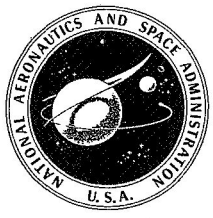
NASA SP-5934(01)

TECHNOLOGY UTILIZATION

ASSEMBLY TECHNOLOGY

A COMPILATION



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-5934 (01)

ASSEMBLY TECHNOLOGY

A COMPILATION

TECHNOLOGY UTILIZATION OFFICE 1970
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

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Foreword

The National Aeronautics and Space Administration and Atomic Energy Commission have established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of their research and development, NASA and AEC earn for the public an increased return on the investment in aerospace and nuclear research and development programs.

This publication is intended to provide information in the area of assembly technology. Subjects discussed in this compilation represent innovations which were developed to accomplish assigned assembly tasks more efficiently and economically. Most of the items can be modified to fit a variety of requirements.

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 and AEC contemplate no patent action on the technology described.

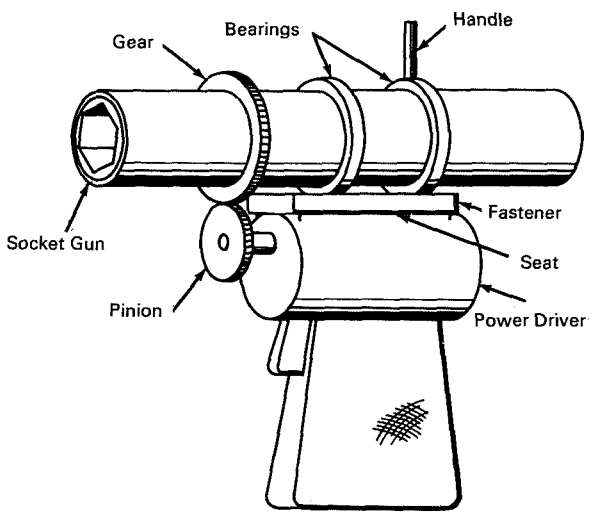
We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

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

Contents

Section 1. Tools and Materials Used in Assembly

MODIFIED POWER TOOL RAPIDLY DRIVES SERIES TORQUE BOLTS



A series of longitudinally attached torque bolts can be driven into place with a modified power tool more rapidly than with conventional hand or power tools. The modification consists of a feeder attachment that fits on a standard power driver. The attachment allows the loading of a series of bolts and then positions the individual bolts in the driving head for assembly as required.

The feeder attachment consists of a socket gun, bearings, a fastener, and a gear, as indicated in the

Series Torque Bolts

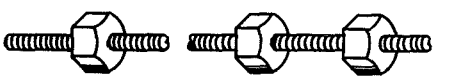


diagram. A seat attached to the power driver holds the feeder firmly in place. In operation, the pinion on the power driver meshes with the gear on the periphery of the socket gun. When the power driver is triggered, the entire socket gun rotates in the bearings and exerts a torque on the heads of the series-connected bolts that have been loaded into the gun. The bolt being driven into the workpiece separates from the series when the applied torque exceeds the sheer strength of the joint at the driven bolt head. The socket gun is equipped with a spring to force the bolts to the nozzle of the gun and a stop to retain the bolts until they are ready to be released.

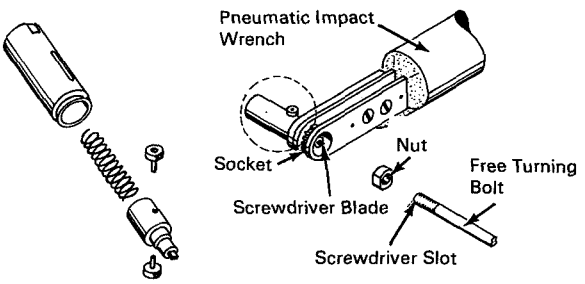
This modified power tool has obvious application in industrial assembly of components requiring torque bolts.

Source: Armen A. Saginian of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-90221)

Circle 1 on Reader's Service Card.

SINGLE WRENCH SEPARATES NUTS FROM FREE-FLOATING BOLTS

Nuts in inaccessible locations may be removed readily through the modification of a standard pneumatic impact wrench incorporating a fixed screwdriver blade. As shown in the illustration, a slot is cut into the threaded end of the bolt shaft. The modified wrench allows the screwdriver blade to protrude through the wrench drive socket and engage the slot in the bolt end as the socket en-

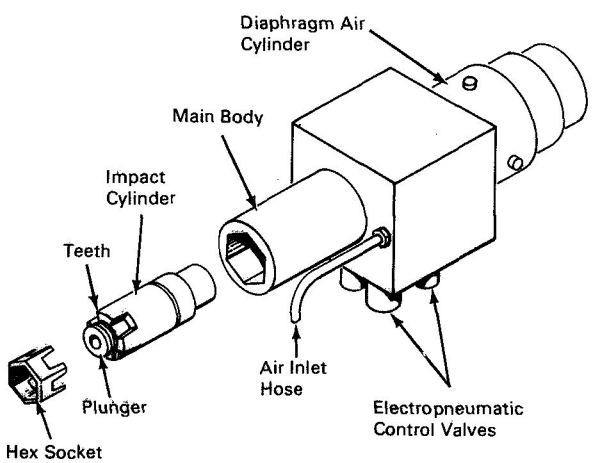


gages the nut. The screwdriver blade is held in the bolt slot by the action of a spring-loading device that permits the blade to slide within a hollow shaft as the nut is withdrawn. The screwdriver blade is pinned from each side by screws that slide in slots cut into the hollow shaft.

