Stepping Down Undercut to Minimize Cracking of Heavy Coatings



(a) WITH ANNULAR GROOVES



(b) WITH SPIRAL GROOVES

(OTHER DIMENSIONS AND NOTATIONS SAME AS (a))

Fig. 4—Shaft After Cutting of Grooves for Groove and Rotary Roughening Tool Method

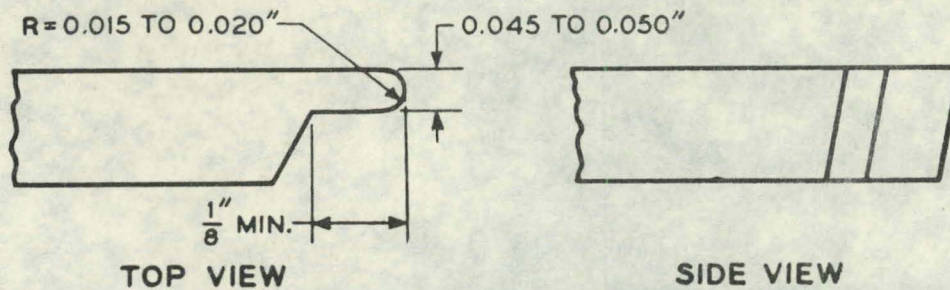


Fig. 5—Method of Grinding Tool for Cutting Annular or Spiral Grooves

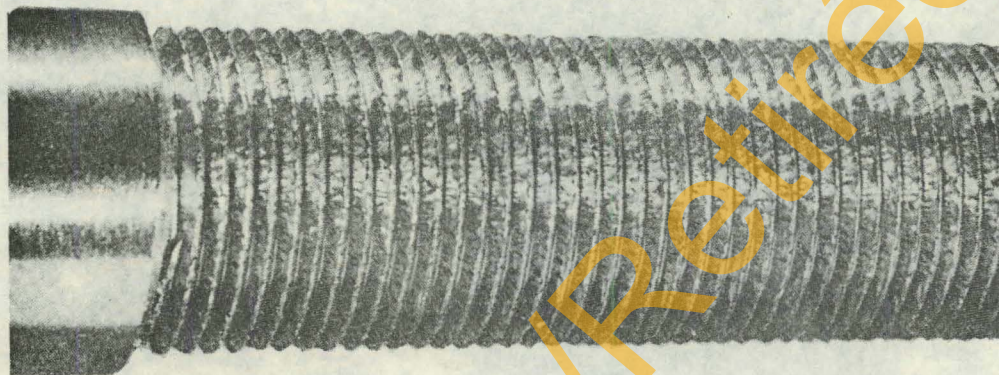


Fig. 6—Appearance of Shaft After Rough Threading

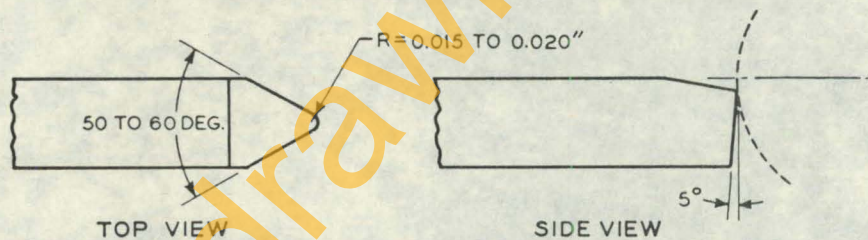


Fig. 7—Method of Grinding Tool Bit for Rough Threading

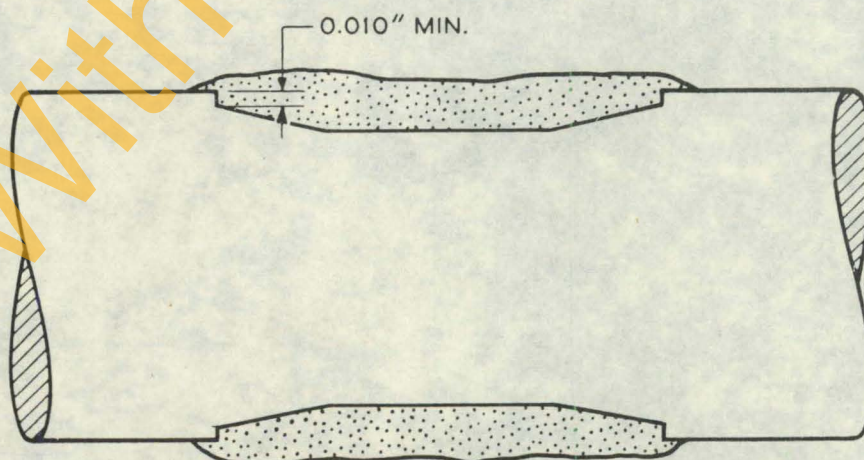


Fig. 8—Method of Undercutting for Metallic Spray Bonding

A suitable molybdenum wire, which incorporates the desirable properties of that element and is also satisfactory from an operation standpoint, must be used. It may be used for a complete build-up but is more commonly used as a bonding coat with the desired metal sprayed directly onto this bonding coat.

