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THE DESIGN AND DEVELOPMENT OF A WHEEL MOUNTED AIRCRAFT TIRE INF--ETC(U)
MAR 66 J D FULMER, M MOLLICK AF33(657)-12491

UNCLASSIFIED ASD-TDR-65-1 NL

1 OF 2

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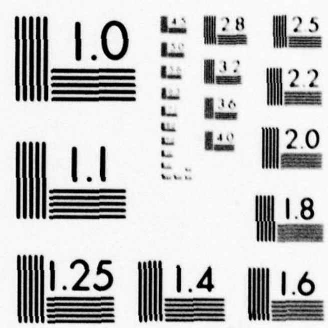

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NATIONAL BUREAU OF STANDARDS-1963-A

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THE DESIGN AND DEVELOPMENT OF A WHEEL MOUNTED AIRCRAFT TIRE INFLATION INDICATOR.

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TECHNICAL DOCUMENTARY REPORT NO. ASD-TDR-65-1

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Aeronautical Systems Division
Wright-Patterson Air Force Base, Ohio

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(Prepared under Contract No. AF33(657)-12491
by U. S. Gauge, A Div. of AMETEK, Inc., Sellersville, Pa.)

by
10 J. D. Fulmer ~~and~~ M. Mollick

NOTICES

FOREWORD

This development contract was issued by AFSC Aeronautical Systems Division, Wright-Patterson Air Froce Base, Ohio, and administered by the Contract Management District, ECMR, 1411 Walnut Street, Philadelphia 2, Pennsylvania. Research, design and test work described in this report were accomplished by U. S. Gauge, A Division of AMETEK, Inc., Sellersville, Pennsylvania under U. S. A. F. Contract Number AF33(657)12491 and U. S. Gauge Project Number 515.

This project was under the direction of Mr. J. R. Whitaker, U. S. A. F. Project Engineer.

The material contained in this report covers the work conducted from December 13, 1963 to September 10, 1965.

Personnel contributing to this report were: J. D. Fulmer, Project Engineer; R. D. Waite, Supervisor, Product Engineering; M. Mollick, Manager of Development; and P. W. Harland, Director of Engineering, U. S. Gauge, A Division of AMETEK, Inc., Sellersville, Pennsylvania.

ABSTRACT

The objective of the subject contract was to establish design criteria and demonstrate by means of models the feasibility of a permanently attached aircraft tire inflation indicator. The pressure indicator was required to visually display the inflation status of the tire to which it is mounted.

Phase I of the contract was directed to a literature search into the state of the art of tire pressure measurement and to a design study and submission of design proposals pertaining to the application of a tire pressure indicator to the KC-135 aircraft wheel.

Phase II of the contract was concerned with the fabrication and testing of two selected designs in sufficient quantity to demonstrate ability to meet the environmental and reliability test conditions outlined in the contract work statement. Upon completion of the qualification testing, the USAF Project Engineer selected one of the two designs for fabrication of the Phase III service test models.

The Phase III work effort was directed to the fabrication of twenty-five (25) complete Tire Inflation Indicators. Twenty (20) were for field testing by the USAF and five (5) were for reliability testing by the contractor.

A pressure gauge which employs a relatively new pressure measuring concept and which can be permanently attached to an aircraft wheel was developed. The environmental and reliability testing demonstrated the ability of the system to withstand the extreme shocks and accelerations associated with aircraft wheels without loss in accuracy. The development contract was also concerned with adapting the inflation measuring system to the standard KC-135 wheel. This required the design of a separable housing which replaced the valve stem of the tubeless tire and accomodated the pressure gauge.

For future applications, it is suggested the gauge housing be made integral with the wheel rim casting rather than attached as a separate part.

ACKNOWLEDGMENTS

1. Corning Glass Works
   Corning, New York

2. Defense Documentation Center
   New York 13, New York

3. Engineering Societies Library
   New York 17, New York

4. Naugatuck Glass Company
   Naugatuck, Connecticut

5. Office of Technical Services
   U. S. Department of Commerce
   Philadelphia 7, Pennsylvania

6. Precision Metalsmiths, Inc.
   Cleveland, Ohio

7. A. Schrader's & Son
   Brooklyn 17, New York

8. Waldes Kohinoor
   Long Island City 1, New York

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ADDENDA

INTRODUCTION

There are numerous occasions when aircraft tires fail due to improper inflation. Improper inflation affects the aircraft floatation during landing which could cause catastrophic failure. A need exists for a permanently attached inflation indicator which will quickly and accurately register the inflation status of the tire to which it is mounted. The present method of checking the tire pressure using a hand held gauge is too slow for use during walk-around inspection.

The purpose of this program was to develop a pressure gauge which could be permanently mounted and be capable of withstanding the shocks and accelerations encountered during landing and take off.

This development program was divided into three (3) basic phases:

I. Investigation and Preliminary Design Study

II. Development, Test and Evaluation of Two Designs

III. Production of Service (Field) Test Models

The purpose of Phase I was to conduct a literature search into the state of art of tire pressure measurment. Also, investigation and preliminary testing of basic pressure elements were conducted to determine those which would most likely meet the severe shock and vibration requirements.

The purpose of Phase II was to develop two (2) designs, build models of them and submit them to environmental and reliability tests to determine the design best suited for the application.

The purpose of Phase III was to fabricate 25 field test models of the final design selected from Phase II. Five of the models were for reliability testing by U. S. Gauge and twenty were to be delivered to the USAF at Wright-Paterson Air Force Base, Ohio for field testing.

I. PHASE I - PRELIMINARY DESIGN STUDY

A. GENERAL DISCUSSION

1. Early in the design study, peizoelectric pressure measurement devices were ruled out because such devices are dependent upon a dynamic pressure to generate a signal. As it is desired to measure static pressure during periods when the aircraft is stationary,this type of excitation is not applicable.

2. Investigation of other electrically excited devices was not conducted. Electrical power for the excitation of a transducer and for transmission of the measured signal is required. A means of commutating power to the pressure transducer or the use of a miniature battery would be required. A pressure indicator would therefore have to consist of a sensor (transducer), a power source (battery) and readout device (meter or the like). The complexity of such a system could only result in a low level of reliability. In addition, the cost of such an electrical transduction system would be so high as to preclude its use on most aircraft. The program was therefore directed exclusively towards the design and development of a mechanical system of pressure measurement.

3. As required by the contract,the gauge developed was designed for use on the KC-135 wheel.

B. LITERATURE SEARCH - A literature search on the subject Air Pressure Measurement of Tires was conducted. Following is a list of the literature received and reviewed:

Source	Document	Title
DDC	AD-277 392	Shock and Vibration Environment. An ASTIA report Bibliography.
DDC	AD-269 920	Theoretical Analysis of The Response of Measuring Systems to Impulsive Inputs.
DDC	AD-290 204	Vibration Damping Studies
DDC	AD-261 012	Investigation and Evaluation of Hydraulic Pressure Snubbers

Source	Document	Title
OTS	59-21211	Central Tire Pressure Control System of the ZIL-157 Truck
OTS	PB 34827	Calibration of Service Tire Gauges
OTS	PB 142 258	Atmospheric Contaminant, Radiation, and Electricity Criteria for Aircraft and Airborne Equipment
OTS	62-24292	The Theory of Pressure Gauges Incorporating Pistons without Packing
Engineering Societies Library		Tyre Pressure Control - Rolling Resistance of Tires

Inventor	U.S. Patent No.	Title
A. E. Bronson	1,893,222	Pressure Indicator
J. L. Woodfill	3,117,195	Pneumatic Tire and Electric Switch for Pressure Indicator
W. S. Clarkson	2,190,530	Tire Gauge
B. D. Boenker	1,855,088	Air Gauge
W. J. Zipper	3,111,930	Tire Pressure Indicator
P. Rubin	2,417,449	Tire Inflation Indicator Valve Cap
I. D. Fenwick	2,329,039	Tire Air Pressure Gauge
M. J. Poster	1,807,752	Automobile Tire Indicator or Gauge
B. M. Galperin	2,770,134	Pressure Gauge
G. M. Quiat	2,689,481	Tire Pressure Indicator

Inventor	U. S. Patent No.	Title
R. L. Mercer	2,579,120	Valve Cap Gauge
R. Gstalder	2,969,086	Device for Measuring and Balancing Air Pressure in Wheel Tire of Automobiles
A. R. Moffett	2,661,626	Fluid Pressure Gauge
L. L. Tapp	2,948,256	Tire Pressure Indicator
W. Gfoll	2,903,888	Pressure Gage Attachment for Tire Valve Stems

OTS - Office of Technical Services
DDC - Defense Documentation Center

1. In general, the literature offered little information in regard to the design of a pressure gauge for this application. One of the documents and one patent were found informative and helpful in developing the gauge design.

(a) Document No. 34827 - This document is a report of the results of tests conducted on standard piston type tire gauges. Errors as high as 25% at the temperature extremes of -65°F and +160°F were reported. This information coupled with other factors led to rejection of the use of spring loaded piston devices.

(b) Patent No. 1,855,088 - The device covered by the patent employs a helical Bourdon element with a pointer affixed to the active end of the helix. No provisions for supporting the Bourdon to protect it from damage due to shock, vibration, and acceleration forces was made. One of the proposals made in Phase I utilized such a helical tube with support provided by a central shaft inside the helix.

C. PRELIMINARY TESTING - Before committing large amounts of effort to any one or two designs, an informal test program was conducted to determine the most promising concepts. Various dial and marking formats were studied. Several pressure element types were subjected to vibration, shock and acceleration, (simulating or exceeding actual operating conditions), to observe their resistance to these forces. A special acceleration machine was built to perform some of these tests.

1. Readability Tests - The readability of various size dials from 3/4" diameter to 1-1/2" diameter was reviewed to determine the minimum dial size which could be read from 3-6 feet within the required accuracy of ±5%. Dial and pointer mock-ups of several designs were made. Personnel not associated with this program were requested to take readings at varying distances and lighting conditions. It was determined from the observations that a 1" dial diameter could be consistently and accurately read from 3-6 feet. As one of the objectives was to keep the size and mass to a minimum, the presentations proposed were limited to 1" and 1-1/4" diameter. These are shown on drawing CSK-9426-C, (Figure 8).

2. Informal Environmental Tests - Acceleration, shock, and vibration tests were conducted on gauges and/or assemblies employing the mechanical pressure measuring elements being considered for use in the gauge.

(a) Specimens - The following specimens were subjected to informal acceleration, vibration, and shock tests:

Specimen 1 - 0-300 psi "C" Bourdon tube pressure gauge with geared movement (Bourdon tube size, 5/8" coiling radius) 270 angular degrees output.

Specimen 2 - 0-100 psi spiral Bourdon tube center, mounted center guided, 70 angular degrees output.

Specimen 3 - 0-300 psi spiral Bourdon tube, center mounted with wrap-around pointer affixed to outer coil 230 angular degrees output.

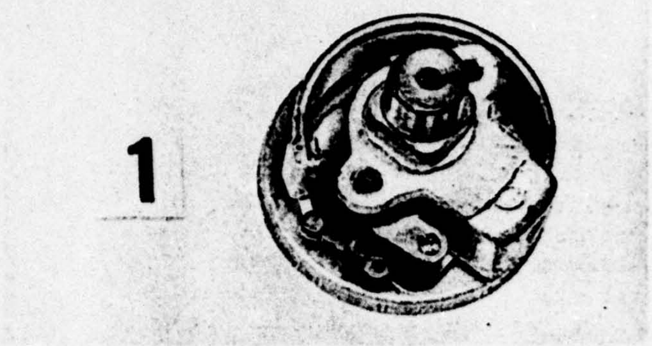
Specimen 4 - 0-100 psi spiral Bourdon tube, center mounted with radial pointer affixed to outer coil, 70 angular degrees output.

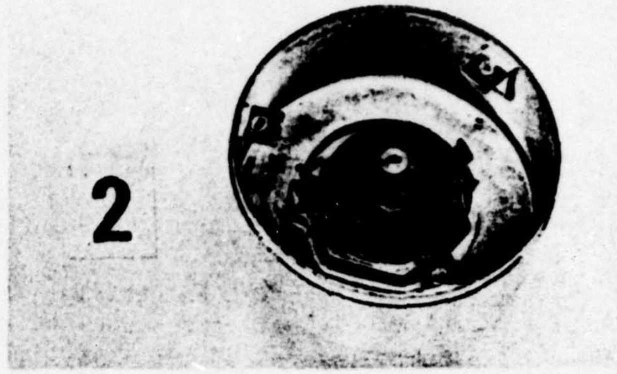
Specimen 5 - 0-100 psi spiral Bourdon tube, outer end mounted, with center takeoff pointer, 70 angular degrees output.

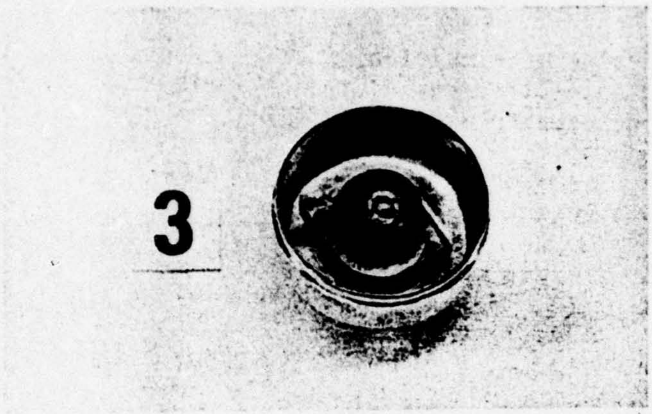
Specimen 6 - 0-300 psi helical Bourdon tube, end mounted, unsupported. 230 angular degrees output.