Source: C. Thompson of
Westinghouse Astronuclear Laboratory
under contract to
Space Nuclear Propulsion Office
(NUC-10013)

Circle 2 on Reader's Service Card.

PNEUMATIC WRENCH RETAINS OR DISCHARGES NUTS OR BOLTS AS DESIRED



A simple modification expedites the removal of a nut or bolt with a pneumatic wrench and its discharge into a common container. This capability is especially important where loosened nuts or bolts may be dropped into hard-to-reach locations. The modification of a standard pneumatic wrench consists of special hex bolt head socket assemblies and a diaphragm air cylinder. The diaphragm air cylinder allows the special socket assembly to travel axially with respect to the pneumatic wrench body as the nut or bolt is backed off. The special socket assembly can grip the bolt head or discharge the bolt as desired. The gripping feature of the special socket assembly is pneumatically operated.

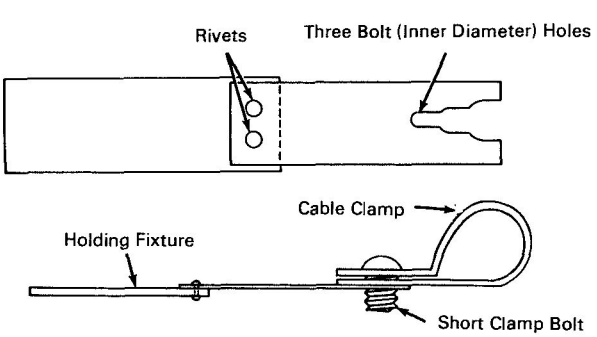
A hex is inserted into the hex socket to operate the wrench. As shown in the diagram, air pressure is applied through the holes in the socket assembly behind the impact cylinder, forcing the impact cylinder forward. Grooves of the cylinder fit the hex bolt head, as the cylinder teeth begin to mesh with the hex socket. As the cylinder moves forward, the teeth engage further, forcing a slight rotation of the hex head which effectively retains it in the hex socket. When the air pressure is released, the depressed plunger effectively forces the hex head out of the hex socket.

Source: J. R. Bouille of
Westinghouse Astronuclear Laboratory
under contract to
Space Nuclear Propulsion Office
(NUC-00085)

Circle 3 on Reader's Service Card.

CABLE CLAMP BOLT FIXTURE AIDS ASSEMBLY IN CLOSE QUARTERS

The difficulty of using short clamp bolts for cable runs in limited space and the necessity of overcoming the tension imposed on the clamp closure area by the contained cable are eliminated by a simple device. As shown in the illustration, a cable clamp bolt-holding fixture has been devised to engage the thread of the bolt through the clamp and maintain tension against the clamp's tendency to open while the operator installs the nut. In the operation, the cable clamp is positioned



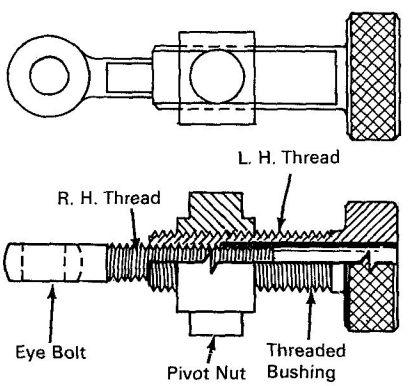
about the cable and the clamp bolt is inserted in the clamp holes. The open ended portion of the holding fixture is forced over the protruding clamp bolt threads and against the underside of the clamp. The fixture engages the bolt threads and holds firmly against the clamp opening tension while the nut is installed. The holding fixture is then withdrawn and the nut tightened to complete the clamp closure.

This device reduces the possibility of hand injuries and expedites electrical cable installation.

Source: Gary H. Sunderland of
The Boeing Company
under contract to
Kennedy Space Center
(KSC-67-80)

Circle 4 on Reader's Service Card.

TELESCOPING ADJUSTMENT SCREW ASSEMBLY



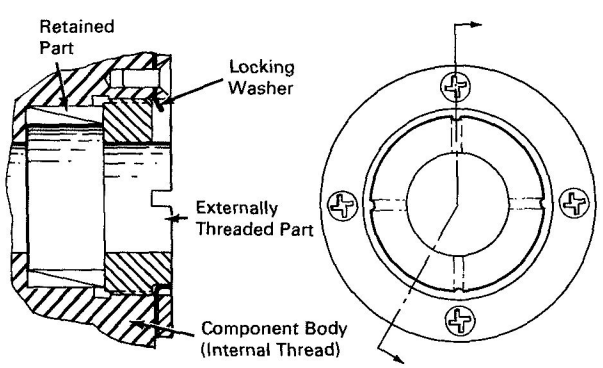
A telescoping adjustment screw assembly has been developed by the combination of a standard eye bolt and a special pivot nut and screw assembly. As shown in the diagram, the special threaded bushing with (left hand) internal and (right hand) external features is combined with the special pivot nut. The eye bolt and pivot nut provide self-alignment during assembly.

This innovation has application in the production of various types of industrial equipment and machinery.

Source: Harold J. Searle of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16507)

No further documentation is available.