The types of undercutting commonly employed for previous bonding methods are not, as a rule, necessary where metallic spray bonding is used. In many cases, it is permissible to allow the coating to taper off to a feather edge, provided the edge is outside the limits of the bearing surface. For example, in restoring a press fit which requires only a small amount of metal, the only preparation necessary is to clean the surface by machining, grinding, blasting or wiping with a clean emery cloth. Frequently the molybdenum itself is all the build-up which is required, but if a high finish is necessary, the diameter should be reduced enough to allow for 0.002 to 0.003 in. of molybdenum, plus 0.002 to 0.003 in. of steel or stainless steel. Because the surface of the base is smooth, much less finish allowance is needed and finishing time can be substantially reduced. The type of undercut shown in Fig. 8 is particularly useful where heavy coatings are needed. Tapering off the coating thickness eliminates hard rings, reduces stresses at the ends of the build-up, and requires a minimum of machining or grinding. It also results in a nearly invisible line where sprayed metal and base metal meet at the shoulder.

It is necessary to mask areas that are not to be coated because molybdenum sticks to smooth surfaces. This is particularly important since this metal is hard and will tend to dull a cutting tool. However, since a very small amount of contamination of the surface will prevent adhesion, masking is easy. A masking compound is recommended and should be brushed very thin on the surface to be masked. Either oil or masking compound should be used to protect bare metal on the machine tool parts exposed to the spray. Oil should not be used on the workpiece, however, since it may run onto the surface being sprayed. Masking tape may be used where it is more convenient.

Even a small amount of condensed moisture on the base metal will greatly reduce the bond strength. To insure that there is no condensate on the work, run the flame of the gun over the work rapidly without the wire feeding, just before applying the molybdenum.

Only acetylene should be used as the fuel gas for spraying molybdenum. Adjustment of both the acetylene and the oxygen pressure is critical. Molybdenum will oxidize badly and will not bond if a slight excess of oxygen is used. The recommendations of the manufacturer should be carefully followed in the operation of the metallizing gun. Gas flow meters are extremely helpful and should be used in accordance with recommendations of the manufacturer.

When used for a bonding coat, the average thickness of sprayed metal should be about 0.0015 to 0.0020 in., which due to surface irregularities, will measure approximately 0.0030 in. by micrometer.

Grooves (or threads) should be used for all coatings over 0.050 in. thick wherever there is an edge, such as at a keyway. Grooves should also be used for all high shrinkage coatings, such as produced with 0.10 carbon steel or 18-8 type stainless steel. Grooves should be used for coatings that do not have edges, such as continuous coatings on cylindrical surfaces, where the conditions of service are extremely severe, where there is danger of layer separation in the coatings or where the coatings are heavy and have high shrinkage values so that danger of cracking exists. Low shrinkage coatings, such as produced with 0.80 carbon steel, or high chromium-high carbon type stainless steel, may be applied in thicknesses up to 0.050 in. without using grooves even where there are edges.

A simple and effective procedure for ordinary build-up work on shafts is as follows:

- (a) Apply a thin coating of masking compound to the ends of the section to be undercut and to the adjacent areas. Allow a few minutes to dry. If masking compound is not available, masking tape may be used to prevent build-up adjacent to the undercut. Oil should never be used for masking parts.
- (b) Undercut in the regular way as shown in Fig. 1, or as shown in Fig. 8. Make sure that the chip is not coming off in such a manner as to contaminate the machined surface with masking compound.
- (c) Preheat slightly using the gun without the wire feeding.
- (d) Apply the molybdenum coating to the machined surface, including the shoulders at the end. Spray just enough to cover fully.
- (e) Proceed in the regular manner with whatever metal is to be sprayed.