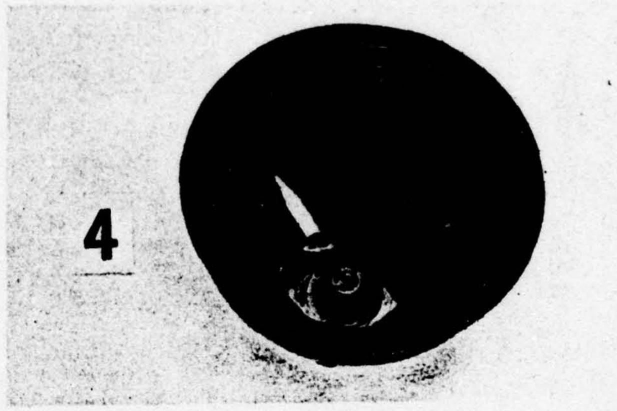
Specimen 7 - 0-60 psi single plate diaphragm gauge with gearless movement, 70 angular degrees output.

Photographs of the specimens are shown in Figure 1.









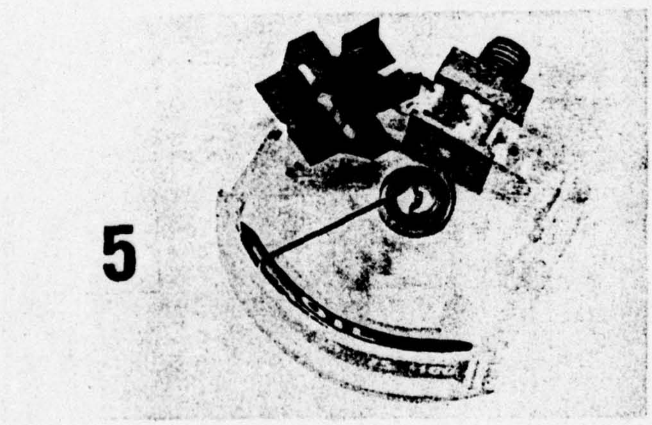
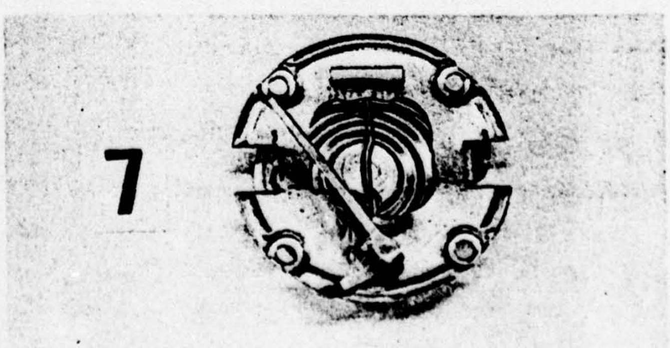


Fig. 1



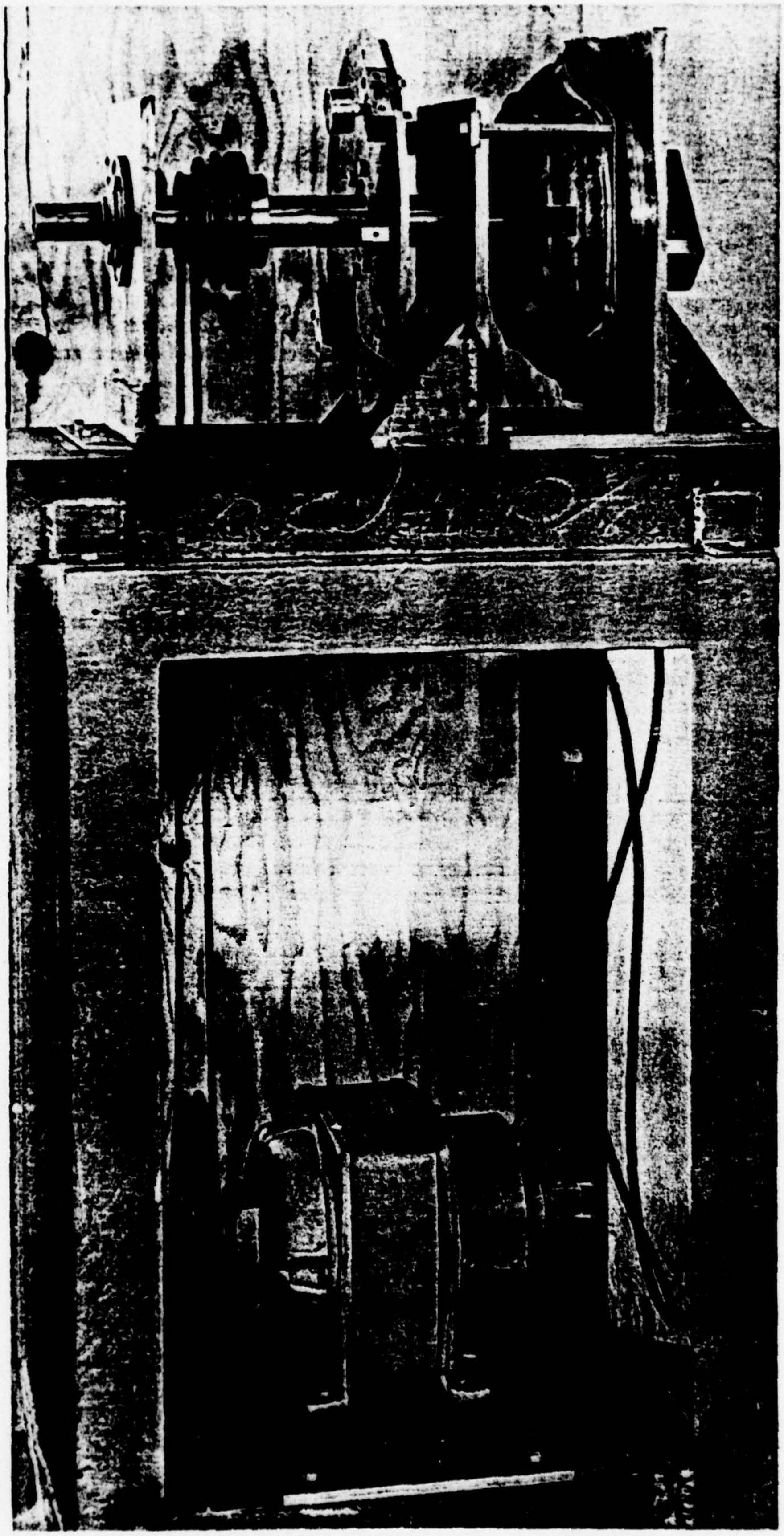


Fig. 2

(b) Acceleration Tests - Combined Acceleration Tests (radial plus tangential) were conducted on specimens listed in (a). Tests were conducted with specimens in three mutually perpendicular planes to verify resistance to acceleration, and to determine the least vulnerable and most vulnerable axis. These tests were performed on a machine especially built for the purpose, (see Figure 2). (See II D 3. (a) for description). 2500 radial acceleration was obtained by allowing the machine to rotate at its maximum speed (3800 rpm). Braking time from this rotation rate was maintained below .125 seconds to assure tangential accelerations in excess of 50 g.

(c) Shock Tests - Shock tests were conducted on the specimens listed in paragraph (a). Shock Test equipment was not used. The units were dropped from approximately five feet onto a concrete floor, a procedure which produces shock forces in excess of several hundred g's. Each gauge was dropped a total of three times (one time in each of three planes) prior to scale error readings.

(d) Vibration Tests - Vibration scanning tests were conducted on the specimens listed in paragraph (a). The tests were conducted in accordance with the "Tentative Test Specification, TS-701". Resonant point frequency and magnitude of oscillation at resonance were noted. The equipment used for this test was MB Model C10VB.

(e) Results of Informal Environmental Tests - The results of the preliminary tests conducted on the specimens listed in paragraph (a) follow. The axis parallel to the pressure connection was considered Plane 1; the axis normal to the pressure connection was considered Plane 2; and the axis normal to the connection and normal to the axis of Plane 2 was considered Plane 3.

(f) Analysis of Informal Environmental Tests

(1) Specimen 1 - C Bourdon tubes appear to be unsuitable for this application. The mass of mechanism required to magnify the small output travel results in high deforming forces when subject to high acceleration. The hairspring necessary to maintain the pointer coupled to the Bourdon (through the segment and link) is quite delicate and easily deformed. Use of this type of Bourdon was therefore not considered in subsequent proposals.

(2) Specimen 2 - This specimen resisted deformation due to shock but indicated a need for additional structural support for the acceleration loads. It was felt that with some increase in the strength of the bearing support, the shifts could be eliminated. The oscillation under vibration was isolated to a narrow frequency band and would probably have no adverse effect on the performance under static conditions.

Specimen	Acceleration Radial Plane 1 Tang. Plane 2	Acceleration Radial Plane 2 Tang. Plane 3	Shock	Vibration Pl. 1	Vibration Pl. 2	Vibration Pl. 3
1	1% shift	Hairspring & segment tail bent	New specimen used pointer lodged behind zero stop pin.	Not conducted due to poor results in other tests.		
2	2.5% shift	9% shift	No shifts	NSRN	±25 psi oscill-ation at 80 cps.	NSRN
3	0.4% shift	0.3% shift	1% shift	NSRN	±25 psi osc at 32 cps ±50 psi osc. at 65 cps.	±50 psi osc.at 32 cps and 65 cps
4	Inoperable due to case & dial distortion	Not conducted	Not Cond.	Not conducted		
5	10% shift	Inoperable Bourdon de-formed	New specimen used inoper-able due to Bourdon tube distortion	Not conducted		
6	Inoperable, Bourdon de-formed See Note 1.	Not conducted	Not conducted	Not conducted		
7	8% shift	12% shift	6% shift	NSRN	NSRN	±8 psi at 110 cps

NSRN - No serious resonances noted

(3) Specimen 3 - The large diameter center support provided support for all coils urged against it by the g forces. The strength of each coil was sufficient to support without deformation of all the coils being forced onto it. The large resonances noted under vibration indicate a need for viscous damping or better balance of the pointer. The damping could be introduced by the use of silicone grease between the coils. The balance could be achieved by the use of a center pivot around which the pointer and its balance would be pivoted.

(4) Specimen 4 - This specimen was permanently damaged on the first test due to the insufficient strength of the case material. As it was very similar in construction to specimen 3, it was felt no additional information could be obtained by its repair and continued testing.

(5) Specimen 5 - The entire mass of the tube and pointer was cantilevered from the outer end of the tube and although the Bourdon was supported by a bracket which trapped the outer coils and the pointer stud, severe Bourdon tube distortion occurred. It was felt the support of the tube could not be improved greatly over the means used in the specimen. All subsequent proposals using spiral Bourdon tubes avoided this method of mounting.

(6) Specimen 6 - Although the informal test results were not encouraging, it was felt that when supported by a close fitting internal post a helical bourdon would be capable of resisting the environmental loads. This view was supported by the fact that military helical element gauges are now in use by the services. The helical element was used for several suggestions in the Phase I proposal.

(7) Specimen 7 - The diaphragm gauge with gearless mechanism performed outstandingly under vibration. The motion of the light mechanism parts was frictionally damped by the sliding of the parts on one another. The high resonant frequency of the diaphragm prevented oscillation in the test spectrum. The overhung, unbalanced mechanism was subject to deformation under high g forces from shock and acceleration.

D. TENTATIVE TEST SPECIFICATION, TS-701 - In view of the "Work Statement" (Exhibit A to the Contract, Addendum II) with the USAF Project Engineer, it was apparent that vibration and shock testing had not been included in the design requirements. A test specification outlining a complete test program including these tests was prepared and submitted to the USAF Project Engineer for review. This specification, after approval by the USAF, was the basis for later qualification testing.

E. DESIGN DISCUSSION

1. Measuring Elements - From the foregoing work, the important attri-

butes of the gauge to be developed could now be stated. The element should deliver sufficient angular motion to require no magnification. The Bourdon tube must be supported to prevent deformation under high g loads but can be quite light to keep these forces low. Wherever possible, appendages (such as the pointer) should be balanced to avoid oscillation error and possible fatigue failure under vibration. If a system with magnification is to be used, the parts should be balanced, light and rugged.

To keep the gauge and housing as small as possible, but provide the necessary readability, the gauge dial should be at least 1" in diameter and be graduated over approximately 230°. The gauge or the housing should incorporate a device to prevent catastrophic loss of air in case of a failure of a gauge part. Several suggestions were made in each of the following categories. Measuring element, housing, fail safe system, dial format, and bezel construction. Three primary elements were proposed. These were considered most suitable for use in the tire pressure indicator. They were selected following study of the literature, analysis of preliminary testing on various types of elements, and in the light of our favorable experience with these types when used in applications with severe environmental conditions prevailing.

(a) Spiral Bourdon Tube - To obtain a large angle of rotation without an amplification mechanism requires a multi-turn, thin walled Bourdon element. Recent developments in this field have shown that a six or seven turn spiral fabricated from a flattened .078 o.d. x .003 wall BeCu tubing is capable of delivering approximately 230° angular travel with a high margin of overpressure protection. This recent advance in the technology was not reflected in any of the patents and papers uncovered in our search. Such an element has a relatively low torsional spring gradient (on the order of 50 gm-cm per full scale). This factor would imply poor resistance to vibration and acceleration. However, when coupled with low mass and small size, and when appropriately restrained from excessive movement, these elements show excellent resistance to these environments. Several designs using this element were suggested.

(b) Helical Bourdon Tube - The same comments concerning angular travel, rigidity, and mass apply to the helical Bourdon element. A helical Bourdon delivering 230° of travel for rated pressure with a margin for overpressure takes the form of a long thin cylinder, which occupies several times the volume of the spiral. Designs VI and VII were proposed to illustrate some possibilities for the use of such an element (Figures 5 and 6).

(c) Diaphragm Elements - Small diameter diaphragms have extremely high resonant frequencies and provide a very rigid (high energy) element capable of driving high magnification mechanisms. They are used in high frequency response military transducers for this reason. The amplifying mechanism must be kept extremely light, but rigid, and good coupling must be maintained between the indicating pointer and the diaphragm during vibration. The mechanism should also avoid the use of such wear inducing components as gear teeth and link bearings. A mechanism which has proven itself very resistant to the vibration and shock encountered in aircraft and farm tractor service is illustrated in Design VIII, (Figure 7). Under very high acceleration forces, the linkage may temporarily separate from the diaphragm. Another shortcoming of this gauge mechanism is the limited angle of motion obtained from the pointer (approximately 70 - 90°).