POSITIVE THREAD LOCK



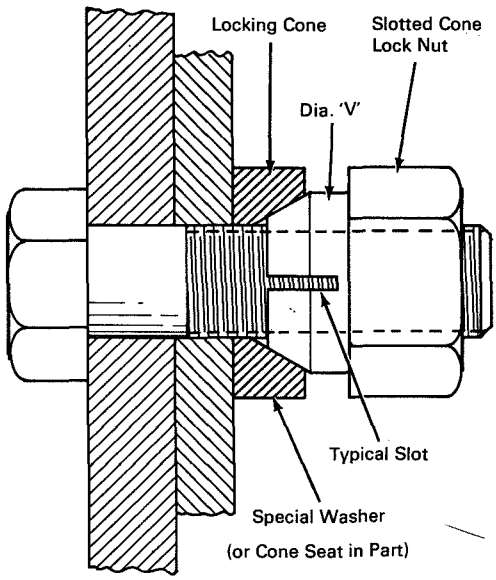
A positive thread lock is achieved by swaging a washer with a raised lip into slots on the threaded member. After the threaded member is installed, the washer, with a raised lip on the inside diameter, is attached to the component by flat-headed screws retained by self-locking inserts. The portions of the lip adjacent to the slots in the threaded member are swaged into position to provide a positive lock against loss of torque on this threaded part.

The device is applicable to large diameter threaded parts (1 1/4 inches and up) that require positive and serviceable locking without the use of lockwire or interference threads and where contamination is not permissible.

Source: T. W. Rose of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14255)

No further documentation is available.

SLOTTED CONE LOCK NUT

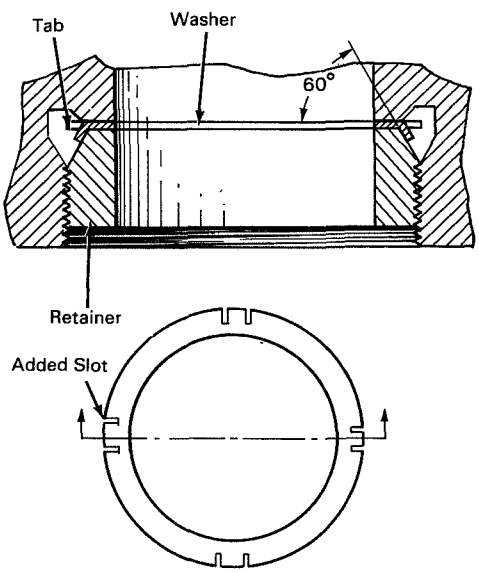


Locking spring action may now be provided by a newly designed slotted-grip lock nut without deformation of the undersized thread section when fitting the male threads during assembly. Previously, the heavy locking action wore the male thread, limited reuse, and required high assembly torque. The new nut combines the slotted-grip lock with the conical-jam type. As depicted, a female mating conical seat is required in the part or in a special washer. With this combination, the nut design can provide a reduced on/off safety torque by varying the diameter, conic angle, or area of mating surface. During the final torquing, the action of the slotted cone portion furnishes a greatly increased jam lock action that insures against loosening. Additionally, the new nut may be designed for unlimited reuse, a feature which would appeal to industrial organizations seeking economy and efficiency in their operations.

Source: B. T. Howland and A. L. Maurin of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15146)

No further documentation is available.

WASHER ALIGNMENT METHOD



The automatic alignment of a washer in relationship to the threaded mating part has been simplified by a multiple-tab washer. The tabs are bent to form an angle which centers the washer by matching the chamfer of the externally threaded retainer.

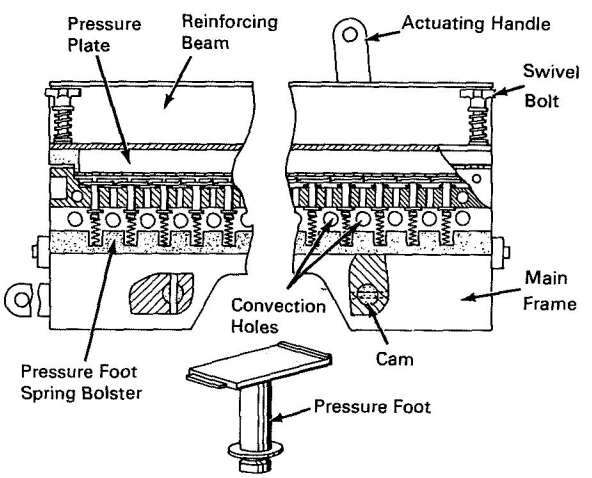
Prior to assembly, the flat washer is slotted on its outside diameter in such a way that the material between two slots can form a tab. The number of the equally spaced tabs depends on the washer material, its size, and the load applied to the retainer. Before installation, the inside diameter of both the washer and retainer is centered. The tabs are then formed by bending them over a 60-degree chamfer provided on the mating end of the threaded retainer plug. When assembled, these tabs will effectively resist the side loads caused by friction between the washer and retainer. The washer remains correctly positioned. The method is applicable whenever washer position is critical, as in the use of orifice plates or spacers.

Source: D. C. Hunter and G. Seckar of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14078)

No further documentation is available.

Section 2. Techniques and Procedures for Improved Assembly

ASSEMBLY JIG ASSURES RELIABLE MODULAR FABRICATION



An assembly jig has been designed which holds components precisely in place as the assembly is soldered and then bonded in an oven. Designed to the configuration of the planned module, the assembly jig has a main frame comprising side and end plates that support the rest of the components. A pressure foot spring bolster is operated upward or downward by the action of handle-actuated cams versus spring tension. The bolster has countersunk recesses containing springs to engage the pressure feet on which the components are placed sensitive side down.

