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TECHNOLOGY UTILIZATION

BONDING AND JOINING TECHNOLOGY

A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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Foreword

The National Aeronautics and Space Administration has established a Technology Utilization Program for the rapid dissemination of information on technological developments which have potential utility outside the aerospace community. By encouraging multiple application of the results of its research and development, NASA earns for the public an increased return on the investment in aerospace research and development programs.

The technology presented represents methods and processes for bonding and joining applications currently used by manufacturers. In many cases, implementation of these approaches can result in considerable cost savings. Industry should find these items economical, efficient, and time saving, as well as contributory to better quality products.

This compilation covers a broad range of technical information in the fields of metallurgy, electrical repair, fabrication techniques for coatings, bonding and brazing, and several special items concerned with electron beam welding. The information varies considerably in technical detail, but is intended primarily for skilled technicians with practical experience in the specific industry where each item is used.

The contents have been divided into three sections. The first, Welding, includes the most technical material, namely electron beam welding systems. Other welding applications involve simple innovations, hardware for simplifying techniques, and methods used to detect bad welds. The information on Bonding ranges from complex bonding processes to methods for joining electrical connections. Soldering and Brazing items describe specific techniques, most of which can be used in large as well as small shops.

Additional technical information on individual devices and techniques can be requested by circling the appropriate number on the Reader's Service Card included in this compilation.

Unless otherwise stated, NASA contemplates no patent action on the Technology described.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

Ronald J. Philips, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

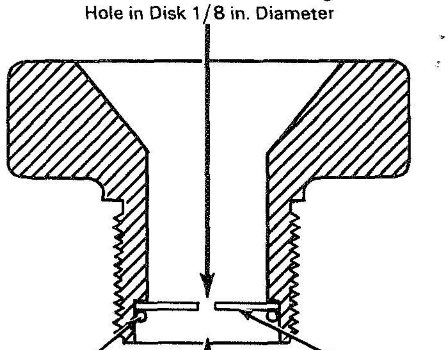
Contents

Section I. Welding

ELECTRON BEAM VAPOR SHIELD

Electron beam welding of aluminum, copper, titanium alloys, or any alloy with high vapor characteristics often results in weld beads containing deep expulsions if the metal vapors are allowed to contaminate the electron gun, causing electron beam arc-out. To avoid this problem, a bent column is available for use with the electron beam welder to bend the beam. However, use of the bent beam column is inadequate because its use prevents the equipment from reaching the required power level.

By installing a diaphragm with an orifice in the anode to serve as a vapor shield, metal vapors are prevented from entering the anode, minimizing possible beam arc-out. As shown in the illustration, an Inconel 718 disk (0.010-inch thick) was placed in the anode to act as a vapor shield during the welding operation. This vapor shield blocked about 90% of the metal vapor path back up the electron stream. Additional advantages included increased filament use and a reduction in maintenance.



Source: W. E. Bredow of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-14344)

No further documentation is available.

ELECTRON BEAM STANDBY ABSORBER SYSTEM

For efficient electron beam welding, it is necessary to absorb the energy of the beam in places other than in the workpiece to be welded. This energy should be absorbed by some means requiring no physical motion of either an absorber or the intended workpiece.

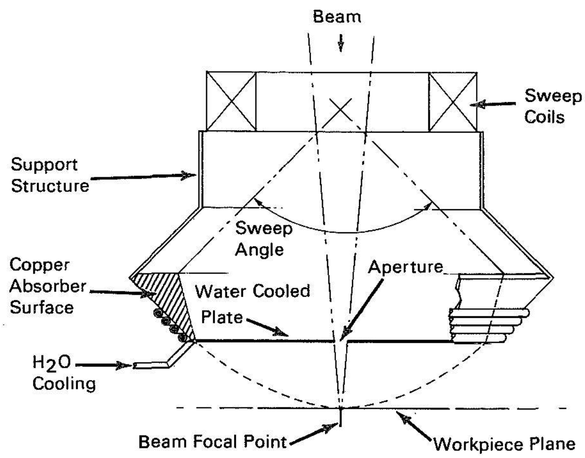
Deflectors cause the electron beam to be distributed over an absorber located between the deflectors and the workpiece. A hole in the absorber permits the undeflected beam to pass through the absorber when the deflection is deenergized. The beam passing through this hole, when the deflection is energized, is kept to a minimum power level by deflection rate change.

As shown in the illustration, a water cooled standby absorber is interposed permanently between the deflection components and the beam workpiece. The energy of the beam is dissipated in the absorber. Along the electron beam axis, the time averaged energy density is much lower than that at its focal point, permitting the absorption of the full beam power without harm to the absorber surface.

The deflections of the beam at high speed and the distributive nature of the beam raster assist in safely dissipating beam power in the absorber. The beam is kept in the raster on this absorber during adjustments of the beam parameters. To use the beam, the deflection is switched off, causing the beam to move to its undeflected position, passing through the hole in the absorber to the workpiece. Switching off the beam is achieved by reversing this process. This system permits adjustment of electron beam systems during full power operating conditions. Other configurations of this system are evident, such as off-axis absorbers situated on one side of the beam.

Source: R. D. Downing of
General Electric Co.
under contract to
Marshall Space Flight Center
(MFS-13642)

No further documentation is available.



ELECTRON BEAM FOCAL POINT DETECTOR

Another item concerned with the efficiency and accuracy of electron beam welding is the electron beam focal point detector. The same illustration as used in the preceeding device applies. With high power electron beam systems, it is necessary to ascertain where the beam is with respect to the desired beam location. This is especially important with apertured systems—that the beam be transmitted with the least loss to the aperture.

A low power level electron beam is positioned upon the area of interest. A luminescent spot on this area, produced by the beam, is observed and its position relative to the desired location noted. Corrections in the relative positions are made until the luminescent spot is coincident with the desired location. Tracking of intended weld joints can be prechecked for alignment with the beam by this method without melting the material, avoiding costly errors.

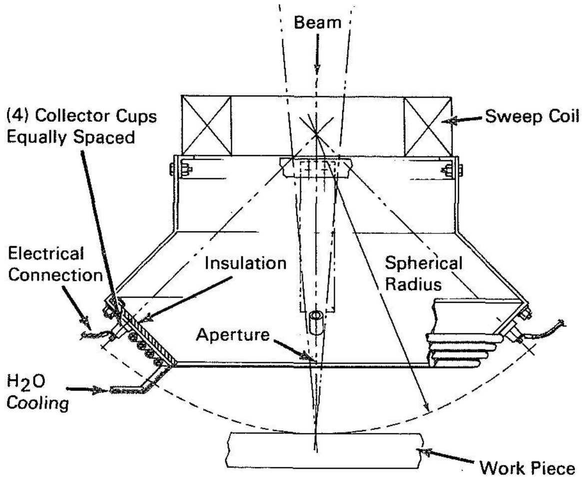
This system uses a gating circuit in conjunction with a swept and scanned high power electron beam. The gating circuit switches the beam raster off rapidly, allowing the full intensity of the beam to pass through a hole in a cooled absorber plate. After a short time, the gating circuit switches the beam raster on again, bringing the beam to the absorber plate. Adjustments are made to the elapsed "off" time and the frequency of switching, so that the average power passing through the hole in the absorber plate is low. However, the beam peak intensity is high enough to cause a luminescent image on the surface of the material to be welded without appreciable heating. The persistence of the luminescent image of the beam spot enables the position of the beam to be seen. Adjustments can then be made safely to ensure the beam impingement on the desired location.

This system permits checking of the programming of the beam-workpiece relationship to ensure that proper alignment exists, and also to check the focal point of the beam by adjusting lens elements for minimum spot size.

Source: R. D. Downing of
General Electric Co.
under contract to
Marshall Space Flight Center
(MFS-13643)

Circle 1 on Reader's Service Card.

ELECTRON BEAM DEFLECTED TO DETERMINE FOCAL POINT LOCATION



As shown in the illustration, this system, closely allied to the preceding electron beam systems, was designed to locate the focal point of an extremely high intensity electron beam. In order to prevent damage to the workpiece, the focal point must be precisely positioned before the full beam intensity is brought to bear.