2. Housings and Mounting - The housing designs shown on drawings SK-9426, (Figures 3 and 4), SK-9426-A (Figures 5 and 6), and SK-9426-B (Figure 7) are not intended for illustration of internal mechanism.

(a) Design I (Figure 3) - This housing was designed primarily for enclosing a gauge utilizing a spiral spring Bourdon tube. It is made to mount in the same opening as for the present tubeless tire valve stem. The assembly is prevented from turning during operation by a special keyed lock washer which indexes in a hole in the rim and a hole in the housing.

Installation of this design requires the removal of the existing valve stem, the drilling of a hole in the rim, as shown, for locking purposes, and assembly of the unit to the rim as shown. As the mounting depends only upon the valve hole and is independent of the wheel contour, this arrangement would require only one gauge type for stocking and retrofitting purposes.

(b) Design II (Figure 3) - This assembly was identical to that of Design I except an additional support was provided for wheel attachment. It provides greater resistance to deformations resulting from tangential g forces. The addition of the mounting pad requires the separation of the wheel halves for assembly purposes. The addition of the mounting pad, would eliminate the need for the lock washer, thereby eliminating the need for any wheel rim modification. Use of this housing would be limited to Bendix wheel 154600.

(c) Design III (Figure 3) - The charging stem on this design extends through the center of the gauge internals and is, therefore, limited to particular internal design in which the pointer rotates around the periphery of the dial.

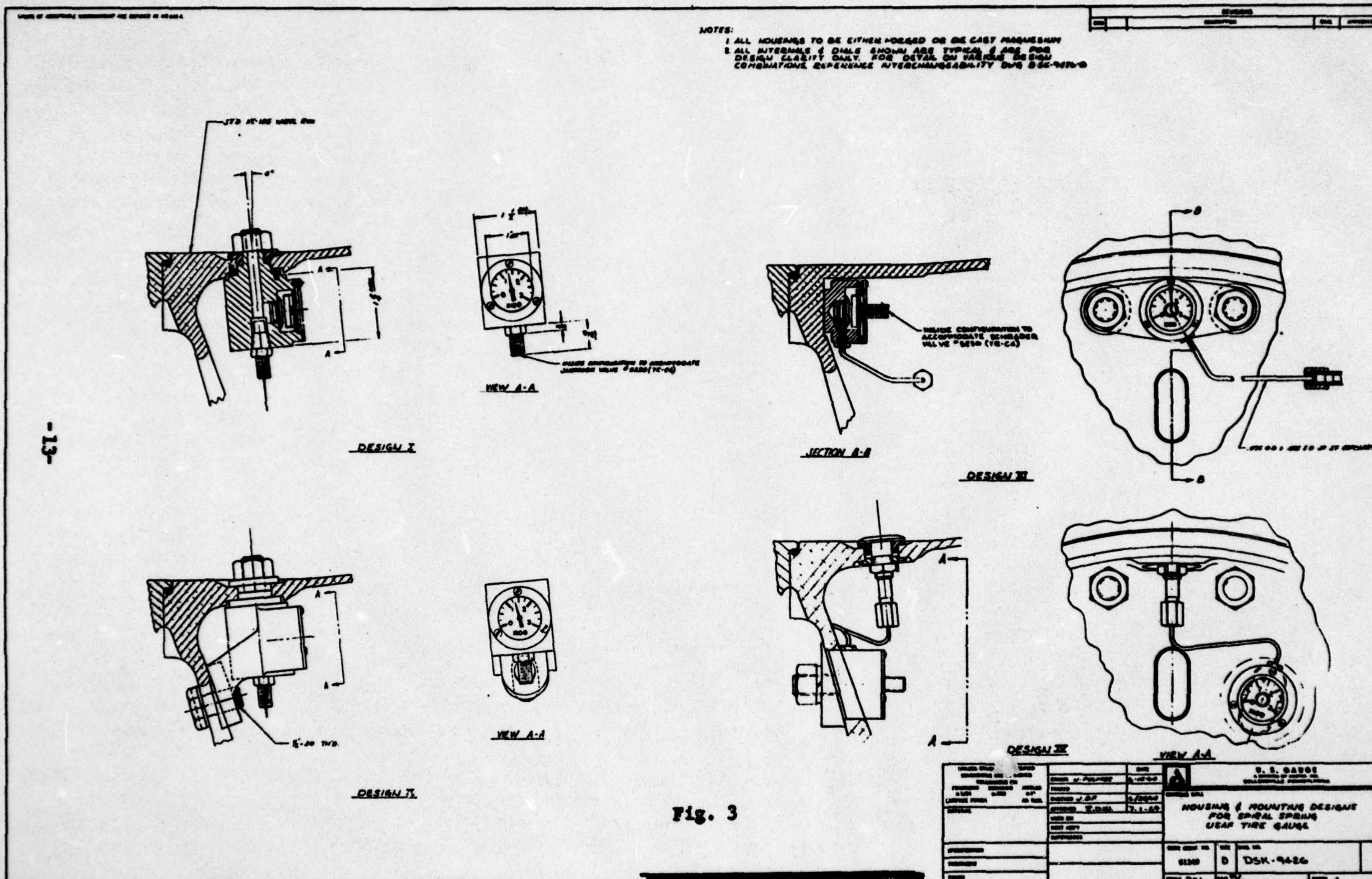

NOTES:
1 ALL HOUSINGS TO BE EITHER FORGED OR DIE CAST MAGNESIUM
2 ALL INTERNALS & DIALS SHOWN ARE TYPICAL & ARE FOR DESIGN CLARITY ONLY. FOR DETAIL ON VARIOUS DESIGN COMBINATIONS, REFERENCE INTERCHANGEABILITY DWG DSK-9426-D
DESIGN I
VIEW A-A
SECTION B-B
DESIGN III
DESIGN II
VIEW A-A
DESIGN IV
VIEW A-A
U. S. GAUGE
HOUSING & MOUNTING DESIGNS FOR SPIRAL SPRING USAF TIRE GAUGE
D
DSK-9426

Fig. 3

(1) Pressure is inducted to the gauge by means of a stainless steel capillary connecting to the valve stem and the pressure port of the gauge. The valve stem end is equipped with a swivel nut which, when attached, depresses the tire valve and creates a pneumatic seal.

(2) The housing is mounted on two of the wheel halve bolts supported by a pair of extended pads integral with the gauge housing. The housing is shown nested into the corner of the wheel between the web and rim. This arrangement minimizes the overhang, but requires the removal of the rather large fillet in the area shown on the drawing. By extending the mounting pads to the center distance of two bolts, the housing could be attached to the wheel without modification of the wheel.

(3) After the wheel is modified, installation is accomplished by removing two of the wheel halve nuts and assembling the gauge unit over the extended bolts.

(d) Design IV (Figure 3) - Design IV was identical to Design III except that the assembly was mounted into one of the elongated holes of the wheel. The housing exterior nests in the elliptical hole and conforms to the wheel rim contour, preventing turning of the housing. A wedge type washer is provided to prevent non-uniform loading when tightening the nut. The wheel rim must be dismantled to install the gauge.

(e) Design V (Figure 4) - This design was similar to Design I except the housing was nested into the wheel contour to provide keying action without a keying washer. This eliminates the need for reworking the wheel rims on retrofit. The 45° orientation of the gauge takes advantage of the superior resistance of the spiral Bourdon to acclerations parallel to the axis of the spiral.

(f) Design VI (Figure 5) - This design employs a helical Bourdon tube. The tube is approximately 2" long and is silver soldered into the internal connection. The output motion is transmitted through a bracket which indicates the pressure on the outer periphery of a cup shaped dial. A small clearance is maintained between the helix and the center post. The outer end of the socket is fitted with the standard filling valve which extends through the center of the lens. Mounting and installation are identical to Design II. The angular output is about 120°, limiting the scale length and readability.

(g) Design VII (Figure 6) - This gauge utilizes a helix approximately 2" long whose axis is parallel to the axis of rotation

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-615-A

REVISIONS				
SYM		DESCRIPTION	DATE	APPROVED

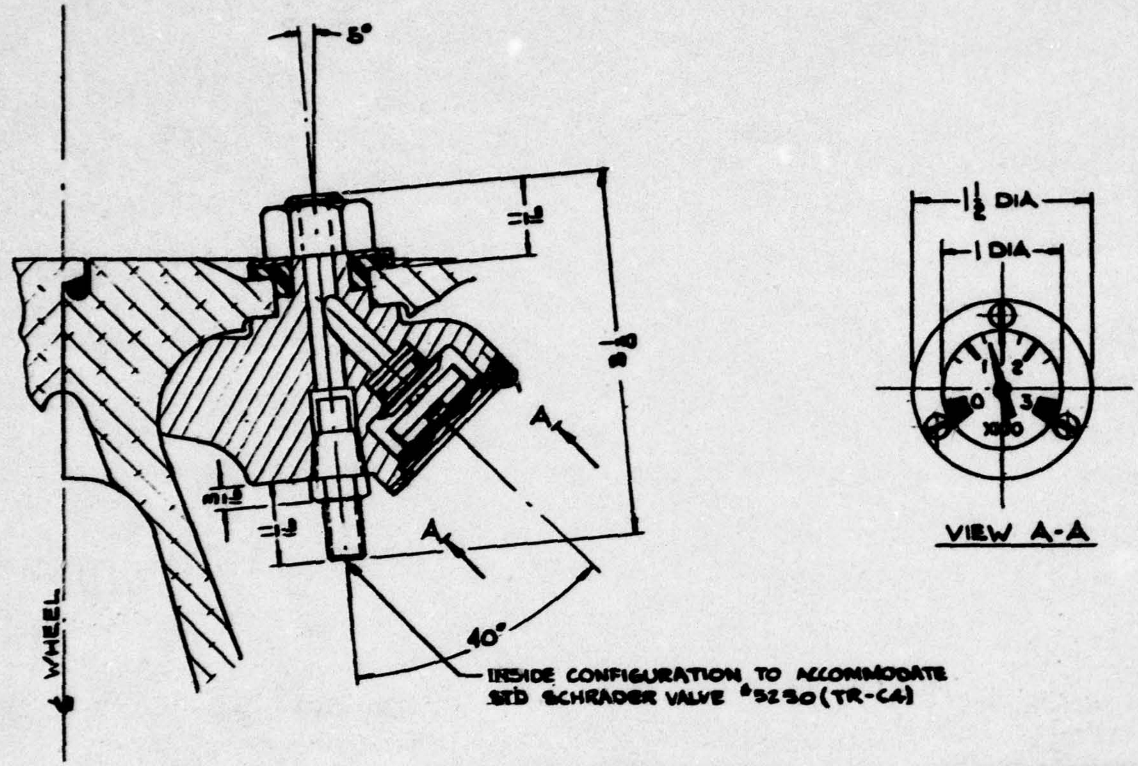


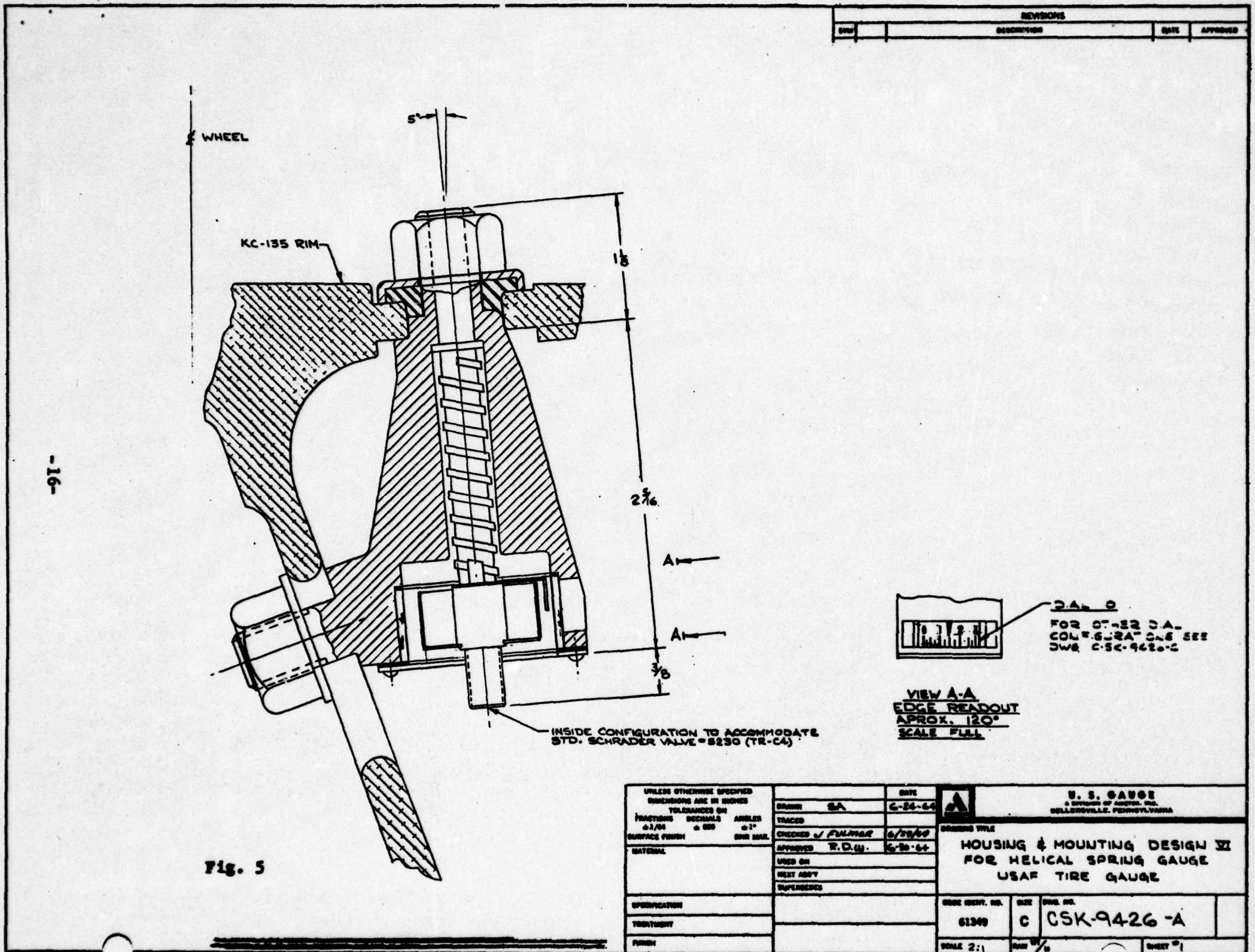
Fig. 4

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.	DRAWN WM HILL	6-26-64
	TRACED	
	CHECKED J. FULMER	6/29/64
MATERIAL	APPROVED R.D.W.	6-30-64
	USED ON	
	NEXT ASS'Y	
	SUPERSEDES	
SPECIFICATION		
TREATMENT		
FINISH		