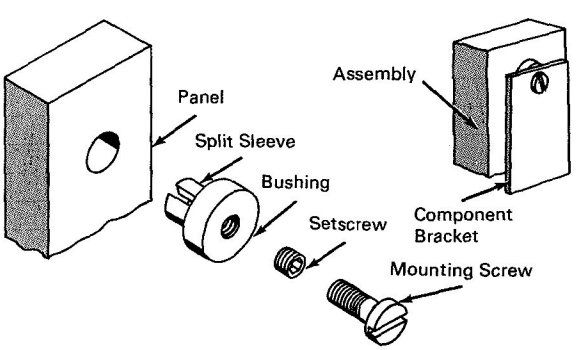
After all the elements are in place, solder strips are placed in the grooves between the cells and a printed circuit board is laid over these components. A suitable bonding agent is placed on the circuit board, the module substrate is placed on the bonding agent, and pressure is applied. Following these procedures, the jig with its assembled module components is heated to the proper temperature for the flow of the solder and bonding agent. The jig and its contents are then removed and allowed to cool. As illustrated, the convection holes along both side plates assist in the heating and cooling processes of solar cell fabrication for which this method was originally devised.

Source: Herbert W. O'Farrell of
TRW Space Technology Laboratories
under contract to
Goddard Space Flight Center
(GSC-00455)

No further documentation is available.

EXPANDABLE INSERT SERVES AS SCREW ANCHOR

Components may be mounted on panels having only one accessible side by using an expandable self-locking adapter. The adapter, made of metallic or nonmetallic material, has a bushing and a split sleeve which fit inside a mounting hole in the panel. As shown in the illustration, the sleeve is internally threaded to receive a short Allen head setscrew, and the bushing is threaded to receive a mounting screw.



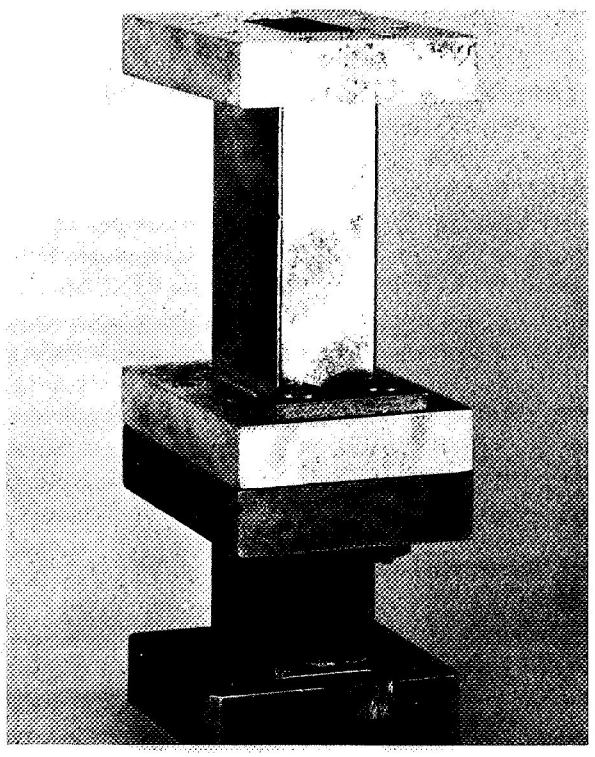
The adapter is securely fastened to the panel by inserting the sleeve into a mounting hole and tightening the setscrew with an Allen key to expand the split end of the sleeve. A mounting screw is then inserted in the threaded bushing and tightened with a screwdriver.

This innovation should have application for electronic and mechanical assembly work and for attaching various household appliances and fixtures to solid panels.

Source: William C. Jones of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-00301)

Circle 5 on Reader's Service Card.

DOWEL PINS AID IN ASSEMBLY OF WAVEGUIDE SECTIONS



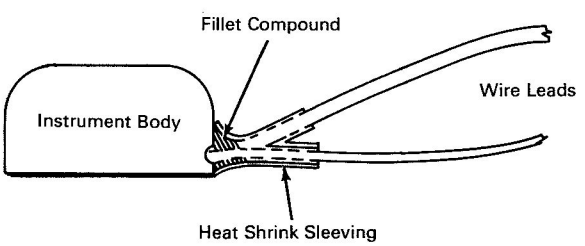
The connection or disconnection of waveguide sections is made easier by the quick removal or retention of the normally hard-to-handle dowel pins in a novel assembly consisting of two screws and a dowel pin attached to a metal plate. As shown, two waveguide sections are aligned by means of the dowel pin assembly. This device has proven useful in the assembly of waveguide sections with flanges in confined areas where special techniques to assemble and dismantle are required. It is particularly useful with S-band, where the dimensions make the sections difficult to handle, and also with vertical waveguides, where the configuration prevents the pin from falling into the waveguide.

Source: D. L. Mullen and C. T. Stelzried of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-11006)

Circle 6 on Reader's Service Card.

REINFORCEMENT OF ELECTRICAL WIRING LEADS FOR SMALL MEASUREMENT INSTRUMENTS

A fillet compound and heat shrink sleeving are used to prevent failure due to flexure of small wire leads entering instruments or devices by increasing the strength of these leads. Conventional electrical wiring leads are normally susceptible to damage from bending at the juncture of the wires and the measurement instruments. As shown in the diagram, strain relief for the flexible electric



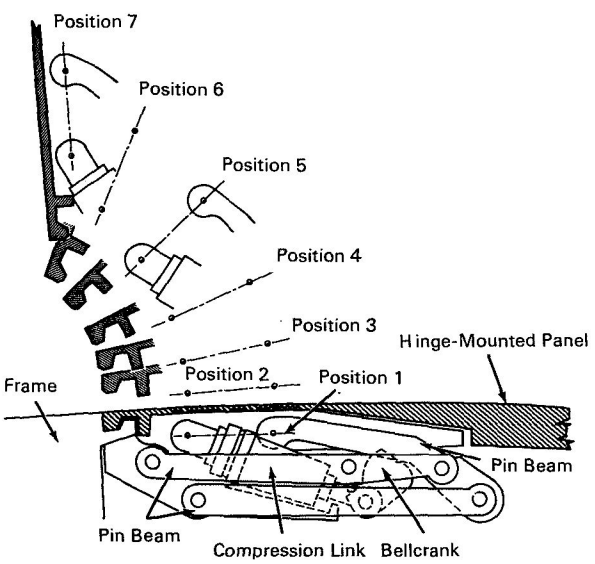
wiring is provided by the application of a commercial type fillet of compound at the juncture of the wire and component body. A heat shrink sleeving is then applied over the fillet.