Faraday cages or other suitable detectors are symmetrically spaced on a plane normal to the at-rest axis of the electron beam. If the beam raster is symmetrical with respect to the detectors, they will collect charge at an equal rate when the axis of symmetry of the detectors coincides with the at-rest axis of the beam. External circuitry computes the time average of the charge collected by each detector, and adjusts the beam position, by steering yokes or other means, to keep the currents equal. This ensures that the unswept focal point lies along the axis of symmetry of the detectors. The position of the focal point along this line is set by adjusting the electrostatic lens or the mechanical position of the beam source, so that the detectors receive the maximum charge.

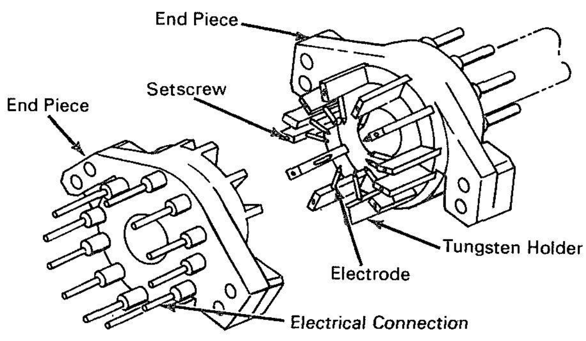
The illustrated locator system sweeps the focused beam periodically past two small Faraday cages whose locations are known precisely. The pulses from each Faraday cage are then integrated and the signal strengths from the two detectors are equalized by steering the beam electrostatically, electromagnetically or mechanically. This ensures that the at-rest beam axis is on a plane equidistant from the two detectors.

Similarly, with another sweep direction, the unswept beam axis on another plane can be located. The intersection of these two planes is the line down which the unswept beam will travel.

Source: R. D. Downing of
General Electric Co.
under contract to
Marshall Space Flight Center
(MFS-13644)

Circle 2 on Reader's Service Card.

MINIATURE WELD HEAD: A CONCEPT



The miniature weld head, although limited in use, has application for welding small diameter tubing in confined areas. The conceptual design of multiple tungsten electrodes, encased in a glass shell, is more complicated than conventional designs, but offers a unique feature which is the condensed spacing of the electrodes, half from each side, to form a circle about the tube to be joined. No rotation is required to perform the welding of this joint. It should be noted that commercial weld heads cannot be utilized in the confined envelope.

Multiple stationary electrodes (radially located) fire sequentially, producing the same effect as a single transversing electrode with 360° rotation. The weld head is split in half to facilitate assembly and disassembly operations. The glass shell permits observation of the electrodes during operation and also contains the inert gas which is supplied through an air inlet tube. The split ends are joined on each side of the joint and are held together by two spacer rods.

Source: A. R. Keir and A. C. Johnson of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15651)

Circle 3 on Reader's Service Card.

INSPECTION DEVICE FOR QUALITY WELDS AND BRAZE BONDS

A special ultrasonic transducer assembly has been developed for reliable inspection of the quality of melt-through welds on fusion-welded tubing couplers for hydraulic lines; other uses include detection of faulty braze bonds in thin-walled, small-diameter joints, and flaws in wall thickness of thin-walled metal tubing. The unit is used in conjunction with high-resolution ultrasonic equipment for the inspection of welded tubing assemblies having 0.25 to 1.0-in. diameters and 0.028 to 0.095-in. wall thicknesses.

The device consists of a 7/16-in.-diameter × 12-in.-long ultrasonic (25 MHz) transducer contained in a mounting block having a water-line connector; a non-rotatable (clamshell) plastic housing with index screw and pointer; and a rotatable clamshell, search unit housing with circular protractor scale.

A tubing specimen is prepared for inspection by positioning the search unit housing over the adapter side of the weld. The nonrotatable plastic housing is firmly mounted on the outer tube wall by two setscrews, while the transducer is placed in its mounting block and secured by a setscrew. The mounting block with the transducer is then arranged in the guide of the rotatable housing. The ultrasonic medium, water, is fed into the mounting block beneath the face of the transducer. Signal traces are observed on the oscilloscope, and the mounting block is moved normal to the tubing axis until an optimum ultrasonic response is obtained. The mounting block is then secured by a setscrew in the guide of the rotatable housing.

Inspection can be performed by rotating the transducer assembly (in the rotatable housing) circumferentially about the weld, while ultrasonic response is observed on the oscilloscope at 10° intervals. Weld quality signal traces recorded on the oscilloscope indicate any of the following melt-through weld conditions: no penetration, partial or full penetration, and excessively rough outer surface. After 36 circumferential readings are completed, the index screw is rotated one-half turn to index the transducer assembly 0.020 inch axially along the weld. The circumferential scanning procedure is then continued at this axial position and successive 0.020-in. increments until the entire weld is covered. The quality of the weld is evaluated from the point-by-point oscillograms.

Source: D. J. Hagemaier of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-18144)

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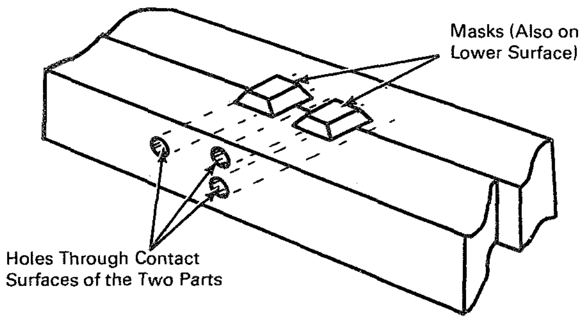
CONTROL OF ELECTRON BEAM WELD MELT BY USE OF MASKS

The use of "masks" with electron beam welding offers a technique for controlling weld penetration by masking the material with additional thicknesses of the same material. Although the masking technique may be limited in its industrial application, any electron beam welding operation in which the depth of penetration must be controlled may be improved.

In a specific case, product improvement required modifications of the sealing areas of the component which initially came from a corrosion-resistant steel forging. The center portion of the component had to be removed and a modified insert joined to the outer segment. Because of the internal passageways, multiapertures, and exceedingly small dimensional tolerances, the apparent method of effecting a successful salvage operation was to use the electron beam welding process. Procedures and techniques, including joint design and "masking" details for making circular butt welds through joints of variable thicknesses, were developed. Subsequently, two modified bearing supports were fabricated using the electron beam welding process for joining the corrosion-resistant steel insert to the finish-machined external component.

Macroscopic examination of test specimens which simulated actual joint design revealed that complete penetration is possible without obstruction of the internal passageways. Also, configuration of masking details proved to be critical. The amount of internal fusion depended upon angle and thickness of the "mask" at the line of contact.



Internal discrepancies may exist in the weld melt and may not be disclosed (due to defect orientation) by conventional inspection methods. Since the weld is in compression, however, the internal defects may not affect the operational life of the component.

Source: R. E. Nugent and
R. E. Fish of
North American Rockwell Corp.
under contract to
NASA Headquarters
(HQN-10425)

Circle 5 on Reader's Service Card.

DYE PENETRANT INDICATION CAUSED BY SURFACE DEFECTS

Occasionally, inspection of weldments using dye penetrant indicates anomalies, and as a result, items have been rejected when the depth of indication has been less than 0.007 inch. Macroscopic and microscopic evaluations of specific weldments indicated four types of superficial surface defects which caused dye penetrant indications: 1) grain boundary melting and cracking; 2) weld spatter; 3) local arc-plasma impingements (cast puddles in the surface of the heat-affected zone); and 4) grain boundaries which have been attacked by the caustic etch used in the dye penetrant inspection procedures.