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE: HOUSING & MOUNTING DESIGN II — USAF TIRE GAUGE

CODE IDENT. NO.	SIZE	DWG. NO.
61349	B	B-SK-9426
SCALE FULL	DRAW WT /	SHEET #2



REVISIONS
WHEEL
5°
KC-135 RIM
$1\frac{1}{8}$
$2\frac{5}{16}$
$\frac{3}{8}$
A
A
INSIDE CONFIGURATION TO ACCOMMODATE
STD. SCHRADER VALVE #5230 (TR-C4)
VIEW A-A
EDGE READOUT
APROX. 120°
SCALE FULL
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS DECIMALS ANGLES
SURFACE FINISH
MATERIAL
SPECIFICATION
TREATMENT
FINISH
DRAWN SA 6-24-64
TRACED
CHECKED J. FULMER
APPROVED R.D.W. 6-30-64
USED ON
NEXT ASSY
SUPERSEDES
U. S. GAUGE
SELLERSVILLE, PENNSYLVANIA
DRAWING TITLE
HOUSING & MOUNTING DESIGN VI
FOR HELICAL SPRING GAUGE
USAF TIRE GAUGE
61349
C
CSK-9426 -A
SCALE 2:1
SHEET #1

Fig. 5

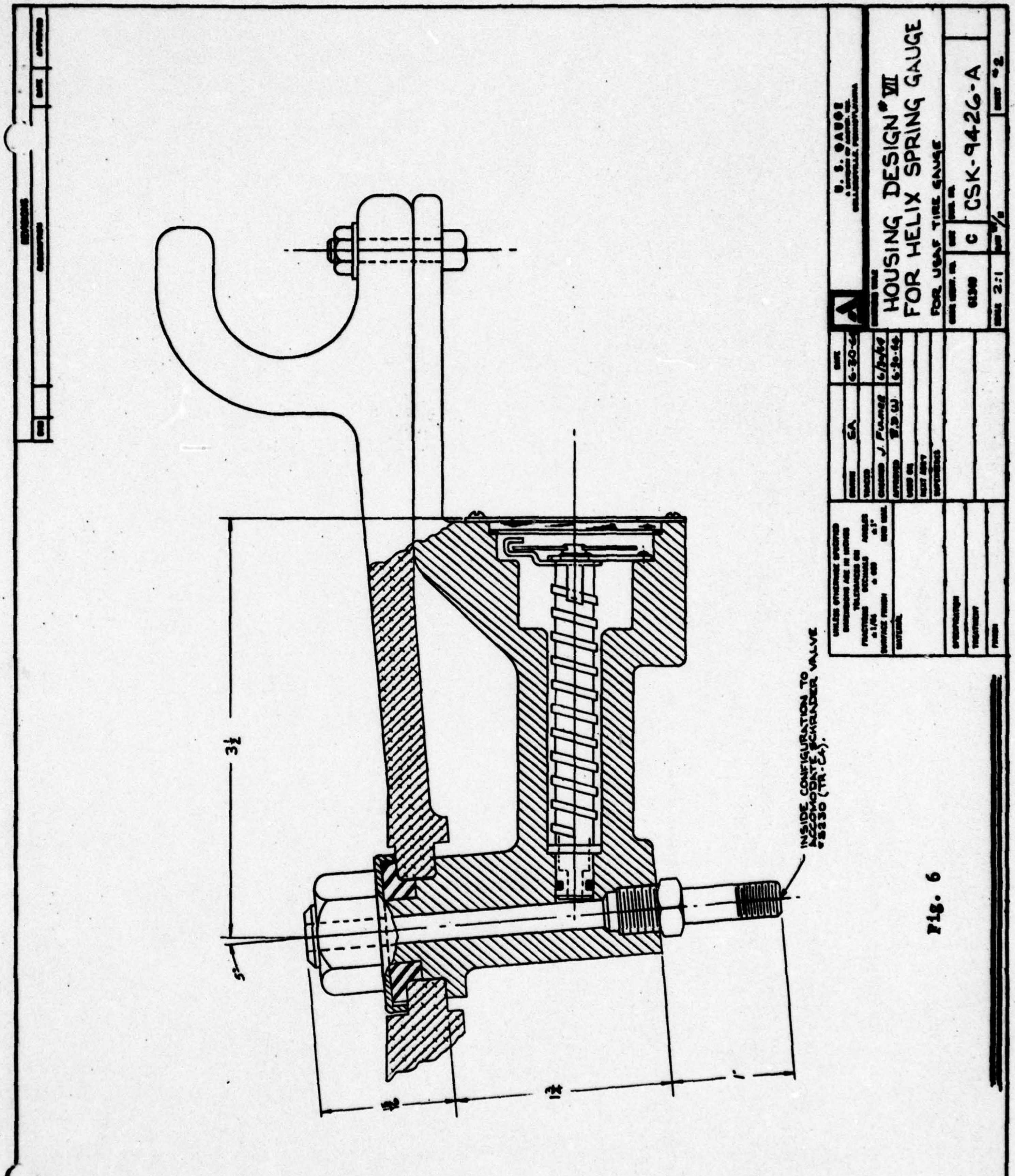

INSIDE CONFIGURATION TO ACCOMODATE SCHRADER VALVE #8230 (TR-C4).
3½
1¾
1
U. S. GAUGE
HOUSING DESIGN # VII
FOR HELIX SPRING GAUGE
FOR USAF TIRE GAUGE
CSK-94-26-A
C
SCALE 2:1
SHEET #2
SA 6-30-64
J. FULMER 6/30/64
F.D.W. 6-30-64

Fig. 6

of the wheel. Such an arrangement provides good resistance to the high centrifugal accelerations of rotation as well as the tangential accelerations of spin up. The dial location, while not recessed as deeply as in all other proposed designs, is sufficiently recessed to protect it against runaway hazards. In daylight the gauge dial will be more visible than if recessed into the wheel.

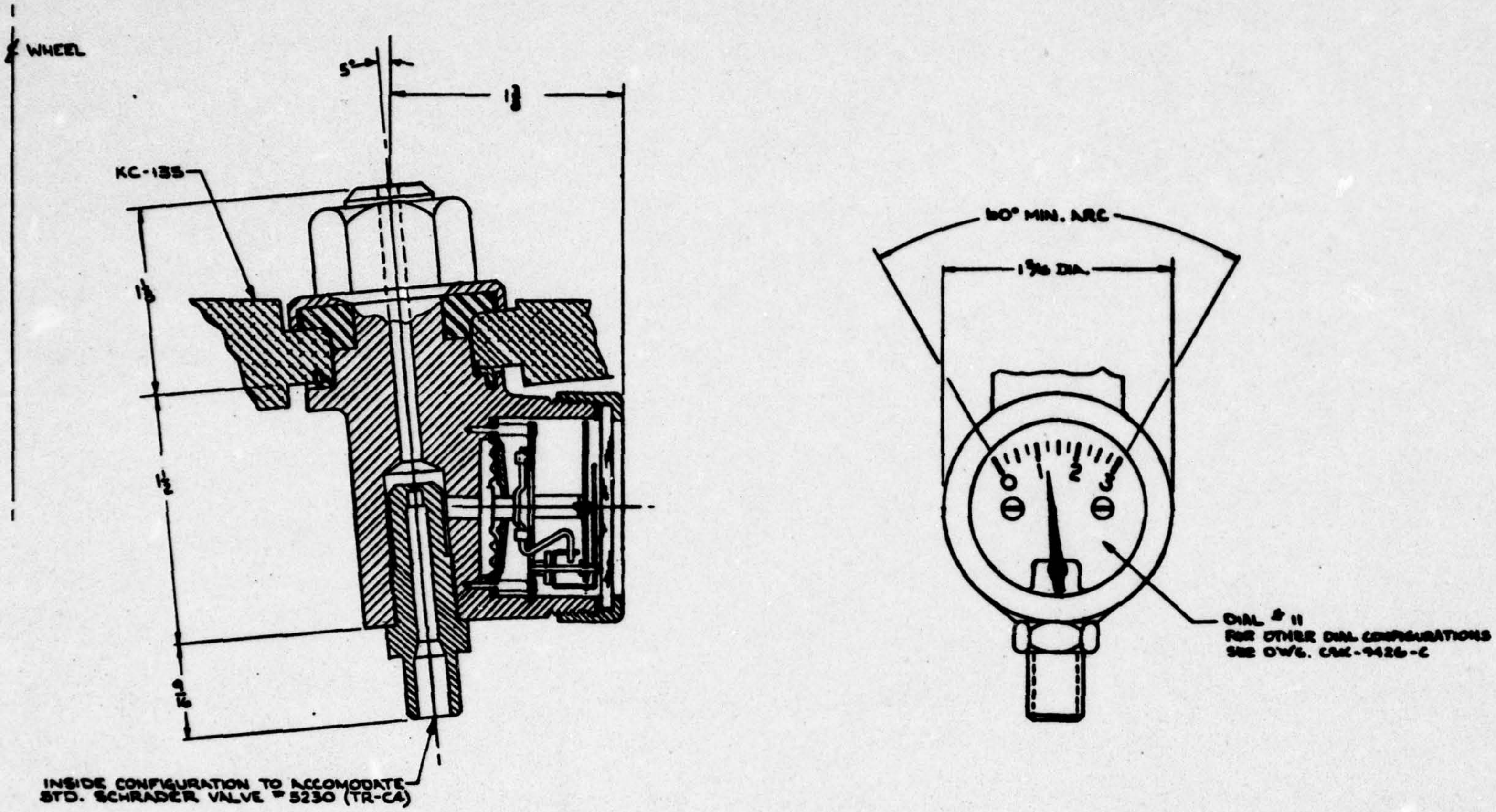
(1) By increasing the active length of the tube (to 3" or 4") a larger reading angle is obtained without sacrificing overpressure protection.

(2) The gauge can be installed in the existing valve stem opening but must be supported by a second screw at the outer lip. The holes in the housing lip can be placed so as to fit several aircraft wheels now in use.

(h) Design VIII (Figure 7) - The mounting arrangements suggested for this design were similar to Designs I and V.

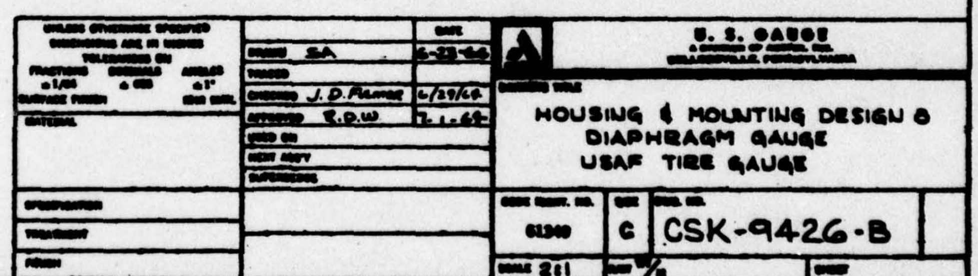
(1) The prime mover is a single corrugated diaphragm plate (approximately .875 diameter) fastened into the housing, driving an extremely light wire rocker arm which in turn drives the pointer pivoted on a wire staff. The mechanism is kept coupled by a spring of sufficient strength to maintain mechanism coupling under most conditions while not contributing significantly to the friction of the mechanism. The scale angle is limited to about 75° in order to obtain a reasonable degree of linearity. Taking advantage of the non-linear effects over larger pointer angles would permit a scale compression between 175 psi and 300 psi resulting in better readability in the operating zone. Overpressure protection is achieved by supporting the diaphragm element with a heavy plate formed to match its corrugations.

3. Dial and Readout Means, CSK-9426-C (Figure 8) - Six (6) 1" diameter dial designs (#1 thru #6) were suggested. These were readable from a distance of six (6) feet. It was suggested that color combinations would be desirable to provide the best contrast for readability. Also shown were dials #7 and #8, 1-1/8" and 1-1/4" diameters, for comparison of readability. These diameters would have required the size and mass of the housing to be increased. Dial designs #2, #3, #5 and #6 have no graduation lines between 0-75 psi and 225-300 psi. Since the operable range is stated as 75-175 psi, no calibration is required for other portions of the dial and therefore, graduations would not be necessary. This would result in a lower cost gauge. The wide bands shown at 0 and 300 psi on Designs 2, 3 and 6 represent the allowable tolerance at these two test points.



℄ WHEEL
5°
1 3/8
KC-135
1 1/8
1 1/2
9/16
INSIDE CONFIGURATION TO ACCOMODATE
STD. SCHRADER VALVE # 5230 (TR-CA)
60° MIN. ARC
1 5/16 DIA.
0
1
2
3
DIAL # 11
FOR OTHER DIAL CONFIGURATIONS
SEE DWG. CSK-9426-C

Fig. 7



U. S. GAUGE
SA
6-23-66
J. D. Palmer
6/29/66
R.D.W.
HOUSING & MOUNTING DESIGN 6
DIAPHRAGM GAUGE
USAF TIRE GAUGE
61349
C
CSK-9426-B
2:1

NOTES:
1. COLORS MAY VARY ACCORDING TO CUSTOMERS SPECIFICATIONS.
2. DIALS #7 & #8 WILL ACCOMODATE DIN CONFIGURATIONS 1 THRU 5.
3. DIAL DIA. 1 THRU 6 IS 1".
4. FOR DIAL #10 DETAIL SEE DWG CSK-9426-A
5. FOR DIAL #11 DETAIL SEE DWG CSK-9426-B

1

BACKGROUND - WHITE. GRADUATIONS, NUMERALS, & POINTER - BLACK.