Shafts having keyways may be sprayed as follows:

- (a) Undercut the section to be built up, and chase a 20 to 30 thread. An accurate thread form is not necessary; it may be rounded at the bottom, and any angle from 60 to 80 degrees is satisfactory.
- (b) Remove burrs from the sides of the keyways and insert a brass, bronze or carbon dummy key so that it will project above the finished size. The key should be cleaned and polished with fine emery cloth. It should be free of fingerprints.
- (c) Apply the molybdenum coating and spray in the regular manner. The key may be removed without difficulty after finishing.

2.3.2.4 Threading and Rotary Roughening Tool Method - The threading and rotary roughening tool method is similar to the groove and rotary roughening tool method. (See Para. 2.3.2.1). The first step is the threading operation after which the tops of the threads are roughened with a rotary roughening tool.

2.3.2.5 Machining and Blasting Method - In this method of surface preparation, almost any type of threaded, grooved, or other serrated finish may be applied to the undercut surface of the work. This prepared surface is then blasted by either direct-pressure or suction-type blasting. (See Para. 2.3.2.7).

2.3.2.6 Electric Bond Method - This method is used for preparing surfaces too hard to roughen satisfactorily by blasting or other mechanical means. Small, irregularly-shaped particles from a nickel electrode are fused to the surface. The over-all contour of the surface thus prepared is very irregular due to the presence of many irregularly-shaped cavities.

A special transformer is necessary to perform this method of preparation. The ground cable should be attached to the workpiece as near to the undercut surface being prepared as possible. The machine settings shown in Table 3 are suggested.

Table 3 - Suggested Machine Settings for Electric Bond Method

Diameter, In.	Surface Speed, Ft./Min.	Secondary Voltage	Relative Texture of Deposit	Remarks
Up to 2	25-75	Low (2.0-4.5)	Fine	Small work- piece. Small areas.
2-6	50-100	Medium (2.5-7.0)	Medium	Average work- pieces. Aver- age areas.
Over 6	75-150	High (7.0-9.0)	Coarse	Large work- piece. Large areas.

The electrode material is applied to the undercut surface with a very light touch, stroking or scratching the electrode over the work with a brushing or rocking motion. The electrode should not be permitted to come to a red heat for a distance greater than 1/2 inch from the contact end. It is important that the operator always protect his eyes by wearing suitable goggles with light-color lenses.

The electrode material should be deposited uniformly over the surface to be sprayed so that there appears to be not more than 15% of the surface unprepared as estimated by visual examination. Any spot larger than 1/8 in. in any direction left unprepared should be touched up. Care should be exercised to see that additional metal is not applied to areas previously covered. High projections above the normal contour of the deposited metal should be removed with the edge of a rough file or machined off by a light cut with a sharp-nosed tool using a fine feed.

The electric bond method may also be used on threaded or other serrated surfaces. In such cases the deposit is applied only to the ridges or tips of the serrations.

2.3.2.7 Blasting Method - This method is seldom used as preparation for building up shafts and similar objects. If, by test, it has been predetermined that the low bond strength obtained will be satisfactory for the job, blasting should be done with G-16 to G-25, clean, sharp, crushed steel grit or similar size aluminum oxide, and a pressure blast machine.

2.4 Care of Prepared Surfaces

Parts should preferably be sprayed as soon as possible after preparation. Where the spraying must be delayed for even a short period of time or where the part must be removed to another location, the prepared surface should be protected from oxidation and contamination and from handling and fingermarks. Wrapping with clean paper will usually provide adequate protection.

3. SPRAYING

3.1 Equipment and Materials

3.1.1 Equipment - Having prepared the surface to be metallized in accordance with one of the methods described in Para. 2, the following

equipment is generally required for the spraying operation:

1. Metallizing gun.
2. Set of air, oxygen and fuel-gas hoses.
3. Air Filter.*
4. Air regulator with gauge.
5. Oxygen regulator with gauge.
6. Fuel-gas regulator with gauge.
7. Oxygen and fuel gas flow meters.
8. Wire reel.
9. Necessary safety equipment.

* Excessive oil or moisture in the compressed air line necessitates a separate dryer.

3.1.2 Wire - Wire used in spraying should be made expressly for that purpose. The recommendations of a manufacturer of metallizing equipment may be followed in selecting the proper wire.

3.2 Rate of Spraying

The rate of spraying in pounds per hour should not exceed that recommended by the manufacturer nor be less than 80% of that rate. The rate of spraying may be determined from the time required for a unit length of wire to travel through the gun, by applying Formula A. The time required to feed 1 ft. of wire through the gun may be calculated by using Formula B.

$$A. \quad M = \frac{3600 W}{X}$$

$$B. \quad X = \frac{3600 W}{M}$$

where:

X = time in sec. to feed 1 ft. of wire

W = weight of wire, lb./ft. (see Table 4.)