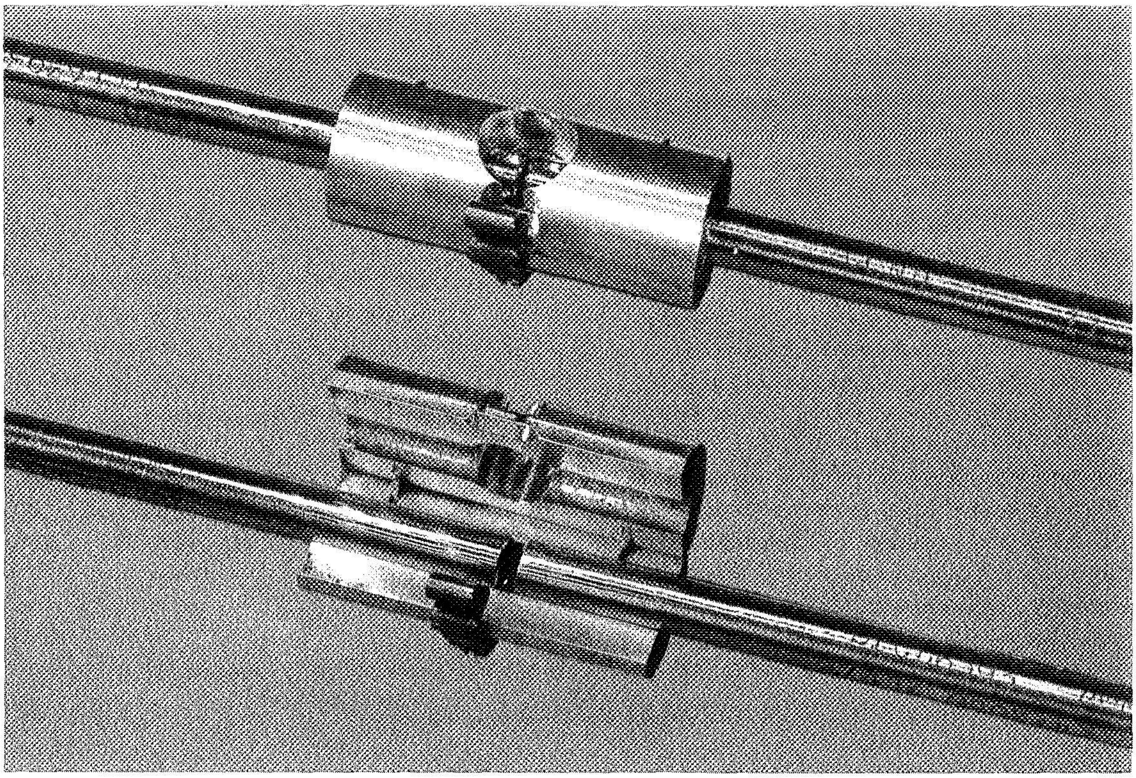
Methods for minimizing these superficial defects included stabilization of the arc; utilization of direct current gas tungsten arc welding procedures; reduction of caustic etch time; and utilization of fine grain material.

Tests on aluminum weldments showed that a 0.1% oxygen addition to the argon shielding gas effectively minimized impingement and surface cracking. The added oxygen apparently eliminated variations in the arc-plasma cone and minimized the heating of adjacent surfaces. In most aluminum weldments, arc-plasma impingement and surface grain-boundary cracking could be eliminated entirely by using the stabilized arc.

Source: K. R. Wilson and R. G. Hocker of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-14068)

Circle 6 on Reader's Service Card.

TUBE ALIGNMENT CLAMP FOR WELDING



In welding or brazing operations, this improved clamping device aligns and holds tubing during prefit. The hinged single assembly and spring latch feature permit rapid assembly and removal, offering time and cost savings. Prior prefit positioning devices were made in separate halves with either four screws or a hose clamp to assemble the device onto the tubing. The new clamp is made by hinging the two halves and providing a spring latch. A centrally located viewing hole permits visual adjustment of the clearance between the tube ends. After prefitment, the alignment clamps are removed and the sections are held by the temporary brackets while the joints are brazed.

This alignment clamp should find general application in the welding industry, and in tubing operations for high pressure fluid systems.

Source: T. A. Blair of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15619)

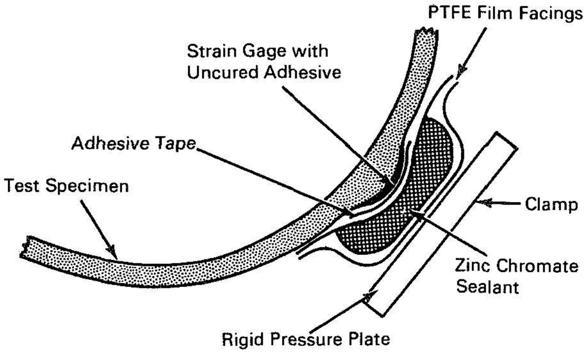
Circle 7 on Reader's Service Card.

Section 2. Bonding

METHOD FOR BONDING STRAIN GAGES TO CURVED SURFACES

A method has been developed for using a high-temperature zinc chromate sealant between polytetrafluoroethylene (PTFE) sheets for pressure pads in bonding strain gages to surfaces. The method may be used wherever strain gage instrumentation is bonded to irregular surfaces, and may have application for other types of bonding. Use of this technique has reduced the need for molds, minimized the replacement of transducers, and has improved the quality of the bonding.

Previously, silicone rubber pads had been used to transmit pressure to hold strain gages to irregular surfaces during the 225°F bond cure cycle. On many curved surfaces, the silicone would not apply a sufficiently uniform pressure. Special aluminum male or female molds had to be made which conformed to the surface in order to obtain acceptable void-free bonds. Using this improved method, the strain gage is attached to the surface of the test specimen by an adhesive tape; the zinc chromate (held between the facing sheets) covers the gage. Pressure is maintained by mechanical clamps with pressure plates or by vacuum bags sealed to the surface of the specimen.



Source: D. D. Foulk and A. L. Williams of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16156)

Circle 8 on Reader's Service Card.

CERAMIC COATING REINFORCEMENT

Ceramic coatings attached to metal substrates often fail at the ceramic-metal interface during heating. Failure is usually due to excessive stresses resulting from thermal expansion differences and structural restraints which prevent bending.

Using a thin layer of intermediate metal having low yield stress between the ceramic and metal substrate relieves the thermal stress and acts as a strain-accommodation layer. The layer must be compatible with the ceramic and metal substrate. Many metals or alloys such as copper or certain braze alloys would be satisfactory. Modulus of elasticity of any metal can be reduced by applying the layer as a very porous structure. The metal can be applied by melt-spraying, brazing, or electroforming.

Another method of relieving strain between the ceramic and the metal is to interpose a layer of glass between the components. At elevated temperatures, the glass will anneal, relieving the thermal stresses. When cooling, stress will not be produced until the glass reaches a sufficiently high viscosity. The glass can be formulated to harden at a temperature sufficiently low to avoid the production of critical stresses.

Source: H. W. Carpenter of
North American Rockwell Corp.
under contract to
Lewis Research Center
(LEW-10924)

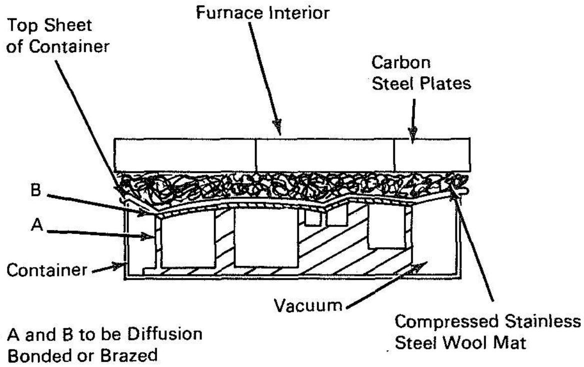
Circle 9 on Reader's Service Card.

CONTOUR CONFORMING HOLDOWN METHOD FOR STATIC VACUUM DIFFUSION BONDING

This technique was devised to improve the uniformity of loading on parts for diffusion bonding by employing a contour-forming stainless steel wool mat, pressurized by a heavy steel plate. Present systems using hydrostatic pressure produce a more accurate structure, but their comparative costs are high due to the need for pressure vessels.

A heat conducting, compressible, contour-conforming stainless steel wool mat uniformly transfers weight to contoured components being diffusion bonded. The steel wool mat is placed between a heavy steel plate and a thin walled vacuum bag, which encapsulates the assemblies being bonded. The uniformly distributed weight provides necessary pressure for the required diffusion bonding operation. Prior static diffusion bonding required a flat heavy plate, heavy tungsten pellets, a hard rubber mold or a mechanical press, to transmit pressure to the part. The new method, using contour conforming stainless steel wool, permits uniform, fluid-like transmittal of pressure. The stainless steel wool is also an excellent thermal conductor and much less expensive than other materials.

This method can be used where minimum facilities exist for diffusion bonding, eliminating the need for expensive mechanical presses. Additional applications are possible in the automotive industry for mass production diffusion bonding of components by passing a continuous line of



Assembly of Components to be Diffusion Bonded in an Evacuated Thin Wall Container, Showing Fluid-like, Contour Conforming, Compressible, Stainless Steel-Wool Mat as the Pressure Transmitting Medium

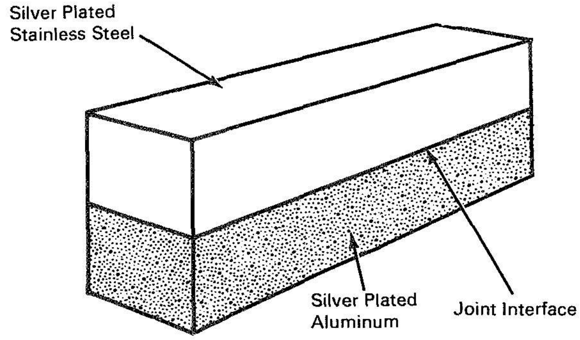
assemblies through a conveyor furnace, and in the jet blade manufacturing industry to hot-straighten blades to specified contours of bow and twist.