MAJOR GRADS. EACH 100 P.S.I., INTERMEDIATE GRADS. EACH 50 P.S.I., & MINOR GRADS. EACH 10 P.S.I.

2

SHADED AREA 75-175 LIGHT GREEN, REMAINING BACKGROUND WHITE. GRADUATIONS, NUMERALS, & POINTER BLACK.

GRADUATIONS AT "0" & "300" INDICATE TOLERANCE OF ±5% OF 300 P.S.I.

MAJOR GRADS EACH 100 P.S.I., INTERMEDIATE GRAD AT 150 P.S.I., & MINOR GRADS EACH 25 P.S.I. IN RANGE 75-225.

3

SIMILAR TO #2 EXCEPT BACKGROUND ALL WHITE.

4

BACKGROUND - WHITE. GRADUATIONS, NUMERALS, & POINTER - BLACK.

MAJOR GRADS EACH 100 P.S.I., INTERMEDIATE GRADS EACH 50 P.S.I., & MINOR GRADS EACH 25 P.S.I.

5

ARCS 0-75 & 225-300 RED, REMAINING BACKGROUND - WHITE. GRADUATIONS, NUMERALS, & POINTER - BLACK.

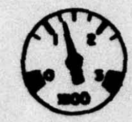
MAJOR GRADS AT 100 & 200 P.S.I., INTERMEDIATE GRAD AT 150 P.S.I., & MINOR GRADS AT 125 & 175 P.S.I.

6

BACKGROUND - WHITE. GRADUATIONS, NUMERALS & POINTER - BLACK.

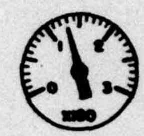
GRADUATIONS AT "0" & "300 INDICATE TOLERANCE OF ±5% OF 300 P.S.I.

MAJOR GRADS EACH 100 P.S.I., INTERMEDIATE GRAD AT 150 P.S.I., & MINOR GRADS EACH 25 P.S.I. IN RANGE 75-225.



7

SIMILAR TO #2 EXCEPT DIAL DIA IS 1 1/8.



8

SIMILAR TO #1 EXCEPT DIAL DIA IS 1 1/4.

9

BACKGROUND - WHITE, MAJOR, INTERMEDIATE AND MINOR GRADUATION LINES, NUMERALS, AND POINTER TO BE BLACK SUB-MINOR GRADUATIONS TO BE LIGHT GRAY.

MAJOR GRADS EACH 100 PSI, INTERMEDIATE GRADS EACH 50 PSI, MINOR GRADS EACH 25 PSI, AND SUB GRADS EACH 5 PSI.

Fig. 8

DRAWN	WM HALL 6-17-64
CHECKED	J. FULMER 6/23/64
APPROVED	R.D.W. 6-30-64

U. S. GAUGE

DRAWING TITLE: DIAL DESIGN USAF TIRE GAUGE

CODE IDENT. NO.	SIZE	DWG. NO.
61349	C	C SK 9426-C

SCALE FULL

(a) In general, it may be said that those dials with fewer graduations (25 psi grads) read more easily from a distance. Using more graduations tends to cause confusion in reading from a distance, but gives better accuracy for close-in reading. A compromise dial which provides good readability for close and far reading was suggested and is shown in dial #9. The sub-minor grads (5 psi) would be printed in a light grey so as to disappear from a distance, but provide the additional precision for close reading.

4. Fail Safe Systems

(a) Design (a) CSK-9426-D, Sheet 1 (Figure 9)

(1) This design provides a fail safe gauge device without the need for a pressure sealed gauge housing. This is accomplished by providing a "piggyback" valve assembly which isolates the gauge from the tire. During ground inspection, it would be necessary to depress the outer valve stem housing which actuates the inner valve core, thereby opening the gauge to the tire pressure. During this inspection check the outer valve core would retain the pressure in the tire. The gauge would then be exhausted by depressing the pin of the outer valve core.

(2) When the tire would require inflation, the inspector need only apply the standard filling manifold to the outer valve stem housing with sufficient force to depress the return spring. This will simultaneously open both valves, thereby opening the gauge and the tire to the filling pressure.

(3) Due to the isolation of the gauge from the tire pressure, the need for the gauge Bourdon tube to withstand the overpressure encountered during landing of the aircraft is eliminated. Furthermore, in the event of a gauge failure, the tire pressure will not be lost.

(b) Design (b) CSK-9426-D, Sheet 2(Figure 10)

(1) This fail safe arrangement is similar to that defined in Design (a) above, except that the tire pressure is isolated from the gauge by a spring loaded valve ball. The spring force is sufficient to support the ball check during periods of radial acceleration of 3000 g's.

(2) In order to inflate the tire, it is necessary to depress the plunger in the side of the gauge which unseats the ball check. While holding the plunger in the depressed position, the gauge will read the tire pressure. Upon release of the plunger the com-

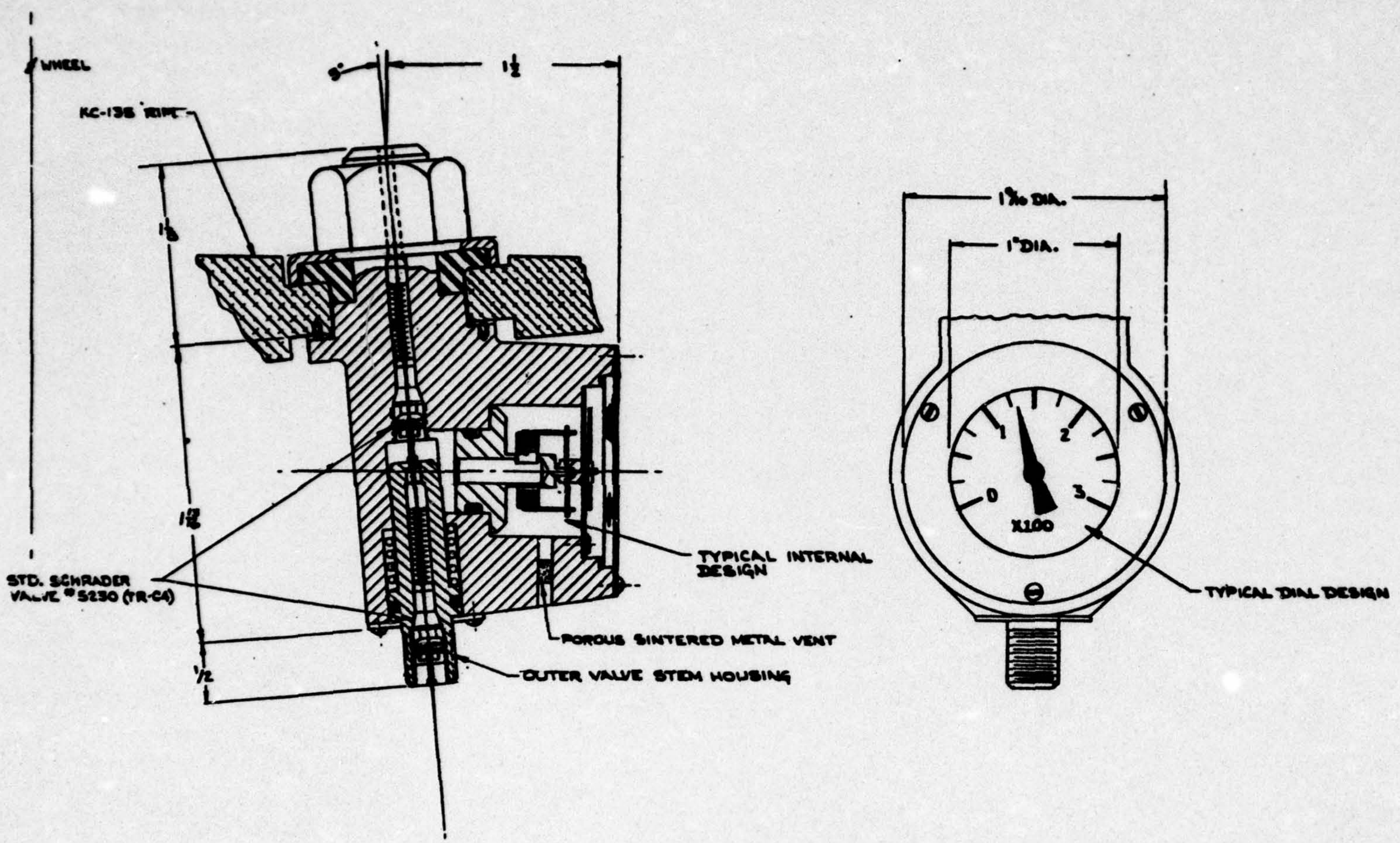


Fig. 9

U. S. GAUGE

FAIL SAFE GAUGE
SYSTEM "a"
FOR USAF TIRE GAUGE

DATE	6-17-64
CHECKED J. Fulmer	6/25/60
APPROVED R.O.W.	6-20-64
SIZE	C
DWG. NO.	CSK-9426-D
SCALE	2:1
SHEET	1

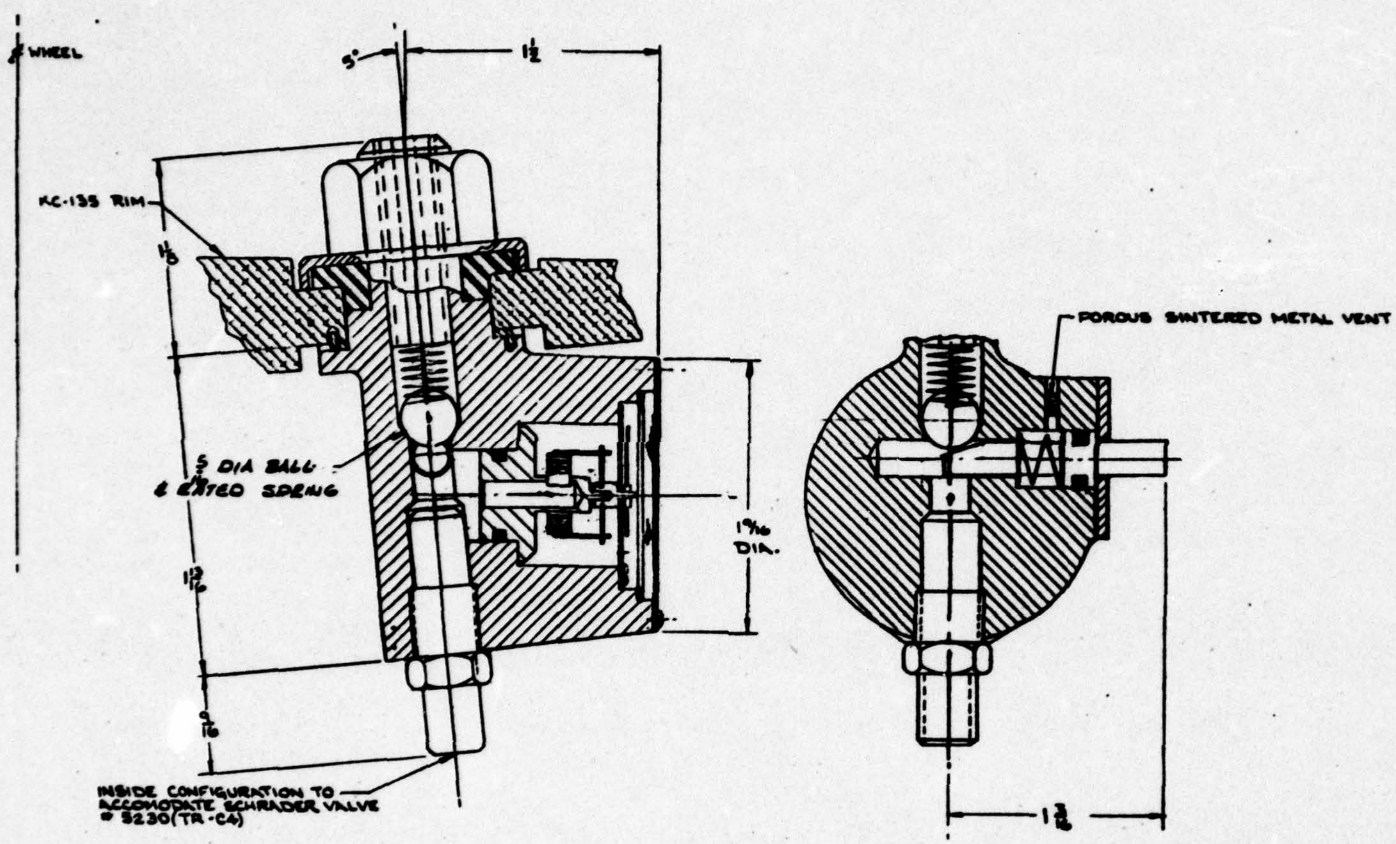


Fig. 10

U. S. GAUGE

FAIL SAFE GAUGE SYSTEM "b"

FOR USAF TIRE GAUGE

DRAWN	WH SA	6-18-64
CHECKED	J. FULMER	6/22/64
APPROVED	R.D.W.	6-30-64

61349 C CSK-9426-D

SCALE 2:1 SHEET 2

pressed air in the gauge is automatically exhausted through a small vent in the plunger chamber.

(c) Design (c) CSK-9426-D, Sheet 3 (Figure 11)

(1) This design protects the tire from loss of air should the gauge develop a leak. The clearance between the ball and its housing is designed to make the ball act as a check valve when flow rates exceed a predetermined level. This level of flow will be sufficiently low to assure that the total loss of air over any period of flight will be insufficient to cause tire under-inflation. Under normal conditions the spring urges the ball to maintain a vent from the gauge. A leaking gauge can be detected by the low reading which will be obtained. To verify whether the low reading is due to under-inflation of the tire or to a gauge leak, the vent pin in the housing is depressed. If the reading increases, a gauge leak exists.

(d) Design (d), CSK-9426-D, Sheet 4 (Figure 12)

(1) This design is similar to Design (c) except that a check valve is not used. The case vent is sized to assure that should a leak develop in the gauge, the flow rate will be sufficiently low to prevent excessive under-inflation for the period of flight. A leak in the gauge will result in a low indication of tire pressure due to a build up of pressure in the gauge housing. If there is a gauge leak and the vent becomes plugged, the gauge will eventually read zero (0) although the tire inflation will remain at safe values.