This innovation may be integrated in the manufacture or assembly of any electrical/electronic unit which has flexible wires extending from a solid case to prevent rupture of a hermetic seal or damage to wire insulation or conductor.

Source: G. T. Sloan of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11608)

No further documentation is available.

CONCEALED HINGE PERMITS DOORS TO BE FLUSH MOUNTED



Flush mounting of doors of varying thickness is provided by a new hinge assembly. As illustrated , the operational motion of the assembly is initially parallel, changing to angular after clearing the panel perimeter.

The hinge assembly is a compound mechanical linkage consisting of three pin beams, two pin links, a spring loaded compression link, a bellcrank, and two mounting brackets. As the hinge mounted panel is moved from the closed position, the outer arm and inner link rotate counterclockwise about the hinge pins. The bellcrank rides on the outer beam but is forced to rotate clockwise by the link attached to the inner hinge pin. This rotation thrusts the spring loaded compression outward, maintaining the angular rotation of the panel to near zero until it clears the surrounding structure. Thus, the hinge assembly produces an axis of instant rotation that changes as the panel is moved. This device has application in structures requiring concealed hinges for purposes of security, utility, or appearance.

Source: Earl V. Holman of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-00623)

Circle 7 on Reader's Service Card.

EXTENDIBLE REFRACTORY NOZZLE STRUCTURE AND FABRICATION: A CONCEPT

Fabrication of an extendible refractory nozzle structure without subsequent welding or riveting is now feasible. This method permits attachment of segmented panels and support of the assembly through a distribution of loads and minimum internal loading. The panels are joined by butting together the "J-formed" edges of adjacent panels, and holding them in position by sliding an interlocking "C-section" strip into engagement with the panels. An improved seal may be achieved by injecting a soluble refractory with suspended asbestos into the joint. With the combination of a lap joint and an interlocking strip, the refractory panels may be joined by welding the strips to a parent nozzle skirt of corrosion-resistant steel. Additional structural support may be added by annular hoops with hoop tension being absorbed by the panels. When the hoops are spring at-

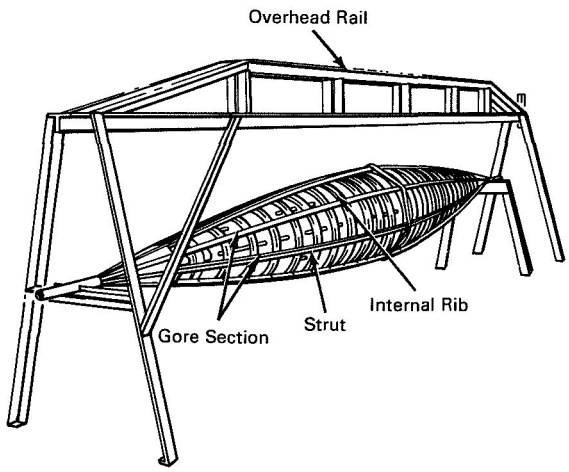
tached, they resist the collapsing effect of loads on the panels.

This concept has application for industrial fabrication of brittle materials by avoiding the local load concentrations that may be encountered during thermal expansion and contraction at subzero temperatures.

Source: J. D. McGroarty of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-12945)

No further documentation is available.

ROTATING MANDREL SPEEDS ASSEMBLY OF PLASTIC INFLATABLES



The accurate cutting, forming, and sealing of plastic gores to assemble an inflatable from such as a sphere is facilitated by a rotating mandrel. Previous methods required excessive material handling and allowed tolerance buildup. The accumulated tolerances created undesirable irregularities at the seams and made assembly difficult.

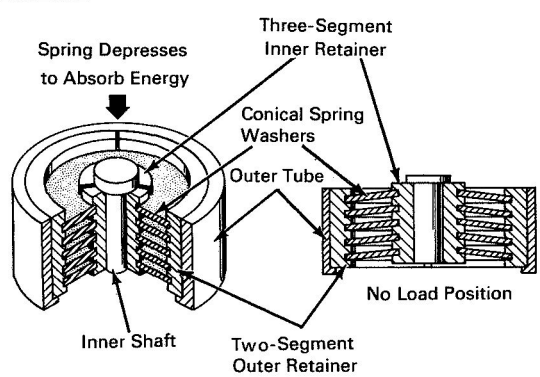
The illustrated rotating mandrel allows the gores to be laid out, cut, and then sealed without being handled until the final seam is reached. Tolerances are tightly controlled since they are directly related to mandrel configuration. In the operation, each gore is defined on the mandrel by two slots that provide a cutting and a sealing guide. The plastic material is held in place across a gore section of the mandrel with pressure-sensitive tape and cut on both sides along the slots in the mandrel. The next adjacent section is similarly processed and the sections joined with a heat sealer. Joined sections are removed from the mandrel and the last seam is heat sealed to complete the surface of the form.

Source: S. J. Stenlund, A. J. Wendt, and
J. A. MacFadden of
G. T. Schjeldahl Co.
under contract to
Langley Research Center
(LAR-00155)

Circle 8 on Reader's Service Card.