Source: E. S. Scherba of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15425)

No further documentation is available.

DIFFUSION BONDING OF ALUMINUM TO STAINLESS STEEL

A new method of bonding aluminum to stainless steel has been developed and tested. The joint strength attained is almost three times greater than bonding by conventional methods. The steel specimen is coated with a thin layer of silver; the aluminum is first coated with a layer of zinc and then plated with silver. The silver plated surfaces are then joined, put in a retort and placed into an autoclave. Heat and pressure cause interdiffusion of the silver atoms across the interface to establish a metallurgical bond.



The advantages of this method of bonding are that components can be fabricated with high strength-to-weight ratio for aluminum, and strength and corrosion resistance for stainless steels; leak tight joints can be established; and no salt compound is required, eliminating corrosion which could be caused by salt trapped in the brazed joint.

This bonding technique can be used effectively in the production of valves and electrical control assemblies, and in any bonding application between aluminum and stainless steel, depending on the availability of adequate temperature and pressure controlling equipment.

Source: D. E. Nord of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-90802)

Circle 10 on Reader's Service Card.

PRECISION MOUNTING FOR INSTRUMENT OPTICAL ELEMENTS BY POLYIMIDE BONDING

Epoxy resin-coated polyimide plastic may be used for bonding materials with different thermal coefficients in applications which require precision mounting such as instrument optical elements and other devices where vibrations, temperature extremes, and low pressures are encountered.

Use of springs, setscrews, or cushioned frames for mounting precision optical glass elements allows a minimum of 10 arc seconds of alignment shift during vibration, and further alignment shift and surface distortion upon exposure to high temperatures. Bonded structures may hold alignment, but transmit stress to the glass, possibly breaking it or the bond.

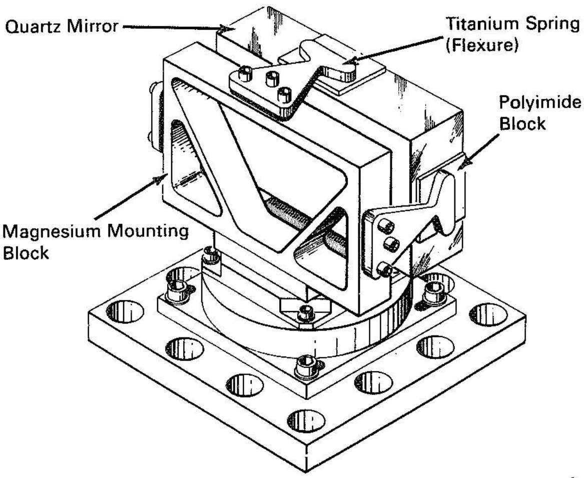
For test purposes, a fused quartz mirror $6 \times 3.35 \times 1.25$ in. weighing 2.5 lb was used as the optical element. The mirror mounting detail is shown in the drawing.

A thin layer of potting compound was applied to both sides of a small 2-square-inch block of polyimide plastic, 1/16-inch thick. This block was then affixed between the mirror and the thin titanium springs. Subsequently, these springs were attached with screws to a magnesium mounting block and the potting was cured.

The titanium springs serve as a bridge between the mirror and the magnesium mount, limit thermal conduction, and accurately maintain the mirror position. The magnesium frame serves for structural rigidity and allows heat radiated from the mirror to pass through the openings in the mount to prevent thermal expansion.

After vibrational tests, alignment of the mirror was within ± 5 arc seconds. A more precise determination was precluded by limitations of the reference system used for checking the accuracy of alignment.

The front of the mirror was then heated with a sun gun and the temperature of the back of the mirror reached 160°F. As determined by an autocollimator reference system, the alignment retention was within ± 1 arc second. The temperature of the magnesium mount, to which the mirror was attached by bonding material and titanium brackets, increased less than 3°F from the initial 75°F temperature of the mirror and mount.



It is predicted that this bonding technique will allow alignment to be maintained within ± 1 arc second from −50 to 180°F, if the frame temperature remains within 75° ± 5°F.

Epoxy resin coated polyimide plastic bonding material has extremely low vapor pressures, precluding outgassing problems and subsequent contamination in high vacuum. Polyimide is resistant to most organic solvents and dilute or weak acids; however, it is attacked by bases and by nitrogen tetroxide.

Source: T. F. Mueller of
Ball Brothers Research Corp.
under contract to
Marshall Space Flight Center
(MFS-20293)

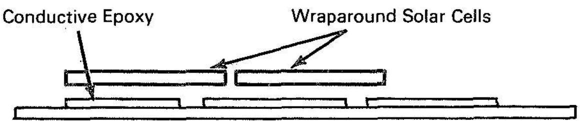
Circle 11 on Reader's Service Card.

METHOD FOR ELECTRICAL AND MECHANICAL CONNECTIONS

Although this wiring technique was originally used to connect solar cells both physically and electrically, the procedure can be applied to any operation requiring good electrical and mechanical connections. The purpose of the innovation was to simplify the present solar cell mounting and wiring technique by combining them into one simple operation. Using a conductive-type epoxy to secure the solar cell to a substrate, and electrically connect it to an adjacent cell, the epoxy acts as an adhesive, an electrical conductor, and a thermal conductor.

Solar cells are currently secured to the substrate by the use of a specific adhesive. The disadvantages to this method are that they are time consuming; each cell is subjected to temperatures in excess of 400°F; the soldering operation is very tedious; and the pressures of handling expose the cells to a higher breakage rate.

The use of a conductive epoxy in conjunction with a wraparound solar cell, either soldered or solderless, would eliminate many of the present hazards. The cell in both cases must be fastened



to a substrate. The conductive epoxy is a new approach combining the wire and the adhesive into one item, and into one operation.

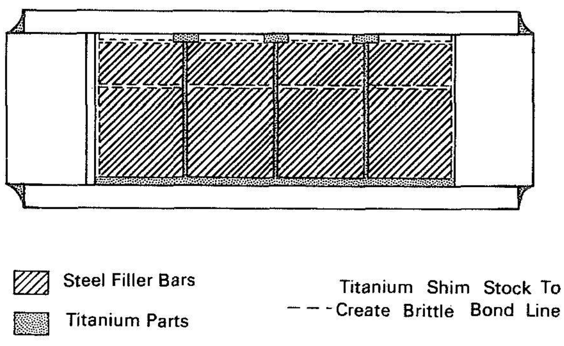
Source: J. E. Beckley, Jr. of
Comprehensive Designers Inc.
under contract to
Goddard Space Flight Center
(GSC-90464)

Circle 12 on Reader's Service Card.

A METHOD FOR ROLL DIFFUSION BONDING

Roll diffusion bonding is achieved by a roll reduction process at elevated temperatures. The parts to be bonded together must be positioned and stabilized for the roll reduction process by steel bars. Usually, a special compound is applied to the surface of adjacent steel bars to prevent them from bonding together during the reduction process, greatly complicating their removal after the rolling process. "Stop off" compounds are used on the surfaces of mating steel bar to steel bar to prevent this bonding. This "stop off" compound represents a contaminate or bond preventative in a pack assembly which otherwise receives utmost care to prevent contamination. The presence of this controlled contaminate may cause particles or chips to be dislocated into areas of desired bonding, during assembly or shipment of the pack.

To avoid the above problems, titanium shim stock can be placed between the mating surface of the steel bars. The shim stock can be tack spot welded to the bars to assure proper positioning. During the bonding process, the titanium shim stock will form a brittle iron-titanium compound which can be removed by mechanical or thermal shock or vibration.



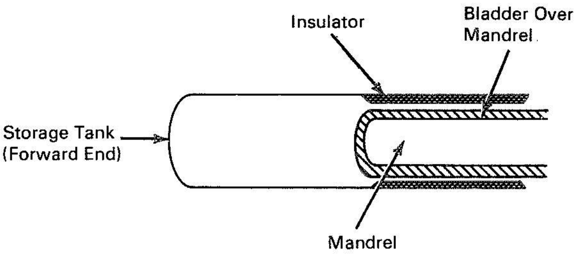
Source: C. E. Conn, Jr. of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-91329)

Circle 13 on Reader's Service Card.