M = metal sprayed, lb./hr.

3600 = number of sec. per hr.

Table 4 - Weights of Wire, lb./ft.

Metal	11 B&S Gauge (0.090 in.)	Diameter of Wire	
		1/8 In.	3/16 In.
Aluminum	0.00750	0.01410	0.03175
5% Silicon aluminum	0.00760	0.01420	0.03195
Aluminum bronze	0.02060	0.03912	0.08800
Tobin bronze	0.02410	0.04550	0.10238
Copper	0.02520	0.04740	0.10665
Monel	0.02520	0.04750	0.10688
Nickel	0.02430	0.04580	0.10305
Carbon steels	0.02200	0.04170	0.09383
Stainless steels	0.02220	0.04170	0.09383
Zinc	0.02000	0.03760	0.08460

3.3 Spraying Procedure

3.3.1 The metallizing gun should be lighted and adjusted with the spray directed away from the work. During the spraying operation the gun should be held 3 to 10 in. away depending upon the equipment

and the size of wire used. (See Fig. 9). The work should rotate at a speed of approximately 50 surface feet per minute. The metal may be deposited in either single or multiple passes. If multiple passes are used the feed should be set to provide a coating thickness of 0.005 to 0.010 in. per pass. Thicknesses greater than 0.010 in. may be applied provided the full thickness of the coating is sprayed in a single pass progressively along the length of the surface to be sprayed. Suitable means must be provided to prevent the accumulation of metal dust ahead of the spraying operation, particularly for single pass spraying.

3.3.2 Ends of the undercut sections should be sprayed first, with the angle of impingement continually varying from about 30 to 60 degrees. Corners should be built up from $1/4$ to $1/2$ the depth of the undercut before proceeding.

3.3.3 After spraying the ends of the undercut sections, spraying should be continued with the gun held at an angle of 45 degrees to the work for at least five passes in each direction, in order to deposit metal under each dovetail, where the following methods of preparation have been used:

- Groove and rotary roughening tool method
- Threading and rotary roughening tool method.
- Groove and electric-bond method
- Threading and electric-bond method.

The work should then be completed by spraying at right angles to the surface.

On all other methods of preparation, after spraying the ends of the undercut sections, the spraying should be continued and completed at right angles to the work.

3.4 Causes and Prevention of Cracking

3.4.1 Causes - Cracks may occasionally appear in the sprayed deposit due to difference in expansion of the base metal and the sprayed metal, shrinkage of the sprayed metal during the transition stage from plastic to solid, thickness of deposit, strength of bond, rate of cooling after spraying and the lack of ductility in sprayed metal.

3.4.2 Methods of Prevention

3.4.2.1 Steps should be taken to minimize the stresses in sprayed metal to avoid cracking tendencies. The following should be considered:

(a) Where a choice of metal to be sprayed is possible select that metal giving a coating with the lowest shrinkage rate. (See Table 5).

(b) Step down the undercut section where cracks invariably start. This tends to reduce the stresses at the ends and reduce the danger of cracking. (See Fig. 3.)

(c) Select the method of preparation which will produce a bond strength adequate for the application.

(d) During spraying, mount lathe tools to remove overspray and prevent build-up at shoulders. (See Fig. 10.)

3.4.2.2 The work should be warmed to a temperature between 250 and 300° F. before spraying when its temperature is below 50°F. or when there is a possibility of cracking. If preheating with a gas flame, the flame should not be applied on the area to be sprayed in order to prevent surface oxidation and contamination by carbon deposits.

3.4.2.3 During spraying, the temperature of the work should not exceed 300°F. If necessary, the spraying should be stopped periodically to allow cooling, or a diffused blast of clean air should be introduced near to but not directly upon the area being sprayed.

3.4.2.4 The work should be allowed to cool normally to room temperature after spraying is completed. If it is necessary to cool the work more quickly it should be rotated while an air blast is directed against it. Do not quench or spray with water or any other liquid.

3.4.2.5 For relatively thick deposits, a metal having a low shrinkage rate should be applied to within 0.020 to 0.040 in. of the finished size and the spraying then completed with the material which is desired on the finished surface.