NEW PACKAGE FOR BELLEVILLE SPRING PERMITS RATE CHANGE, EASY DISASSEMBLY

The undesirable high-hysteresis effects, caused by stacking Belleville spring washers in the conventional manner, have been significantly reduced by separating the springs in a tubular assembly or spring package. The package consists of grooved sleeves for individually supporting each spring at its inner and outer periphery. The sleeves are segmented to permit assembly and are retained in position by an inner shaft and an outer tube. Each spring flexes the same amount and carries the same proportion of the load. Spring washers



can easily be removed or added to effect a change in the spring load without altering the envelope dimensions of the spring package.

The spring package may be disassembled by first removing the inner shaft and taking out the three-segment inner retainer; then by slipping off the outer tube, the two-segment outer retainer may be removed, thereby releasing the stack of spring washers.

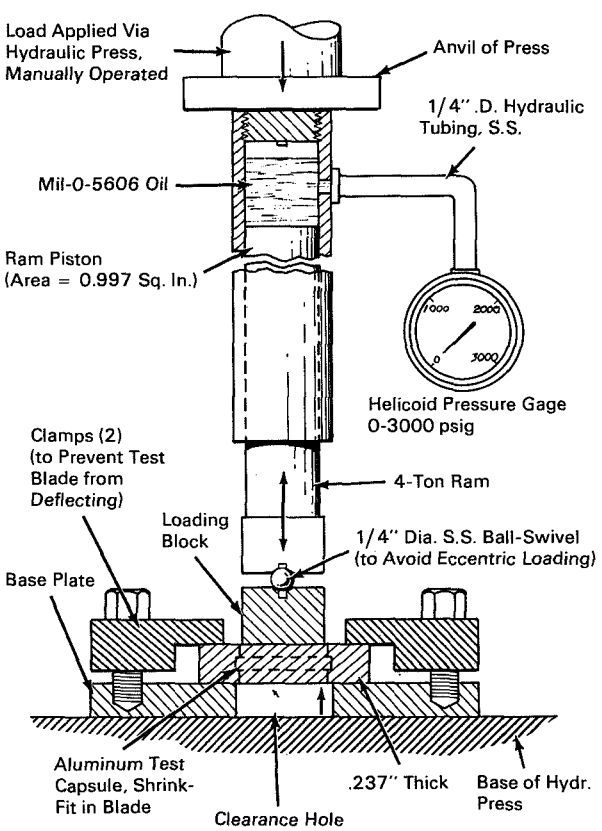
Although originally designed as a force-balance spring for a high pressure regulator in space technology, the spring package is applicable to any service where the Belleville spring load-versus-deflection characteristics are advantageous.

The innovation could also be used as the popoff-valve spring of a boiler because of the inherent spring-package features such as light weight, high load, low or negative spring rate, and low hysteresis.

Source: William F. MacGlashan of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-00392)

Circle 9 on Reader's Service Card.

METHOD OF ATTACHING PERMANENT MAGNETS TO NONFERROUS TURBINE BLADES



The difficulty of retaining magnetic slugs imbedded directly in aluminum turbine blades has been eliminated by encapsulating the slugs in aluminum housings which are shrunk-fit to recesses in the blades. These magnetic sensors are used for measurement of fluid flow in terms of turbine rpm. When installed in the original manner and operated in a liquid nitrogen environment, the slugs are sometimes forced out of the blades by nitrogen which has leaked into the cavities behind the slugs and then gasified.

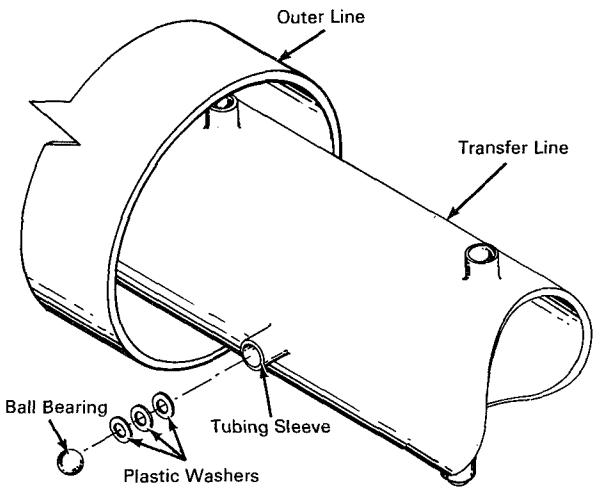
During the assembly process using the new method, the welded, machined, and irradiated capsule assembly is submerged in a bath of liquid nitrogen for maximum shrinkage. At the same time the blade is heated in an electric oven until its temperature reaches a range of 350°/375°F for expansion of the recess in the blade. After assembly, the blade is allowed to return to room temperature to complete the full shrink fit and to permit final machining to the desired size and finish.

This assembly method has wide application in industrial research requiring measurements which are obtained by flowmeters and similar instruments.

Source: The Whittaker Corp.
under contract to
Marshall Space Flight Center
(MFS-91562)

Circle 10 on Reader's Service Card.