INSULATOR BONDING PROCESS

This time-saving process was developed to produce good bonding insulation on interior surfaces, and to help insulate the inside of metal containers to withstand high temperatures. In a specific case, when bonding the aft insulator into a storage tank, some insulators required rework and others were removed because of tape delamination and unbonding. This improved, pressurized method holds the insulator in position during the curing cycle by application of an inflatable bladder and a mandrel.

For obtaining a good bond and preventing tape delamination, the insulator is installed into the ullage case by using a mandrel and a bladder. The aft insulator is positioned, a bladder is slipped over a mandrel, and the two are inserted into the ullage case. When the bladder is pressurized to 175 psi, it presses the insulator to the inner wall of the case and holds it in this compressed condition during the cure cycle required for bonding the insulator to the case. The pressurized bladder eliminates unbonded areas between the case and the insulator, and prevents delamination of the insulating tape.



Source: S. Finelt of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-91238)

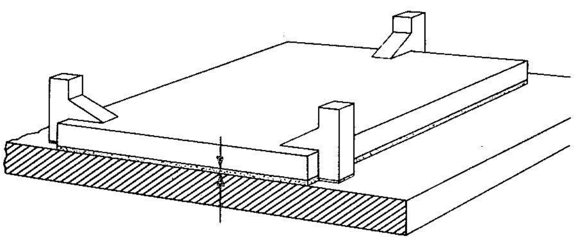
Circle 14 on Reader's Service Card.

QUICK-SET TEMPORARY BONDING CLAMPS

A method of bonding materials to a flat surface has been devised which is particularly useful when bolts or other permanent hardware for holding the pieces together are undesirable. This technique should have general interest for builders, and is applicable wherever fixtures must be positioned above floor levels. Two adhesives are used in the process: the primary or permanent bonding material, and a "quick setting" adhesive.

The clamps can be cut to any required size. The permanent bonding substance is applied to the surface of the structure. The piece to be bonded is set and the quick setting adhesive is placed on the bottom of the clamps; the clamps are then put in place. When the permanent bonding material has set, the clamps can be snapped off easily and any residual material can be cleared off by use of a solvent. A typical configuration is shown in the figure.

This method of bonding materials is very easy to use, and can be effected very quickly. No permanent defacements are left on the surfaces to which the materials are bonded, such as mounting holes resulting from the use of other methods. This method can be adapted to accommodate almost



any size component. since only the number and size of the clamps need to be varied or changed. An additional advantage is that a uniformly thick bond line of permanent adhesive can be obtained to secure the article to the surface.

Source: C. D. Baker
NASA Pasadena Office
(NPO-10695, 10696)

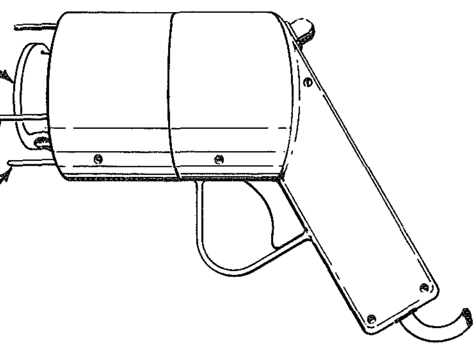
Circle 15 on Reader's Service Card.

GUN FACILITATES ADHESIVE BONDING OF STUDS TO SURFACES

This tool will facilitate the bonding of thermoplastic-backed studs to smooth, hard surfaces such as marble. The studs can be used for mounting heavy loads, pictures, or signs on walls in public buildings where defacement with drilled holes is prohibited. These studs can be removed easily by softening the plastic bonding with heat from the gun.

Design characteristics of the gun are as follows:

1. Maximum wattage 1 kW at 28 volts dc.
2. Input controllable from external dc power supply.
3. Operating temperature to 700°F maximum.
4. Insulation protects user; exterior temperature rise does not exceed 36°F after 30 minutes operation.
5. Spring is easily removed to permit spring-force adjustment.
6. Standoffs interlock with trigger to prevent operation unless all standoffs are depressed, indicating that the stud is perpendicular to surface.
7. Weight approximately 3 pounds.



Source: W. G. Simpson and B. K. Davis
Marshall Space Flight Center
(MFS-20299)

Circle 16 on Reader's Service Card.

MINIATURIZATION OF MAGNETIC LOGIC CIRCUITRY

Special partial-set-state characteristics, present only in cores cut ultrasonically from larger toroids, are important to magnetic logic circuit operations. Not until the fabrication of integrated ferrite structures was it known that these characteristics could be produced by other means. With fabricated structures, the desired characteristics can be obtained in materials having a coercive force ranging from below 0.8 oersted to above 8.0 oersted. Ferrite structures offer a definite advance because previous long path lengths used to control flux can now be replaced by a small size core having the necessary high coercive force. This development indicates the feasibility of making a structure that would functionally replace a logic circuit containing 80 toroidal cores. In addition to miniaturization of magnetic logic circuits, the development may also be useful in memory, inductor, permanent magnet and microwave applications and should be of particular application in the design and development of computer and microwave hardware.

Two ferrite materials, each having different formulation and magnetic characteristics, can be bonded into a continuous ferrite structure by preparing the materials as a slurry, and then using the doctor blade method to form flexible ferrite sheets. After firing, the sintering process was continuous across the bond. Bimaterial structures prepared by this method showed that each magnetic material retained its unique magnetic characteristics. Magnetic cores in sizes 300 mils, 130 mils and 70 mils, have been pressed and processed to have the same partial set-state threshold values.

Source: P. D. Baba of
Ampex Corp.
under contract to
Langley Research Center
(LAR-10037)

Circle 17 on Reader's Service Card.

DIFFUSION BOND METHOD OF JOINING STEEL AND A TEFLON-BRONZE COMPOSITE

Teflon-bronze composites are used as dry lubricants for steel gears which must often operate in harsh environments. Previous methods of bonding the composites to steel, such as adhesive bonding, have several disadvantages including adhesive outgassing, radiation damage, and frequent delamination during final machining of the gears. The new method eliminates these problems by means of a diffuser at the Teflon-steel interface, and joins the composite and steel in a time/temperature relationship that neither affects the mechanical properties of the steel nor the strength of the Teflon.

Standard procedures are used with the exception of the interspaced diffuser. The parts to be joined are cleaned with methyl alcohol and the metal interfaces are copper flashed, after which a coat of flux is treated with fine-mesh oxygen-free copper granules. The parts are then placed in a straightforward bonding press, raised to a temperature of 580°F at a pressure of 2500 psi for 15 to 20 minutes, and then allowed to cool to room temperature. This method offers a superior bonded product and takes only 1-1/2 hours to process. The bonding process using adhesives takes approximately 26 hours for setup time and adhesive curing.

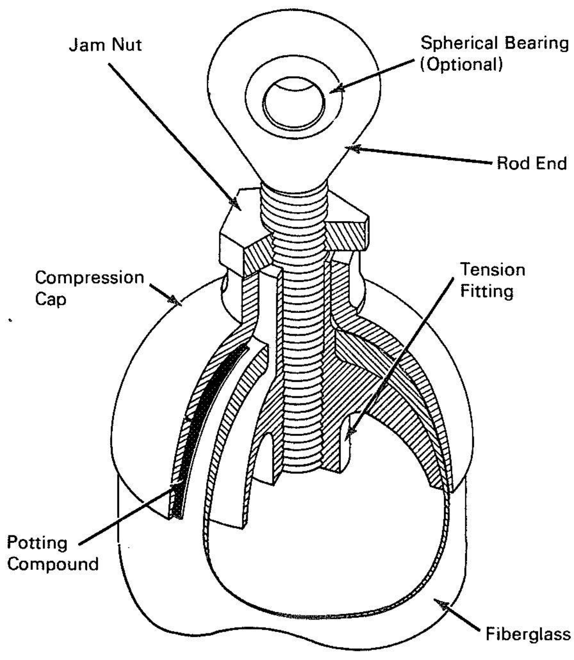
Source: F. P. Lalacona
Marshall Space Flight Center
(MFS-20482)

Circle 18 on Reader's Service Card.