Table 5 - Mechanical and Physical Properties of Sprayed Metals

Metal	Specific Gravity	Rockwell Hardness	Tensile Strength Psi.	Ultimate Strain %	Shrinkage, In./In.
Aluminum	2.408	H-72	19,500	0.23	
5% Silicon-aluminum		B-64	37,500	0.54	
Aluminum bronze		B-92	31,000	0.62	0.0048
Tobin bronze	7.461	B-64	14,000	0.51	0.010
Copper	7.535	F-78	13,000	0.45	
Monel	7.671	F-79			
Nickel	7.551	F-88			
Low-carbon steel	6.673	B-90	30,000	0.30	0.008
Medium-carbon steel	6.782	B-95	34,700	0.46	0.006
High-carbon steel	6.356	C-39	27,500	0.42	0.0014
Type 420 stainless steel	6.742	C-35	40,000	0.50	0.0018
Type 304 stainless steel	6.934	B-84	31,000	0.27	0.012
Zinc	6.363	H-46	13,000	1.43	

4. FINISHING

4.1 General

Sprayed deposits may be finished by either tool machining, grinding or both. Tool machining or grinding may be performed either dry or wet, provided all traces of the cutting compounds are removed after the operation. Lapping, valve grinding compounds, etc., should not be used.

4.2 Tool Machining

4.2.1 Rough machining should be started near the center of the sprayed area and worked out to the edges. The work should be machined in accordance with Table 6. Rough cuts should be taken to within 0.020 in. of finished size, followed by finishing.

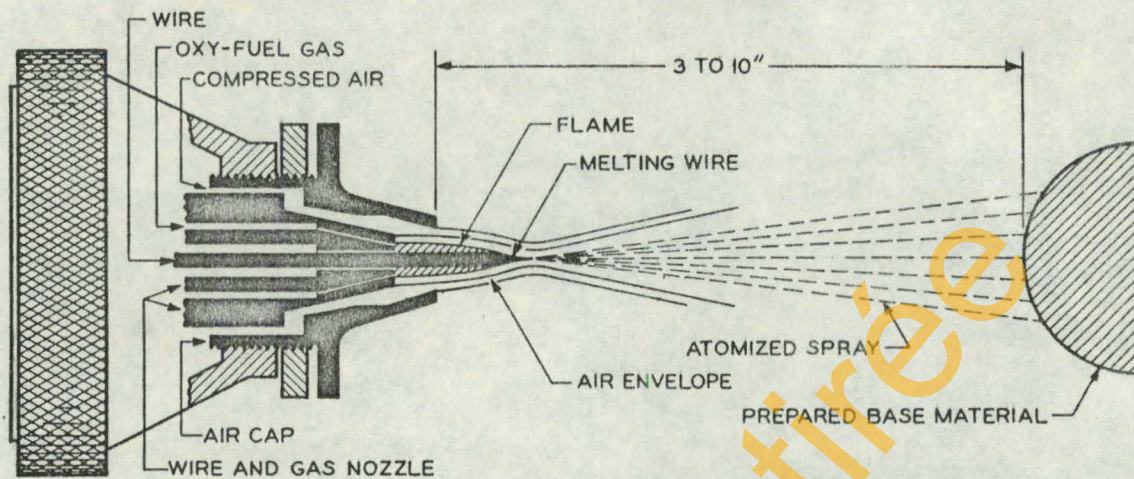


Fig. 9—Schematic Diagram Showing Operation of Metallizing Gun

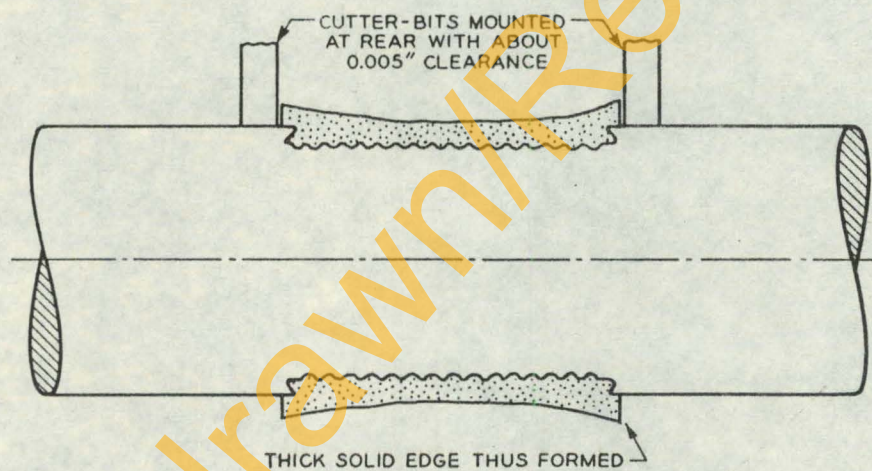


Fig. 10—Method of Preventing Cracking in Thick Metal Sprayed Deposits on Shafts

Cutter bits mounted at rear with about 0.005 in. clearance. Thick, solid edge thus formed.