(e) Design (e) CSK-9426-D, Sheet 5 (Figure 13)

(1) This design is similar to Design (c) above, except the case vent valve is normally closed. This seals the gauge housing and provides complete protection against dust and moisture. The sealed construction does make the gauge subject to pressure errors due to ambient temperature changes. These errors are on the order of ±3 psi, depending on whether the temperature is above or below the temperature at which the gauge was last vented. For the most accurate indication of tire pressure, the case should be vented by pushing the vent valve open, prior to taking the reading.

(2) The sealed gauge housing provides a self-temperature compensating effect since the change in spring modulus of the Bourdon tube causes an error which is partially offset by the change in air pressure within the sealed case.

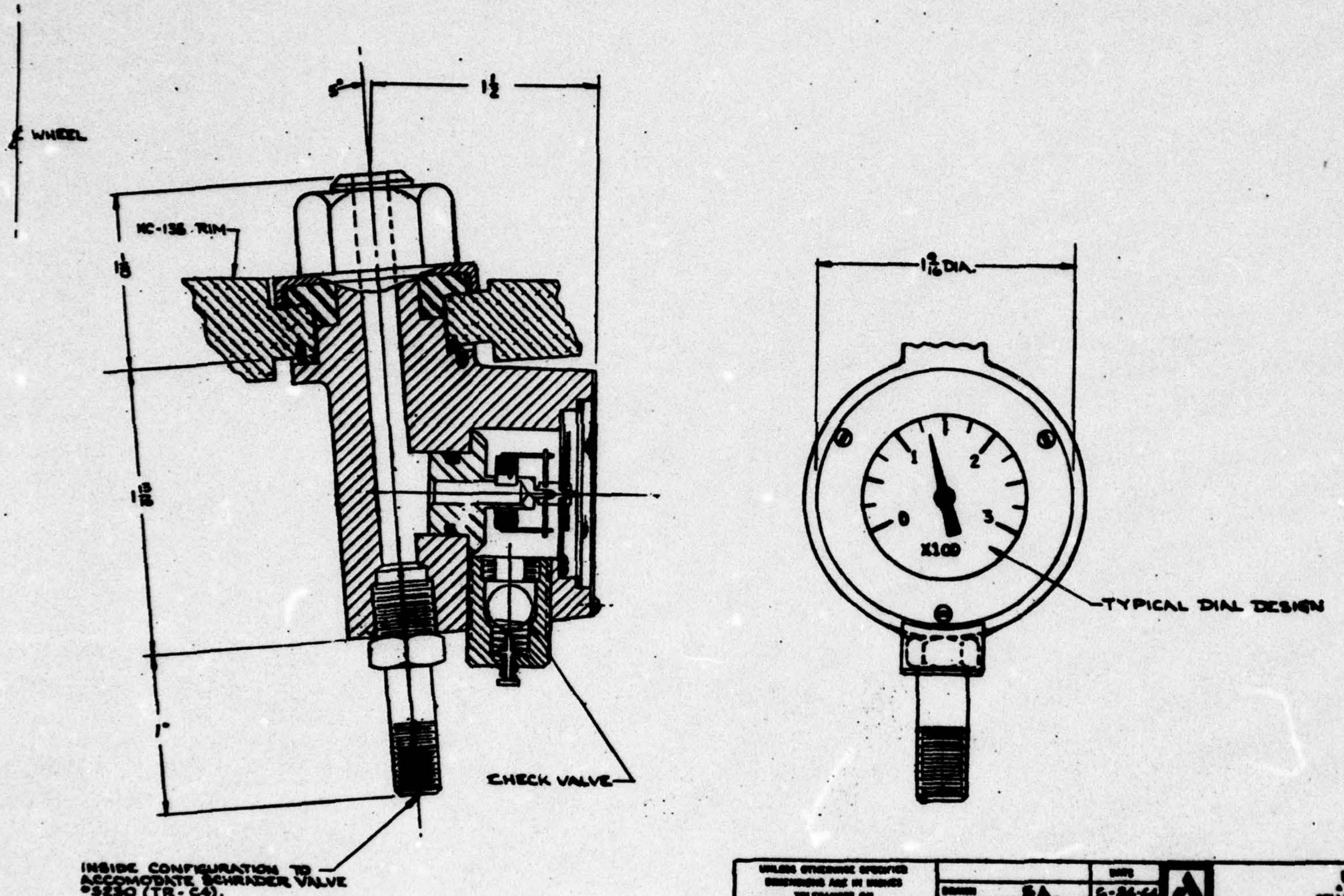


Fig. 11

DRAWN	SA	6-26-64
CHECKED	J. FULMER	6/27/64
APPROVED	R.D.W.	6-1-64

U. S. GAUGE

FAIL SAFE GAUGE SYSTEM "C"

FOR USAF TIRE GAUGE

CODE IDENT. NO.	SIZE	DWG. NO.
61349	C	CSK-9426-D

SCALE 2:1

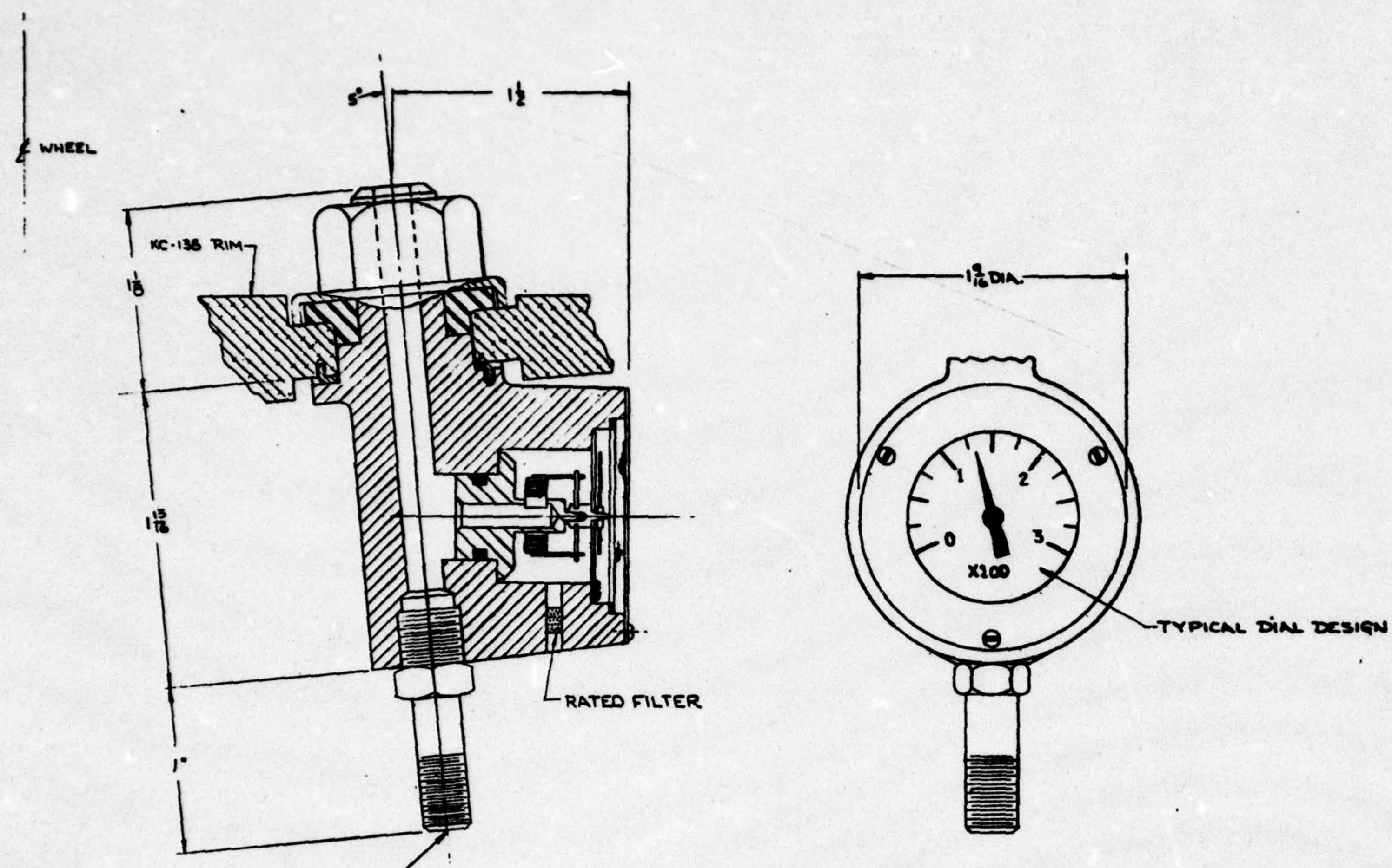


Fig. 12

U. S. GAUGE

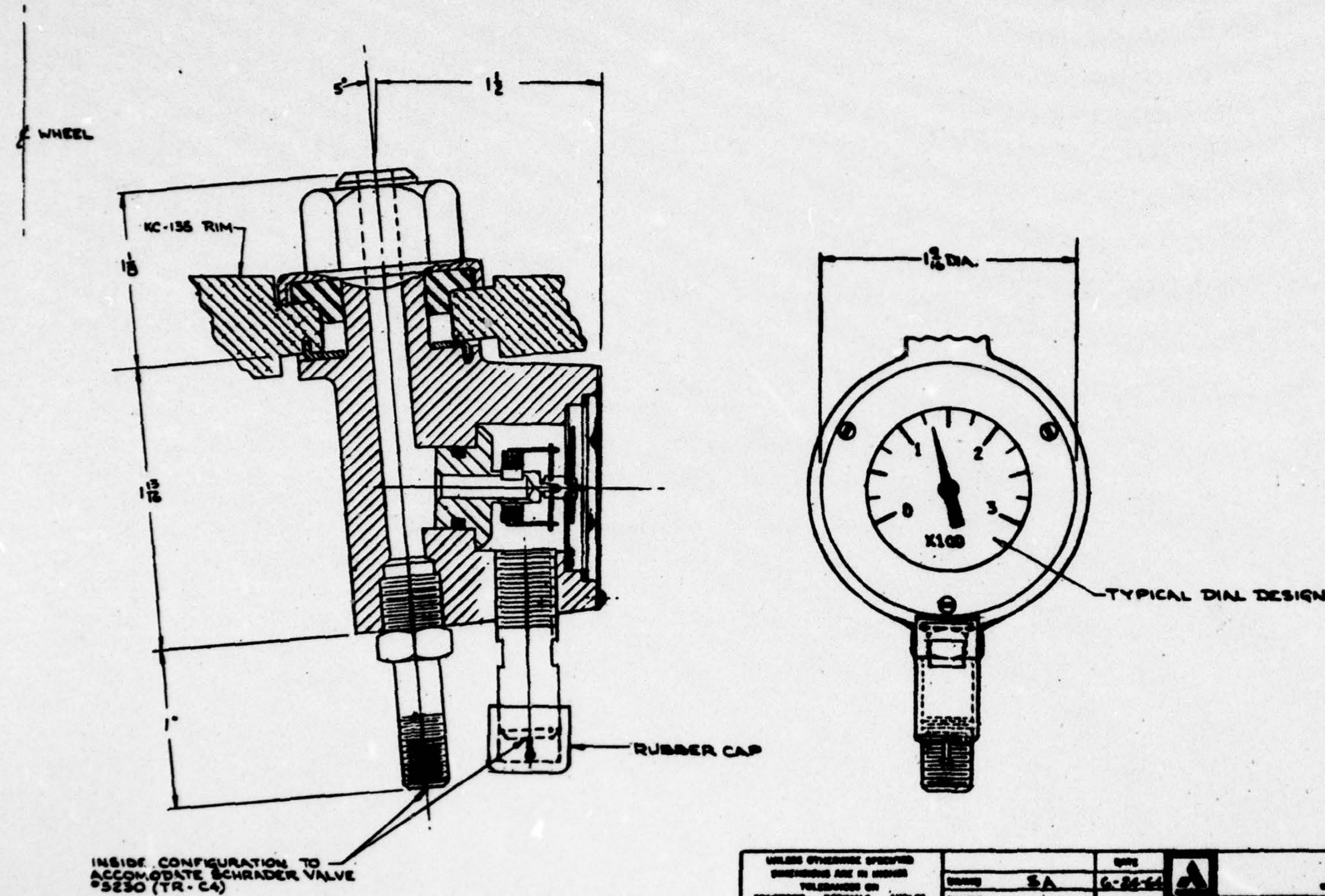
FAIL SAFE GAUGE SYSTEM "d"

FOR USAF TIRE GAUGE

DRAWN	SA	6-26-64
CHECKED	J. FULMER	6/26/64
APPROVED	R.D.W.	6-30-64

CODE IDENT. NO. 61349 — SIZE C — DWG. NO. CSK-9426-D

SCALE 2:1 — SHEET 4



U. S. GAUGE

FAIL SAFE GAUGE SYSTEM "e"

FOR USAF TIRE GAUGE

DRAWN	SA	6-26-64
CHECKED	J FULMER	6/29/64
APPROVED	E.D.W.	6-30-64

61349	C	CSK-9426-D	
SCALE 2:1			

Fig. 13

(3) If a low gauge reading exists, the cause of the low reading may be under-inflation of the tire or a leak in the pressure gauge. By use of the vent valve, the actual cause can be determined if the low pressure condition is a result of tire pressure loss, the gauge reading will not change when the vent valve is depressed; however, if the gauge reading increases when the valve is despressed, a leak in the gauge would be indicated.

5. Bezel and Pressure Index CSK-9426-E (Figure 14)

(a) Design (A) - This design utilizes a pointer painted on the underside of the crystal. A threaded ring, when tightened, provides locking of the crystal and sufficient force to seal the gasket. The ring is locked in place by an overcenter leaf spring attached to the housing. Upon tightening the ring the spring is engaged in an edge knurl on the ring which restricts any back rotation. In order to adjust the set pointer, the ring must be loosened by depressing the spring ratchet and rotating the crystal until the pointer indicates the desired pressure on the dial. The ring is then retightened, thereby locking the crystal. This index pointer arrangement can be used with the 3-screw and ring hold down illustrated in Design (B).