TENSION COMPRESSION STRUT ATTACHMENT SYSTEM DESIGNED FROM FILAMENT-WOUND ROVED FIBER

This system is designed to permit the transmission of axial tension and compression loads in a two-force, filament-wound member. The system uses continuous fibers, and all loads are transferred axially by the integral end effect obtained through the use of mechanical clamping and bearing surface potting. Reliability is improved by elimination of an adhesive load transmitting link. The system is suited for application where load transfer in a desired location will provide heat isolation, high strength, low dielectric and ease of cleaning. This would include laboratory structures, "super cool" installations, food handling equipment, playground equipment, electric power installations and aircraft structures.

The design is adaptable with equal mechanical advantage to any spherical or ellipsoid shape, depending upon the type of fiber being used. Unique features incorporated in this design are: use of a clamp composed of a tension fitting inside the tubular member; a compression cap attached by potting to the exterior of the member; the tension fitting and compression cap clamp the strut end windings as the jam nut is torqued on a rod end; and the member is a single piece part where any applied load is distributed axially around the circumference of the part.



Source: J. D. Godsy of
The Boeing Co.
under contract to
Marshall Space Flight Center
(MFS-15019)

No further documentation is available.

IMPROVED PRIMER FOR BONDING POLYURETHANE ADHESIVES TO METALS

A primer has been developed to ensure effective bonding integrity of polyurethane adhesives on metal surfaces at temperatures ranging from -423° to +120°F. The primer-adhesive system provides greater metal surface protection and bond strengths than can be attained with other adhesive systems. Use of this primer also reduces gas permeability and lowers surface tension of the film, facilitating adhesive application. The primer can be sprayed directly or brushed on clean metal surfaces.

The primer, a modified polyester/isocyanate, is prepared from a commercially available polyester resin and a trifunctional polyisocyanate (e.g. polymethylene polyphenylisocyanate). To produce the primer, the polyester resin is dissolved in 1, 1, 2-trichloroethane (a chlorinated hydrocarbon), and the polyisocyanate is added to the solution. The ratio of the reactants is 80 parts by weight of the polyester plus solvent (7 to 8% solids) to 1 part of the polyisocyanate. When catalyzed, the mixture has a shelf life of more than 8 hours at room temperature. The mixture can be cured within 4 hours at room temperature or within 2 hours at room temperature (setup) plus 2 hours at 150° to 180°F. The mix ratio of resins to catalysts can be varied, depending on the resin content of the uncured mixture, to provide primer coatings with varying degrees of toughness and flexibility.

Source: L. J. Constanza of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-90591)

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BONDING TECHNIQUE IMPROVES TRANSFORMER RELIABILITY

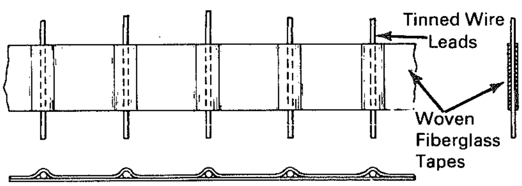


Figure 1

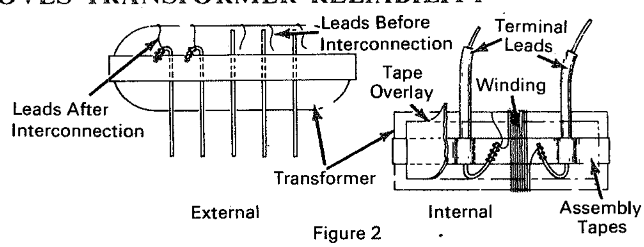


Figure 2

A new technique has resulted in improved spacing and anchoring of terminal leads for transformers and toroidal coils. Fine leads from transformers, toroidal coils and similar devices were formerly soldered to larger terminal leads; the soldered joints were held close to each unit by adhesive tape. With gradual deterioration of the tape, the fine wire often broke, resulting in the taped leads being pulled out from the transformer, or crossover of wires shorting at the soldering.

This novel method is especially useful for manufactured transformers using wires finer than 36-gage; reliability is increased, especially by better anchoring of the leads. Appropriate spacing of the tinned terminal leads is effected between two tapes of woven glass fiber that are sandwich-bonded with pliable epoxy adhesive, shown in Figure 1. The individual leads may or may not be enclosed in glass-fiber sleeves. For external lead-termination of a transformer, shown in Figure 2, leads from the transformer are wrapped about the taped terminal leads and soldered to them; two of five leads are shown connected. Figure 2 also shows use of the terminal tape in an internal lead-termination; a tape overlay provides additional insulation after the soldering.

For practical application, groups of terminal wires could be assembled and taped on a continuous strip machine or in an injection-molding machine. This method uses a mold made of a TFE fluorocarbon for assembly and curing of the tapes.

Source: E. M. Wiler
NASA Pasadena Office
(NPO-10842)

No further documentation is available.

Section 3. Soldering and Brazing

CLOSED CIRCUIT IMPULSE SOLDERING

Closed circuit impulse soldering is an improved metered soldering technique. Two electrodes are bridged with a nichrome element which is the soldering tip. An energy pulse of predetermined amplitude and duration is impressed across the soldering element. The tip pressure is also prescheduled and set. Tinned leads to be soldered are positioned under the soldering tip and the energy is released. The solder reflows and a quality solder joint results.

Parallel gap impulse soldering is another technique in current use, and is basically a welding technique used to reflow solder previously applied to the joining surfaces. A set of air gapped electrodes is carefully positioned on the lead to be joined. A metered unit of energy is then impressed on the electrode circuit. This current flow in the lead between electrodes elevates the temperature which reflows the soldering and joins the surfaces.

The improved method, closed circuit impulse soldering, is also a reflow technique; however, the air gapped electrodes are bridged permanently with a resistive element. This element contains the metered energy within its closed circuit. Therefore, the possibility of current flow to the lead to be soldered is minimized. The energy pulse raises the resistive element temperature in contact with the surfaces to be joined. This thermal pulse impressed on the lead reflows the solder producing the connection.

Advantages to both techniques include: positive and controlled electrode pressure; positive and controlled pulse duration; controlled energy by means of a preestablished energy schedule; and component heating of minimum duration.

Closed circuit impulse soldering, by adding a nichrome shorting wire to the present electrodes, maintains the advantages of positive pressure, pulse and energy control. In addition, the possibility of electrode arcing is eliminated as well as deposition of undesirable conductive material on the board surface and generation of transient voltages. The optimum equipment operating level is not critical, and soldering can be accomplished in restricted areas because of smaller contact size. This technique establishes only visual inspection criteria rather than using sectioning or other destructive techniques previously required for verification.

Source: J. Shelton of
Radio Corp. of America
under contract to
Goddard Space Flight Center
(GSC-10006)

Circle 20 on Reader's Service Card.

IMPROVED NICKEL PLATING OF INCONEL X-750

A method has been developed for applying a plating of nickel, on Inconel X-750 tubing, to serve as a wetting agent during brazing. Previous platings blistered and flaked because of the heat of brazing and the presence of Co, Ti or Cr in the alloy. The new electroplating technique uses acid pickling which produces a clean surface free of impurities resulting from the heat-treated condition; the low-stress nickel-plating bath contains none of the organic wetting agents that cause nickel to blister at high temperatures.

The tubing is degreased before alkaline cleaning, with brushing, for not less than 1.5 minutes at from 180° to 210°F; it is then rinsed. The pickling bath contains 15 to 20% of nitric acid and 3 to 5% of hydrofluoric acid (both by volume), the balance being water. The bath lasts no longer than 20 minutes at no more than 120°F before rinsing.

Activation takes from 30 to 60 seconds at 70°F in an aqueous solution of 1 to 1.5% nitric acid (42° Be) and 1 to 1.5% hydrofluoric acid (45 to 60% by weight). A nickel strike is made of 70°F in an aqueous solution of nickel chloride at 30 oz/gal and hydrochloric acid at 4.8 oz/gal; the process lasts from 1.5 to 2 minutes with a current density of 50 A/ft^2.