VACUUM-JACKETED TRANSFER LINE INSTALLATION TECHNIQUE



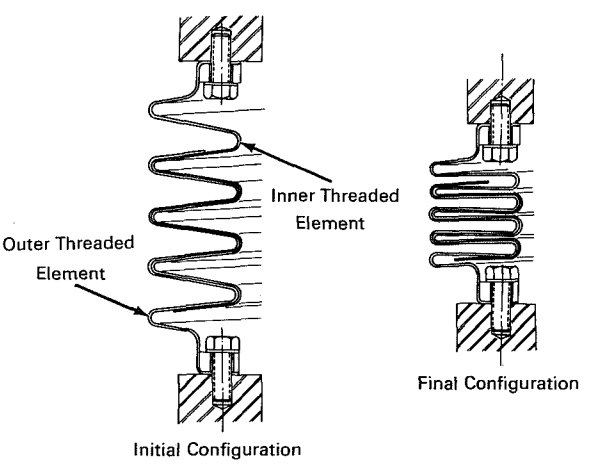
Rolling spacers affixed at intervals to the exterior of the transfer line will permit easier installations of that line into its vacuum jacket (outer line). Steel ball spacers in appropriate sleeves act as stand-offs to position the transfer line concentrically. As illustrated, the stainless steel sleeves are welded in an appropriate geometric pattern on the exterior of the transfer line. After the plastic washers are inserted, the stainless steel balls are sealed to make positive contact with the interior surface of the vacuum jacket line as the transfer line enters. Tolerances between ball, sleeve, and jacket afford relatively free linear movement of the transfer line within the jacket without excess radial play.

Source: William M. Bowers of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14496)

No further documentation is available.

SEAL ALLOWS BLIND ASSEMBLY AND THERMAL EXPANSION OF COMPONENTS

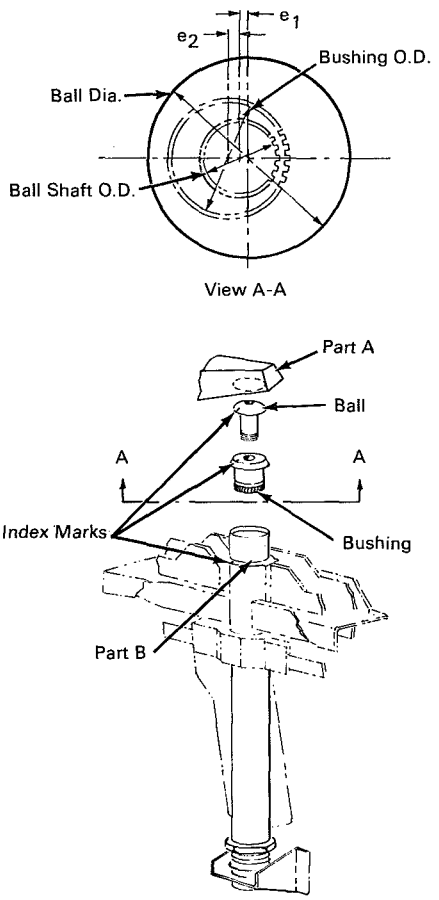
A seal capable of blind assembly and able to withstand large temperature changes has been developed from two concentric cylindrical elements, one threaded internally and the other externally. A cylindrical threaded element is attached to each side of the system interface as illustrated. During assembly the elements are threaded together as far as possible. The two face surfaces of the system joint are then brought together as close as possible to complete the seal. During fastening, the mating threaded elements distort and form many lines of contact perpendicular to the leakage path. Because threaded elements normally seize during assembly, they may have to be replaced if disassembly is required. Selection of materials with appropriate coefficients of expansion assures seal integrity over a wide range of temperatures. Since this design accommodates a considerable range of thermal activity in the structure interface, the innovation should interest industrial manufacturers.



Source: T. A. Mantia and D. C. Thompson of
Westinghouse Electric Corp.
under contract to
Space Nuclear Propulsion Office
(NUC-00005)

Circle 11 on Reader's Service Card.

POLAR ALIGNMENT METHOD



Adjustment of mating points between large assemblies may be made easier by a new procedure which allows a mismatch between them. This is accomplished by rotating two eccentric shafts on one member to place the true center of an inner shaft anywhere within the adjustment diameter. The method is analogous to the use of two dovetails normal to each other for linear adjustment but is much simpler and less costly.

The polar alignment method illustrated uses a ball and socket, although the same method could be used with a flange attachment. The ball has a true center which mates with part A and attaches to the bushing through an eccentric serrated shaft. The bushing fits to part B through another eccentric serrated shaft. By rotating the ball relative to the bushing, a displacement of the ball relative to the centerline of part B is obtained. After the final displacement adjustments are made, the parts are aligned and prevented from further rotation by the serrated shafts (parts are lifted to rotate and lock when they are seated).

Source: Earl M. Altman of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15548)

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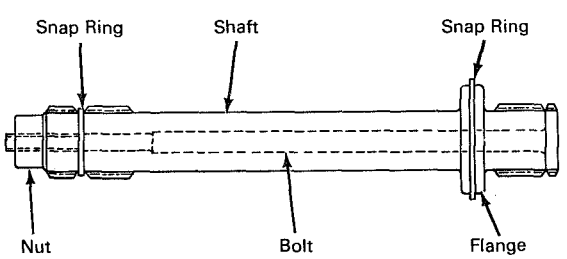
IMPROVED POSITIONING OF A QUILL SHAFT