(b) Design (B) - This arrangement consists of a balanced wire pointer attached to a bushing which extends through the center of the crystal. An o-ring seal and a spring washer provide sufficient friction to overcome any rotation of the balanced pointer mechanism. A screwdriver slot is provided in the head of the bushing for field adjustment of the set pointer. The three hold down screws are locked after tightening by the use of lockwire. The threaded ring arrangedshown in Design (A) is interchangeable with this index pointer design.

(c) Lens

(1) Several types of plastics and glass materials which are capable of withstanding the high temperature exposure requirement (350°F) were investigated. The lens must be strong enough to withstand the effects of the shock, vibration, and acceleration forces.

(2) Study of available literature on high temperature transparent materials narrowed the choice to two materials. These are "Glass-Resin" manufactured by Owens-Illinois and Chemcor Glass manufactured by Corning Glass Company.

6. Summation of Phase I Work Effort

(a) Throughout the Phase I design study, many approaches to the design of a suitable means of monitoring the tire pressure of air-

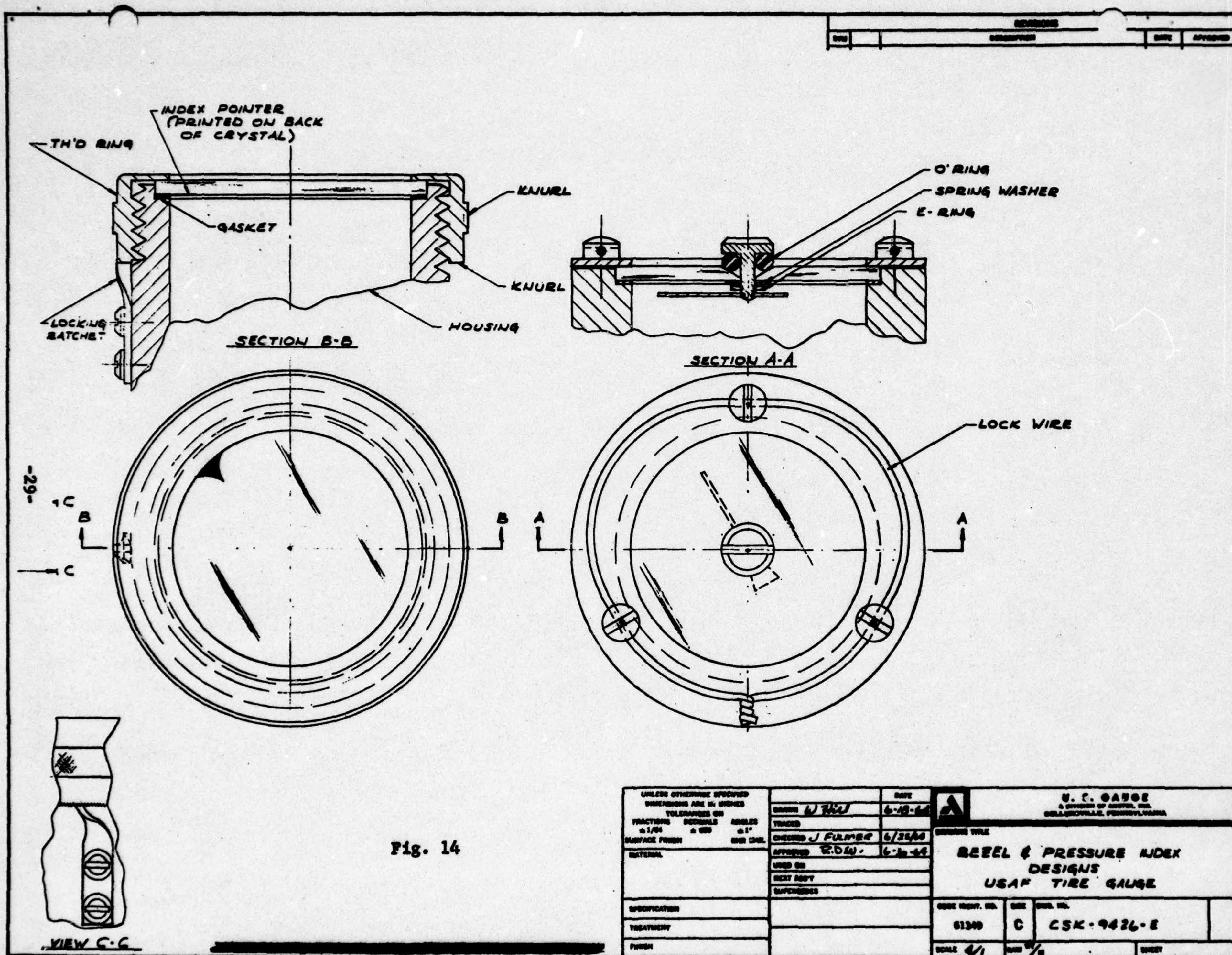

INDEX POINTER
(PRINTED ON BACK
OF CRYSTAL)
TH'D RING
GASKET
KNURL
KNURL
LOCKING
RATCHET
HOUSING
SECTION B-B
O' RING
SPRING WASHER
E- RING
SECTION A-A
LOCK WIRE
C
B
B
A
A
C
VIEW C-C
DRAWN W. HW 6-18-64
CHECKED J FULMER 6/25/64
APPROVED R.D.W. 6-26-64
U. S. GAUGE
BEZEL & PRESSURE INDEX
DESIGNS
USAF TIRE GAUGE
61349
C
CSK-9426-E
SCALE 4/1

Fig. 14

craft were reviewed and considered. From the preliminary tests of acceleration, vibration, and shock which were conducted on representative pressure elements and associated mechanisms, some of the possible approaches which were originally considered were rejected. These tests also defined and clarified the problems which had to be overcome in the later phases of the development.

(b) Three element types appeared to be sufficiently rugged to withstand the severe environment of this requirement. These were the helical and spiral Bourdon tube, and the single plate diaphragm with gearless mechanism. Each type showed certain advantages and disadvantages from the standpoint of readout, mounting, and convenience of retrofit.

(c) Several fail safe systems which would assure that no catastrophic deflation could occur were proposed. Some of these may be considered to inconvenience the walk-around inspection; others may not be considered sufficiently reliable. Most of these systems may be applied to any of the three elements.

(d) We investigated dial visibility and readability and made suggestions to permit the Air Force Project Engineer to select that configuration which best suits the needs of the Air Force.

(e) Several methods of housing and mounting this gauge and various gauge closures were presented for consideration by the Air Force.

II. PHASE II - DEVELOPMENT, TEST AND EVALUATION OF TWO GAUGE DESIGNS

A. GENERAL - Based on the results of the Phase I Design Study, the USAF Project Engineer selected two of the Phase I design proposals for fabrication and testing in Phase II. A common housing configuration was selected to accommodate spiral and helical Bourdon pressure sensing elements. The 1" diameter dial size was selected as it was readable from a distance of 3 to 6 feet. It was decided that both the filter and dual valve fail safe systems be developed to determine the most suitable for this application. The Phase I proposals did not detail a complete design for a tire pressure indicator. This phase was left open and was accomplished in Phase II to meet the particular functional requirements. The contract required that a sufficient quantity of each of the two designs be fabricated and tested to assure conformance to the environmental and reliability performance requirements. Mock-ups of each gauge were built to conduct preliminary environmental and reliability tests for general design evaluation. The tests to which the gauges were subjected were thought most likely to cause gauge failure. The results of the tests conducted are reviewed in paragraph II.B.4 of this report.

B. DESIGN STUDY

1. Pressure Element Materials - Iconel X, Ni Span C, and beryllium copper were considered for use in the pressure sensitive elements (spiral and helical Bourdon tubes). Each of these materials posses properties which would be advantageous for this application. Of these three materials, beryllium copper embodies the best combination of properties required for this application, these are:

(a) Relatively low modulus to provide maximum angular travel and readability.

(b) High tensile and fatigue strength for good over-pressure and vibration resistance.

(c) A relatively short heat treat cycle which can easily be adjusted to optimize tensile strength and hardness.

(d) Commercially available in a wide variety of diameters and wall thicknesses at a relatively low price.

(e) Good corrosion resistance.

One disadvantage of beryllium copper is that it exhibits a 2%/100°F thermoelastic coefficient. Tests were therefore made on five beryllium copper spiral Bourdon tubes range 0-300 psi at room temperature, -65°F and +165°F (see Table 1). The maximum hot shift was +6 psi and the maximum cold shift was -7 psi. This shift was considered to be small enough that it could be tolerated.

2. Spiral Bourdon Tube

(a) Previous experience on 6" long small o.d., spiral Bourdons had shown that 230 angular degrees of tip travel could be obtained with a wall thickness of approximately .003 inch. This is sufficient pointer travel to eliminate the need for mechanical amplification.

(b) Production limitations on maintaining the wall thickness, diameter, and spiral shape necessitated the incorporation of a means of adjusting the angular output of the Bourdon to the indicating dial. Previous experience has indicated that this adjustment should be capable of correcting for angular output variations of ±15% from nominal. Varying the active length of the Bourdon by attaching a movable takeoff to the outer coil provides such an adjustment.

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TABLE I

BERYLLIUM COPPER SPIRAL BOURDON TEMPERATURE TEST DATA

SPECIMEN NUMBER

INPUT PRESSURE	1 ROOM ERROR	1 COLD ERROR	1 COLD SHIFT	1 HOT ERROR	1 HOT SHIFT	2 ROOM ERROR	2 COLD ERROR	2 COLD SHIFT	2 HOT ERROR	2 HOT SHIFT	3 ROOM ERROR	3 COLD ERROR	3 COLD SHIFT	3 HOT ERROR	3 HOT SHIFT
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	+3	0	-3	+4	+1	+2	0	-2	+4	+2	+3	0	-3	+4	+1
100	+1	0	-1	+4	+3	+2	0	-2	+4	+2	+2	0	-2	+4	+2
150	0	-6	-6	+4	+4	+1	0	-1	+3	+2	+1	0	-1	+3	+2
200	-1	-5	-4	+3	+4	0	-5	-5	+3	+3	0	-5	-5	+3	+3
250	-1	-6	-5	+4	+5	0	-5	-5	+5	+5	0	-7	-7	+4	+4
300	-2	-7	-5	+3	+5	-1	-7	-6	+5	+6	+2	-3	-5	+7	+5

SPECIMEN NUMBER

INPUT PRESSURE	4 ROOM ERROR	4 COLD ERROR	4 COLD SHIFT	4 HOT ERROR	4 HOT SHIFT	5 ROOM ERROR	5 COLD ERROR	5 COLD SHIFT	5 HOT ERROR	5 HOT SHIFT
0	0	0	0	0	0	0	0	0	0	0
50	+2	0	-2	+4	+2	+3	0	-3	+4	+1
100	+1	0	-1	+4	+3	+2	0	-2	+4	+2
150	+1	-3	-4	+4	+3	0	0	0	+3	+3
200	0	-7	-7	+3	+3	0	-4	-4	+3	+3
250	0	-7	-7	+4	+4	+1	-5	-6	+4	+3
300	+1	-5	-6	+5	+4	+1	-5	-6	+5	+4

Room Temperature: 75°F
Cold Test Temperature -65°F
Hot Test Temperature +160°F

TABLE 2

SPIRAL BOURDON CALIBRATION AND LINEARITY TEST DATA

TEST POINT (PSI)	ANGULAR OUTPUT (DEGREES) #1	#2	#3	#4	#5	#6	#7	#8
150	97	98	92	96	91	95	93	93
300	200	199	200	199	198	198	201	198
% ANGULAR OUTPUT FOR 50% INPUT	46.5	49.3	46.0	48.2	45.8	48.0	46.3	46.9
LINEARITY %	1.5	0.7	4.0	1.8	4.2	2.0	3.7	3.1

TEST POINT (PSI)	ANGULAR OUTPUT (DEGREES) #9	#10	#11	#12	#13	#14	#15	#16
150	96	95	98	96	91	91	94	96
300	199	199	201	200	199	200	200	200
% ANGULAR OUTPUT FOR 50% INPUT	48.4	47.7	48.8	47.9	45.8	45.5	47.1	48.1
LINEARITY %	1.6	2.3	1.2	2.1	4.2	4.5	2.9	1.9

TABLE 3

TYPICAL CALIBRATION DATA WITH NON-LINEAR DIAL

INPUT PSI	ERROR IN PSI #1	#2	#3	#4	#5
0	-5.5	+3.5	+3.0	-3.5	-7.5
50	-2.5	-1.0	+2.0	-4.0	-4.0
100	+1.5	-1.5	0	-3.5	-2.0
150	+0.5	0	-0.5	-1.0	0
200	-1.0	+3.0	-1.0	-2.0	0.5
250	-2.5	+6.0	+2.5	-0.5	+1.5
300	-4.5	+7.5	+4.0	+1.0	+2.0

(c) Assuming a Bourdon having a nominal angular output of 230° ±30° for a 6" long spiral, a dial graduated over 200 angular degrees for 300 psi input was used. The motion takeoff can then be adjusted to remove active material from the outer coil until the 200 angular degrees is obtained. By thus controlling the total angular travel for full scale pressure, scale errors of only a fraction of that permitted were achieved, throughout the 0-300 psi range.

(d) Sixteen 0-300 psi spiral Bourdons were used to perform linearity tests and to check the feasibility of the range adjustments. These Bourdons produced travels in excess of 200 angular degrees for 300 psi input. A wire pointer was attached to the outer coil of the spirals at a point which produced the 200 angular degrees of travel. Pressure tests were then conducted at 150 and 300 psi. (See Table 2).

(e) The linearity error varied between -0.7% and -4.5%. The average non-linearity was 2.5%. A 300 psi scale with the 150 psi point at 47.5% of full arc was designed for use on the sixteen Bourdons.

(f) The sixteen Bourdon assemblies were calibrated against this dial to determine if the scale error tolerance could be met. All specimens calibrated were judged sufficiently accurate to allow for subsequent shifts resulting from exposure to severe environmental conditions. (See Table 3 for Typical Calibrations.)