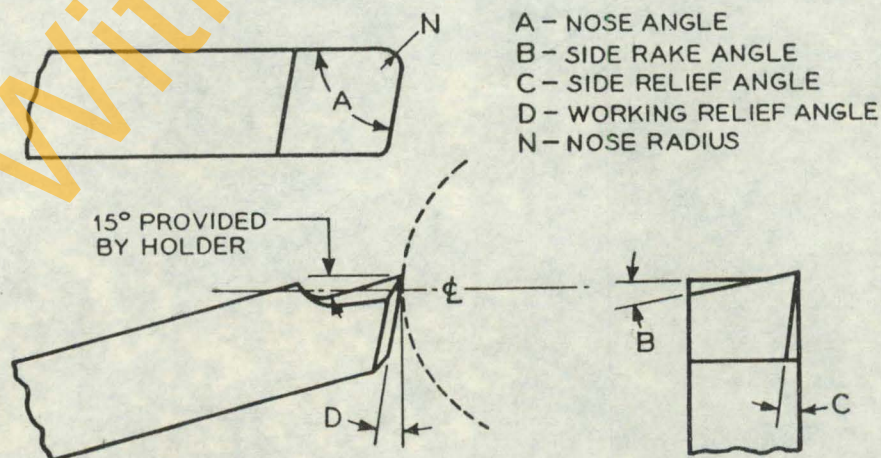


Fig. 11—Grinding Tool Bits for Machining Sprayed Metals

Table 6 - Suggested Machining Settings

Type of Metal	High-Speed Steel Cutting Tools		Carbide Cutting Tools	
	Surface Speed Ft./Min.	Carriage Feed In./Rev.	Surface Speed Ft./Min.	Carriage Feed In./Rev.
High melting point metals (i.e. steel, stainless steel, nickel)	50-100	0.003-0.005	50-100	0.003-0.004
Medium melting point metals (i.e. aluminum, copper, copper alloys)	100-150	0.003-0.005	200-350	0.002-0.006
Low melting point metals (i.e. babbitt, zinc tin, lead)	150-250	0.005-0.007		

4.2.2 Tool bits may be high-speed steel or cemented carbides ground to the dimensions given in Table 7. (See also Fig. 11).

Table 7 - Dimensions for Grinding Tool Bits

Dimension	High-Speed Tool Bits	Cemented Carbide Tools
Nose angle, deg.	80, approx.	75, approx.
Side rake angle, deg.	0-15	0
Side relief angle, deg.	10	7
Working relief angle, deg.	7 max.	7 max.
Back rake angle, deg.	8 max.	8 max.
Nose radius, in.	0.030-0.040	0.030-0.040

4.2.3 The cutting edge of the tool should be either on the horizontal center of the work or very slightly (5 degrees) above.

4.3 Grinding

The correct selection of grinding wheels is essential for finishing sprayed metal surfaces. Selection should be made on the basis of the type of metal sprayed and the finish desired.

The following are the general recommendations for the structural contents of the kind of grinding wheel required for a normal sprayed metal surface:

Kind of abrasive: Silicon carbide wheel
 Grain size: Medium
 Hardness Grade: Medium soft
 Structure: Medium spacing
 Kind of bond: Vitrified.

The following general operational instructions for grinding will be found useful:

- (a) The wheel speed should be such as to give a surface speed of 6000 ft. per minute for dry grinding and 6500 ft. per minute for wet grinding.
- (b) Very light passes should be used for finish grinding. The infeed should be approximately 0.001 in. per pass for rough grinding.
- (c) When a coolant is used, it should be kept clean and free of foreign matter. The grinding wheel must not be allowed to remain immersed in the coolant, since the wheel will absorb moisture and thereby become unbalanced.

It is suggested that the manufacturers of grinding wheels, the Grinding Wheel Manufacturer's Association or the manufacturers of metallizing equipment be consulted for actual recommendations for the finishing of each type of sprayed metal.

Correspondence regarding this Schedule should be addressed to the Secretary, Canadian Government Specifications Board, National Research Council, OTTAWA, Canada.