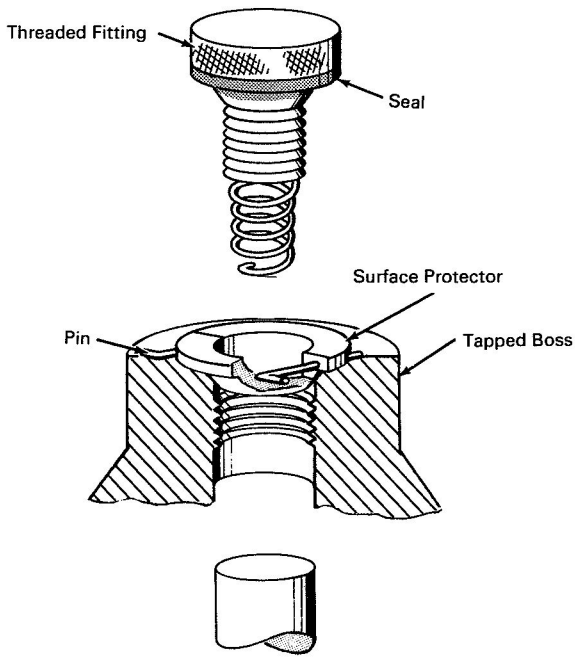
A newly designed quill shaft provides effective control of axial forces generated by rotation, and also controls the slip friction resulting from any misalignment of the quill shaft. Snap rings are used as load-carrying members to restrain the shaft in axial movement, while the bolt and nut arrangement facilitates assembly as shown in the illustration. The new arrangement consists of attaching one end of the splined misalignment shaft to one rotating member by means of a draw bolt and retaining ring which permits small angular motion. The other end is attached by a retractable retaining ring to permit assembly. Positioning of both members (such as a turbine and a pinion gear) is dependent on one thrust bearing, with axial freedom provided on the other for more than the axial excursion from the initial position.



Source: Ernest J. Bodensieck of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-91683)

No further documentation is available.

SEAL SURFACES PROTECTED DURING ASSEMBLY



Damage to the highly polished seal surfaces at the entrance of tapped bosses may now be prevented by the installation of close fitting, spring loaded and threaded fittings.

As shown, the split seal surface protector fits over the chamfered portion of the boss while the threaded male fitting is inserted against tension into the tapped boss. When several threads have become engaged, the surface protector is withdrawn by pulling its attaching pins and removing the two separated halves. The male fitting is then torqued as required to effect the seal.

The surface protector may be modified to meet dimensional and materials requirements of specific industrial applications.

Source: G. L. Richardson of
Aerojet-General Corp.
under contract to
Space Nuclear Propulsion Office
(NUC-00067)

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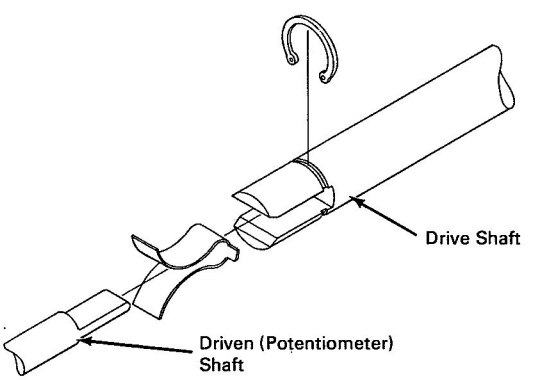
SELF-ALIGNING, ZERO BACKLASH SHAFT COUPLING

Elimination of coupling backlash, and quick replacement of potentiometers are provided by a newly designed spring loaded shaft coupling. As shown in the illustration, a preformed spring provides sufficient clamping force (preload) on the flats of the inserted shaft to transmit the designed operating torque to relieve or cushion excessive transient loads. The spring is retained in the machined slot by a snap ring.

Adequate deflection space is provided in the machined slot to allow continued rotation of the drive shaft without damaging the coupling, should the driven shaft freeze. Precise shaft alignment is not required, since the preformed spring can be displaced a short distance without affecting the torque carrying capability of the coupling. The coupling may also be used as a universal joint, to some degree, because the two shafts do not have to be perfectly colinear to form the couple.

The innovation has application in any system



where the two ends of a shaft are connected together.

Source: C. S. Doyle of
The Boeing Company
under contract to
Kennedy Space Center
(KSC-10234)

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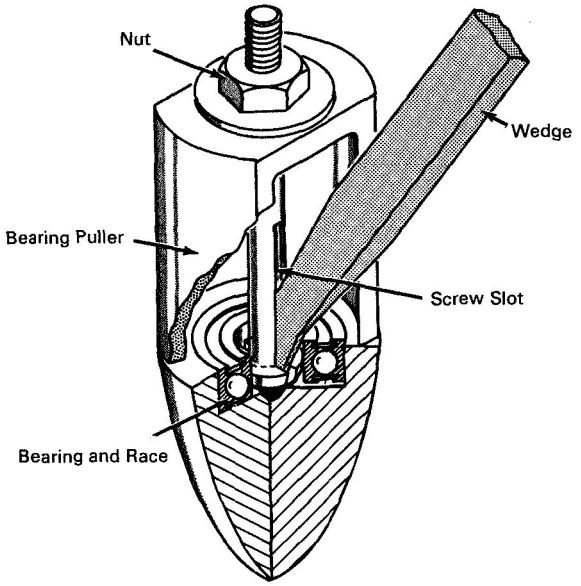
BEARING PULLER AIDS REMOVAL AND REPLACEMENT OF BEARING ASSEMBLIES



The removal of bearing assemblies from support members is aided by a bearing puller matching the bearing configuration. Usually these bearings are semiconcealed, difficult to replace, and lengthy delay results if they are returned to the manufacturer.

In using the bearing puller, the head of the slotted screw is inserted in the inner race of the bearing to be removed. As shown in the diagram, the wedge is then inserted in the screw slot expanding the head to secure a firm grip on the bearing race. A sleeve is sized to clear the outer race of the bearing assembly and positioned over the bearing assembly. In the final step, the bearing is drawn into the sleeve by tightening the nut against the top of the sleeve.

Source: R. B. Schaus of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-01538)

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