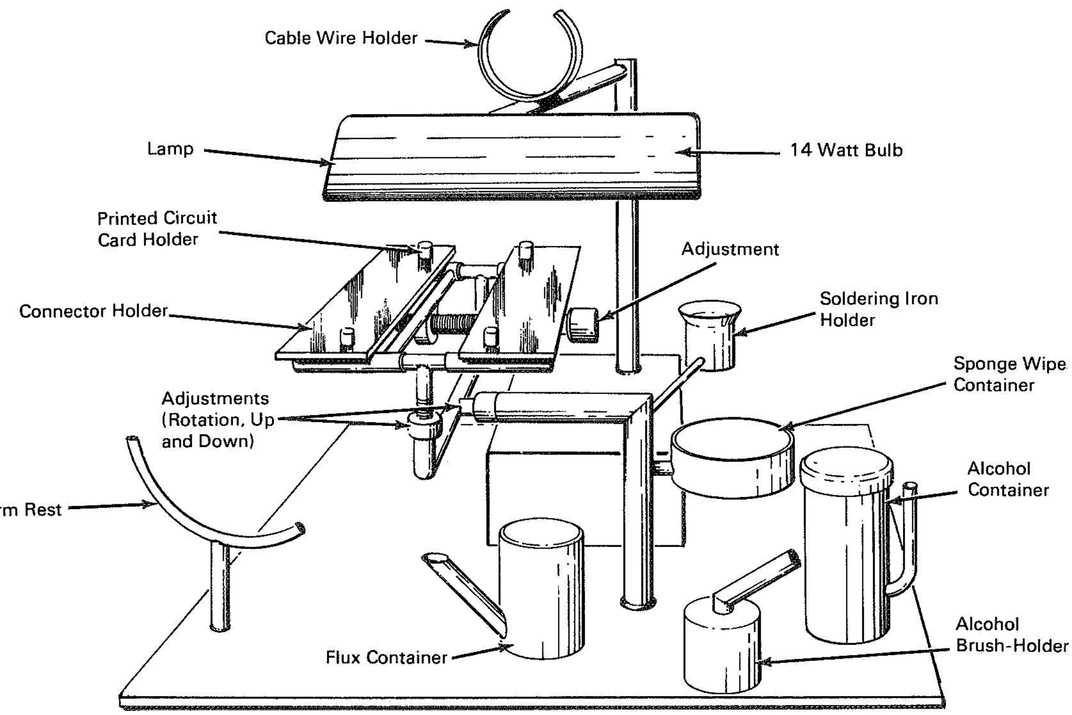
The tubing is then plated to the required thickness in one of two aqueous solutions. The first, from 115° to 140°F and pH 1.5 to 2.5 (electrometric), contains nickel sulfate at 44 oz/gal, both nickel chloride and boric acid at 5 oz/gal, and 30% hydrogen peroxide at 0.057 oz/gal daily. The pH which tends to rise, is lowered with sulfuric acid or raised with nickel carbonate. The current density is from 25 to 100 A/ft^2.

The alternative plating solution at 100° to 140°F contains nickel sulfamate at 60 oz/gal, boric acid at 4.5 to 6 oz/gal, and 30% hydrogen peroxide at 0.057 oz/gal; the pH is maintained between 3 and 4 (electrometric) with either sulfamic acid or nickel carbonate, and the solution is filtered continuously. The current density is from 40 to 80 A/ft^2. The plating must be smooth and continuous, with no discoloration indicative of burning.

Source: C. A. Kuster, J. E. Freeney, and M. E. Farmer of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-18604)

Circle 21 on Reader's Service Card.

FIXTURE FOR SOLDERING OPERATIONS



This soldering fixture, designed for printed circuit cards, is a basic bench-mounted, self-contained integral unit combining all soldering needs into a compact, readily available work station. All tools, materials, and accessories are readily available to provide an ideal station to perform critical soldering. Special emphasis is placed on cleanliness, simplicity of operation, and special devices required to perform extremely critical soldering operations. The fixture lends itself to production-line or single-unit work equally well. The prototype fixture was constructed of stainless steel to meet clean room requirements, but other materials could be utilized with resultant cost savings. Overall dimensions of the fixture are 12 ×13 × 12 inches.

Electrical power is supplied by a single power connection to a normal 115 V ac, 60 Hz receptacle by power cord or bench-top mounting. Additional power receptacles are provided for thermal strippers, solder pot, and other accessories, when required.

Many desirable characteristics have been incorporated in the fixture. Variable voltage level is supplied through a fused potentiometer for accurate control of soldering iron temperature. Indirect fluorescent lighting of 100 foot-candle power is supplied directly on the work area. A split ring at the top of the fixture provides a means for retaining wire harness assemblies from the work area. Containers for normal soldering materials (alcohol, flux pot when allowed) are provided as integral units and are designed for easy access and maximum cleanliness. A convenient soldering iron holder is mounted on the fixture which serves as a heat sink to maintain a constant iron temperature for intermittent operations. The soldering iron cord is connected to the fixture. A nylon brush drip cup with reverse brush holding provides for added system cleanliness. The sponge container is securely mounted to the fixture. A miscellaneous-parts holder is included for clips, screws, and pins which may have to be removed and replaced during soldering. Solid arm rests are provided as a part of the fixture to minimize operator fatigue. Finger rests on the work-holding unit enable maximum control during critical soldering operations and ensure a high degree of cleanliness.

Although the fixture was originally designed for operation by right-handed persons, a minor change during fabrication can make the tool suited for left-handed operators.

Source: C. M. White of
The Chrysler Corp.
under contract to
Marshall Space Flight Center
(MFS-14456)

Circle 22 on Reader's Service Card.

FIXTURE TO IMPROVE SOLDERING OPERATIONS

Ultrasonic vibrations are used to prevent the formation of voids and to release trapped gases which weaken the strength of soldered connections. This holding fixture, which is part of a transducer, eliminates voids in solder connections, particularly the solder pot-type terminal; it also improves tinning and thereby provides higher quality to the joint.

The transducer imparts energy on command to the part being soldered. If the part can tolerate sonic or ultrasonic vibrations, introduction of such energy allows entrapped gases to escape and improve the flow of solder in the joint. The energy source is removed before the soldering iron tip to permit normal undisturbed cooling of the solder.

Currently, the prevention of the formation of voids is achieved by agitating the solder tip of a soldering iron by ultrasonic vibrations. The new method is more economical to use; development of a holding fixture as part of a transducer can be achieved more readily than the sophisticated agitated solder tip. Most important, the holding fixture can be designed to deliver as much energy as required for a particular application; the soldering iron type is limited by the geometry of the device. One final advantage: the holding type fixture offers an almost unlimited number of choices from which to select the optimum frequency for the particular component. This degree of versatility is not available in other devices.

This fixture should find application in the manufacture of multiconnector cables, and in most soldering operations.

Source: F. Leto of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-18473)

No further documentation is available.

METHOD OF SOLDERING COPPER TUBING TO COPPER PLATED MAGNESIUM CYLINDERS

This technique was devised for holding and soldering a helix of copper tubing (or shapes other than tubing) to a copper plated magnesium cylinder or canister. The assembly is used as a gas-to-liquid heat exchanger, i.e. a gas is contained or flows within the magnesium cylinder and a liquid coolant flows through the copper tubing. Conventional methods proved tedious and uneconomical for achieving uniform heating of the canister which prevents distortion or spalling of the copper plating.

This method achieves inexpensive, easily controlled heating of the entire canister to within 50°F of the soldering temperature, with the final additional heat supplied locally as soldering is performed along the length of the tubing.

The copper plated canister surface and the preformed copper helix are first cleaned thoroughly by conventional means. The terminal blocks of the copper tube helix are then solder tinned. The copper tube helix is positioned on the canister and clamped there by means of large hose clamps placed over portions of the top and bottom turns. Notched spacing bars (about 6) are positioned over the helix to maintain proper turn spacing. The spacer bars, and therefore the main portion of the helix, are clamped to the canister by another large hose clamp. The canister is filled with peanut oil to a few inches above the position of the top turn of the copper helix. Solder preforms, about 3 inches long and curved to fit the circumference of the canister, are laid down on turns of the helix with approximately a 1/2-inch gap between ends. A thermostatically controlled electric immersion heater is immersed in the peanut oil and the temperature of the oil brought to a level of 50°F less than the melting point of the solder to be used. A small gas torch supplies local heat progressively along the helix, starting at one end until the entire helix is soldered to the canister.

Source: B. R. Nichols of
Allis-Chalmers Manufacturing Co.
under contract to
Manned Spacecraft Center
(MSC-13170)

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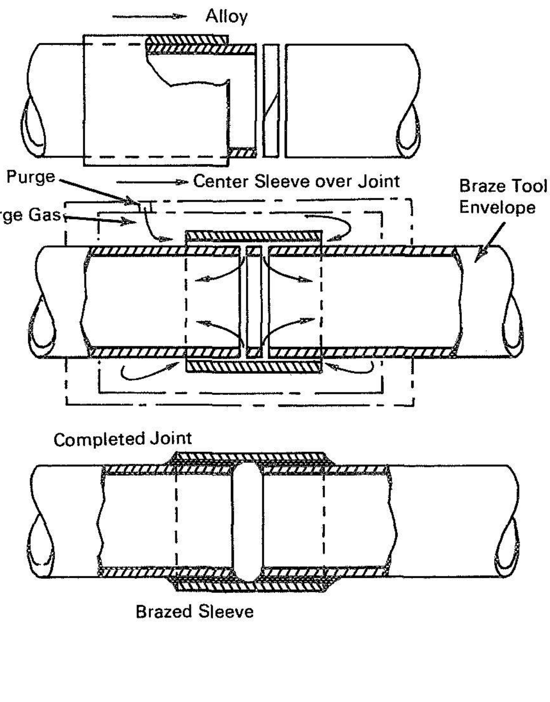
BRAZING CORROSION-RESISTANT STEEL TUBING JOINTS

The brazing of corrosion resistant steel tubing joints in an inert gas atmosphere offers wide commercial application, and could be used in high reliability/corrosion resistant joints, gaseous pressurization systems, hydraulic systems, and corrosive liquid operations. The method has reduced costs of sleeve machining and braze alloy preforming; improved capillary flow has resulted in fewer rejects; and particulate contamination has been reduced during sleeve assembly. Also, the inert gas purge has proved more effective by eliminating trapped air pockets in alloy grooves; the alloy preplacement gap provides sleeve removal (cutting) area with no damage to the tube ends.

This method is accomplished, as shown in the illustrations, by first preplacing a braze alloy ring between the butt ends of the tubing and then centering a sleeve of the same material over the joint. The entire braze joint area is purged with an inert



gas and heated with induction coils until the alloy flows (by capillarity) to fill the gap between the sleeve and the tube, forming a metallurgical bond. The resultant joint is stronger than the parent metal and leakproof to high pressure helium as well as to corrosive liquids.

Source: R. E. Leavitt and L. W. Myers of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11986)

No further documentation is available.

TECHNIQUE FOR X-RAYING WELDED AND BRAZED TUBING JOINTS

A technique has been developed for X-raying welded and brazed tubing joints which produces a clear continuous picture of each joint on a single film with one exposure. Conventional techniques require multiple films and exposures to obtain a clear and complete picture of a single joint. The apparatus can be made in sizes and of materials appropriate to a variety of other inspection situations and is adaptable to inspection of other configurations of welded, forged, or cast workpieces. It could also be applicable to medical X-rays.

This technique employs a stationary X-ray source located in the plane of the joint to be inspected, a means of rotating the tube, and a unique internal film holder and positioning fixture.

The film holder, shown in Figure 1, consists essentially of two concentric aluminum tubes. The outer tube has a removable rubber plug at one end, and a drilled and tapped aluminum plug at the other end. The inner tube is filled with lead and drilled and tapped for attachment of a pulling tool. The inner surface of the outer tube and the outer surface of the inner tube are polished. The X-ray film in a protective plastic envelope is wrapped around the inner tube in a darkroom. This tube and film are then inserted into the outer tube which is then plugged to protect the film from light.

The positioning fixture, Figure 2, consists of a threaded rod to which the film holder can be attached, plus an expandable tube. The expandable tube consists of a slotted tube and two tapered plugs. One tapered plug is locked in position by two nuts and the other is welded to a pipe handle. By holding the threaded rod stationary and rotating the pipe handle, the tapered plugs are forced together and the slotted tube expanded.

In operation, the loaded film holder is attached to the positioning fixture and inserted into the tubing until it is located at the joint to be inspected. The expandable tube on the positioning fixture is expanded to lock the film holder in place longitudinally and radially, and to ensure that it will rotate with the tube to avoid slipping or wobbling. The X-ray source is activated and the tubing rotated one

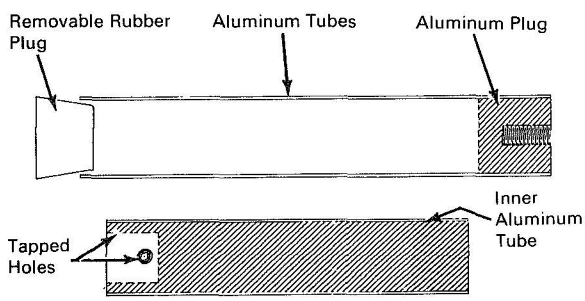


Figure 1. Film Holder

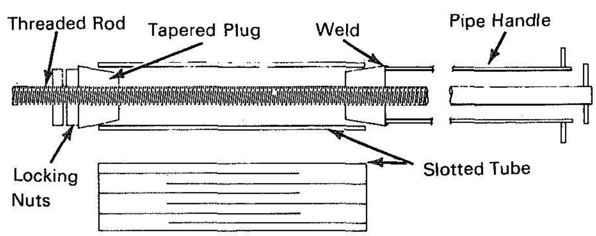


Figure 2. Positioning Fixture

complete revolution. When the exposure is completed, the apparatus is withdrawn and the film removed and processed.

Source: J. W. Diamond, V. H. Hunt
and C. Mikesell of
Aerojet General Corp.
under contract to
Lewis Research Center
(LEW-10382)

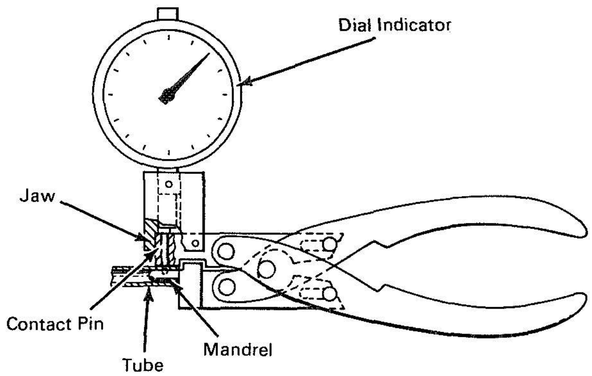
No further documentation is available.

TOOL FOR DIP-BRAZED JOINTS

When tubes of different diameters are brazed together in a series-flow relationship, the tube of smaller diameter is not always centered with respect to the larger tube that sleeves it, and the resulting mismatch at the brazed joint adversely affects the brazed joint. If nipples could be formed in an even pattern on the end portion of the larger tube in the same sort of pattern, they would serve as spacers to accurately center the smaller tube prior to brazing.

A tube dimpling tool has been made in the form of ordinary pliers that may be hand-held while accomplishing precise tube dimpling and nipple forming operations. Conventional lever arms, connected by a pivot pin, operate to open and close jaw members. The jaw members are mounted to move only in parallel motion relative to one another. One jaw member carries a mandrel over which the tube to be worked is sleeved. A projection is provided on the surface of the mandrel and the second jaw has a clamping surface and through-bore in registry with the mandrel projection.

When a tube is sleeved over the mandrel and its projection, compressing the lever arms closes the jaws forcing the tube against the clamping surface. A contact pin that extends through the bore in the second jaw contacts the surface of the tube opposite the mandrel projection and forms a dimple on the inner surface of the tube and a corresponding nipple on the outer surface. The contact pin is



directly connected to a dial indicator that measures the depth of penetration and, therefore, the height of the nipple formed on the outside of the tube end.

Source: C. S. Beuyukian and
R. M. Heisman of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-90533)

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WELDING, BRAZING, AND SOLDERING HANDBOOK

A handbook has been compiled to provide for design engineers a single comprehensive source of information on the selection and application of welding, brazing, and soldering techniques to the joining of various metals. The handbook includes 106 illustrations and tables of data, as well as a short bibliography (52 citations). This illustrated reference work provides summary descriptions of the joining processes, criteria for the selection of a particular process for specific alloys, types of joints, structural configurations, and material thicknesses, and details the advantages and disadvantages of the different joining methods for various structural designs and applications. The following joining methods are covered: fusion welding (arc welding, electron beam welding, electroslag welding, laser beam welding); resistance welding: solid state welding; brazing (including filler metal compositions and properties); and soldering (including solder compositions and properties).

Source: M. L. Koehler, A. B. Kilgore,
J. W. Metzler and S. R. Sturges
Marshall Space Flight Center
(MFS-20504)

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NASA-Langley, 1971

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