(g) The specification requires the gauge to withstand an overpressure of 500 psi. Several spiral Bourdon tube assemblies, delivering 200 angular degrees, for 300 psi, were equipped with stops to limit the free travel of the Bourdon to approximately 225 angular degrees. Upon application of the 500 psi, the Bourdons distorted and exhibited severe zero shifts. In some cases the outer coil straightened and the Bourdon became inoperable. These particular Bourdons were age hardened at 900°F for three hours to obtain maximum burst pressure.

(h) An additional group of Bourdons was heat treated at 600°F for three hours. These were assembled and equipped with stops and subjected to five cycles of 0-525 psi. After cycling, the specimens were overpressure tested by subjection to 500 psi for ten minutes. Upon removal of the pressure, the Bourdons exhibited no observable set.

3. <u>Helical Bourdon Tube</u>

(a) It was determined that with some minor changes in the contact angle of the coiling point and the tubing, helical tubes could be fabricated on the same equipment as used for the spiral tubes. The helices produced by the machine used, delivered counter-clockwise rotation to the indicating pointer. Since this work phase was involved in prototype effort only, no useful purpose would have been served by expending effort to produce coils of opposite rotation.

(b) A test lot of helical Bourdon tubes was coiled as above to develop the tubing size and configuration which would produce tip travels consistent with those defined for the spiral Bourdon. (Reference paragraph 2 above.) The angular travels and linearities observed on two typical assemblies are shown in Table 4.

(c) These data indicate the helical Bourdons exhibited more non-linearity than the spiral Bourdons. By using a slightly heavier section and more turns, helical Bourdons exhibiting linearities comparable to the spirals could be obtained.

4. Preliminary Environmental Tests

(a) General Remarks

(1) Our more extensive manufacturing experience in the spiral Bourdon field permitted the utilization of available hardware to perform tests without actual fabrication of the final gauge. In order to produce a mock-up of the helical design, it was necessary to fabricate final hardware. Therefore, preliminary environmental tests were not conducted on the helical design except as noted under "Pulse Amplitude".

(2) The necessary debugging of the helical design was conducted during the final Phase II tests. In the event of a failure, the unit was repaired and retested to that particular environmental condition which caused failure.

(b) Acceleration Tests

(1) One spiral internal assembly identical to that proposed was prepared and subjected to the acceleration test. The unit was calibrated to produce 200 angular degrees for 300 psi input. This necessitated the pointer to be positioned approximately 1/2 coil from the tip of the Bourdon. (See Table 5.)

(2) The acceleration forces in the direction of 12 o'clock to 6 o'clock caused an average shift of approximately 15 psi. It was determined that the shift in scale calibration was a result of the center coil of the Bourdon being deformed by the pressure of the outer coils at high acceleration.

(3) The center coil suffers a loss in physicals due to the high temperature (1200°F) necessary to silver solder the

TABLE 4

ANGULAR OUTPUT OF HELICAL ELEMENTS

	1		2	
INPUT (PSI)	OUTPUT (DEGREES)	% OF ANGULAR OUTPUT	OUTPUT (DEGREES)	% OF ANGULAR OUTPUT
0	0	0	0	0
25	14		7	
50	28		20	
75	42	21.4	37	18.5
100	56		52	
125	72		68	
150	88	45	84	42
175	104		104	
200	120		120	
225	138	70.5	141	70.5
250	156		159	
275	176		182	
300	196	100	200	100

TABLE 5

PRELIMINARY ACCELERATION FOR SPIRAL BOURDON GAUGE TEST DATA

SCALE ERROR PSI

INPUT PRESSURE PSI	PRIOR TO DECELERATION	AFTER ACCELERATION 3X FROM 3500 RPM (2500 g's RADIAL AND 75 g's TANGENTIAL MIN.	
		ACC. DIRECTION	
		3 o'clock to 9 o'clock	12 o'clock to 6 o'clock
0	+4	0	-19
50	+6	+5	-15
100	+6	+5	-12
150	+4	+2.5	-11
200	-1	-2	-11
250	-4	-4	-13
300	-6	-3	-14

Bourdon to the socket. Depending on the direction of the acceleration forces, the point where the inner coil is attached to the socket may or may not have been subjected to these deforming forces. The lower tensile strength of the inner coil permitted the entire Bourdon to shift and assume a new center with respect to the dial.

(4) As the gauge must withstand 350°F, the Bourdon must be silver soldered to the connection. With production soldering equipment we expect the degradation in the physicals will be reduced, but this condition cannot be eliminated completely. A Teflon bushing was designed to fit snugly over the socket shank with an outside contour spiraled to match the inner coil. This provides sufficient support for the inner coil to prevent distortion under acceleration and shock loads.

(5) The damaged unit was equipped with the support bushing described above and subjected to the acceleration test. (See Table 6) Since the added bushing firmly supports the inner coil and restricts any motion output from that coil, a loss in tip travel was noted. No attempt was made to restore the output motion to 200° for the remaining portion of these tests.

(6) The results of tests shown in Table 6 indicate that the spiral Bourdon with a center support bushing for the inner coil meets the acceleration (reliability) requirements of the specification.

(c) Vibration Tests

(1) The spiral mock-up was subjected to the vibration test in accordance with Paragraph 4.6 of TS-701. (U. S. Gauge Tentative Test Specification.) This specification requires vibration testing in accordance with MIL-STD-810, Method 514. The required vibration program is as follows:

CPS	DISPLACEMENT
5-14	.100
14-23	1g
23-90	.036
90-500	15g

Resonance scanning was conducted in each of three mutually perpendicular planes to determine the resonance points. Since no resonance was observed, the unit was subjected to an endurance vibration test for three hours in each plane as required by the time table, Figure 514-II

TABLE 6

SPIRAL BOURDON GAUGE ACCELERATION TEST DATA AFTER MODIFICATION

INPUT PRESSURE PSI	ERROR (PSI) BEFORE ACCELERATION	ERROR PSI AFTER ACCELERATION *
0	+3	+3
50	-1	-1
100	-6.5	-7
150	-14	-14
200	-17	-18
250	-18	-19
300	-20	-21

*The acceleration test was conducted in each of 12 directions (each 30° of gauge rotation). Three cycles were applied in each of the 12 directions. No zero shift of the pointer occurred after each cycle of deceleration. The final scale error test was conducted upon completion of the test.

of MIL-STD-810. Scale error tests were conducted after endurance vibration in each of the three planes. (See Table 7).

(2) The vibration data from Table 7 indicated the proposed spiral Bourdon would meet the vibration requirements of the specification.

(d) Mechanical Shock Tests - The same spiral mock-up was subjected to mechanical shock tests in accordance with paragraph 4.8 of TS-701. The shock tests were conducted on a Barry Drop Tester, Type 20 VI, in each of three mutually perpendicular planes. No effect on scale calibration resulted from this test. (See Table 8)

(e) Pulse Amplitude Tests (See Table 9)

(1) At the start of this program there was no requirement for a Pulse Amplitude Test. In reviewing the design requirements with the Air Force Project Engineer, it appeared necessary to qualify the Bourdon tubes on their ability to withstand pressure impulses (simulating the pressure pulse of a landing).

(2) A pressure cycle of 175 to 500 psi and back to 175 psi was assumed for this test.

(3) In all cases of failures, fracture occurred on the outer coil beyond the point of motion takeoff. This failure was a result of permitting the Bourdon section beyond the takeoff point to flex freely. The active portion of the Bourdon was not permitted to flex this far, and is likely to have had a much longer impulse life than was noted.

(4) As a result of the suggestion to incorporate a Pulse Amplitude Test, an amendment to the work statement was requested to add to U. S. Gauge "Tentative Test Specification" TS-701, paragraph 5.5, "Pulse Amplitude Test". This request was granted and the procedure specified by the USAF. The requirement is noted in attached TS-701. It can be seen that this requirement is considerably less severe than the tests performed and therefore we were confident that no difficulty would be encountered from the final Pulse Amplitude Test. No further effort was directed to increase impulse life.

TABLE 7

SPIRAL BOURDON GAUGE VIBRATION TEST DATA

INPUT PRESSURE (PSI)	SCALE ERROR PSI			
	BEFORE VIBRATION	AFTER VIBRATION* PLANE #1	AFTER VIBRATION* PLANE #2	AFTER VIBRATION* PLANE #3
0	+3	+2	+1	+1
50	-1	-1	-3	-3
100	-7	-8	-7	-9
150	-14	-14	-13	-14
200	-18	-18	-18	-19
250	-19	-20	-20	-20
300	-21	-21	-22	-22

*Plane 1 - Gauge face vertical
Plane 2 - Gauge face horizontal - Normal Readout
Plane 3 - Gauge face horizontal - 90° from normal readout.

TABLE 8

SPIRAL BOURDON GAUGE MECHANICAL SHOCK TEST DATA

INPUT PRESSURE PSI	SCALE ERROR (PSI) BEFORE MECHANICAL SHOCK	AFTER * MECHANICAL SHOCK
0	+1	+1
50	-3	-2
100	-9	-9
150	-14	-15
200	-19	-18
250	-20	-20
300	-22	-22

*Three 15 g shocks in two directions of each of three mutually perpendicular planes.

TABLE 9

SPIRAL AND HELICAL BOURDON
PRELIMINARY PULSE AMPLITUDE TEST DATA

	UNIT #	NUMBER OF CYCLES AT FAILURE	CAUSE OF FAILURE
Spiral Bourdon	1	804	Bourdon Tube Fracture
	2	835	Bourdon Tube Fracture
	3	1100	Bourdon Tube Fracture
	4	1400	Bourdon Tube Fracture
Helical Bourdon	1	8000	Test Equipment failed to cycle full range.

C. DESIGN OF DEVELOPMENTAL MODELS

1. Pressure Elements

(a) Spiral Bourdon Tube - The Phase II prototype spiral Bourdons were coiled from .0775 o.d. x .0032 wall BeCu tubing. These Bourdons have approximately 6" of raw tubing formed to obtain 4-5 active coils. This configuration consistently produces a minimum of 200 angular degrees for 300 psi applied pressure. After forming, the Bourdons are heat treated at 600°F for a period of three hours to obtain maximum tensile strength. With this age hardening, the units are capable of withstanding the required 66% overpressure without damage. The inner coil is formed across the center of the spiral to provide for assembly to the connectors and subsequent pressure sealing by silver soldering. (See Figure 15)

(b) Helical Bourdon Tube - The helical Bourdon tubes were also fabricated from .0775 o.d. x .0032 wall beryllium copper tubing. The free length of the helix is 1-1/2" which is made up of 10 active coils formed on a coiling diameter of approximately 7/32 o.d. This Bourdon will produce a minimum of 200 angular degrees for 300 psi applied pressure. The age hardening and method of socket connection and pressure sealing are identical with the spiral. (See Figure 16.)

2. Housing - The basic housing design which was selected by the USAF Project Engineer is shown in Figure 6. This drawing illustrates general outline features only. The final configuration, size, etc., was dependent upon further development of the gauge internals and review of the method of mounting to the wheel rim. Reference is made to Figure 17 of this report for the final housing definition and outline dimension. This drawing illustrates a complete tire inflation indicator with the helical Bourdon gauge installed. The spiral Bourdon design is completely interchangeable except that the gross weight retaining ring markings would be reversed. The housing material of the Phase II prototype was aluminum. Final material specifications will depend on the wheel rim material (aluminum or magnesium).

3. Dial - At the conclusion of Phase I, the USAF Project Engineer specified a dial to be marked with graduations at 5 psi intervals (reference CSK-9426-C #9, Figure 8). It was agreed at that time to use lines for 10 psi intervals and small dots for 5 psi intervals. This permits an inspector to accurately read the pressure at a close distance but will not blur the dial markings when read at a distance of 3 to 6 feet during walk around inspections. A green sector from 75 to 175 psi was provided to indicate the operating range.

Fig. 15

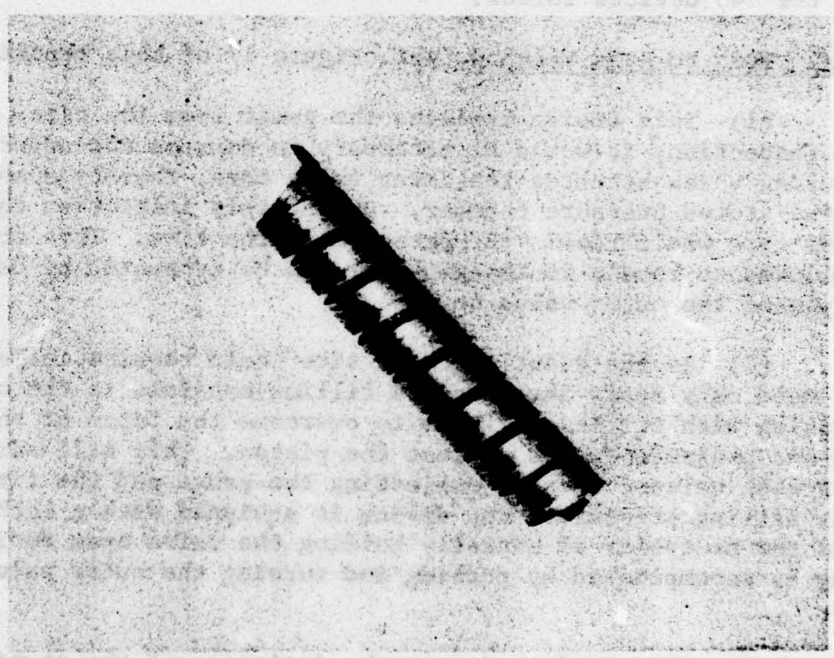


Fig. 16

(a) It was proposed by the USAF Project Engineer to adjust the total range so that the operating range (green sector) would center on 12 o'clock. A Bourdon delivering 200 angular degrees output for 250 psi applied pressure would be required to withstand 100% overpressure (500 psi) without loss in calibration. This would result in a less reliable element than the proposed 300 psi element with a 67% overpressure requirement. We therefore provided the prototypes with dials graduated 0 to 300 psi. In the event it is desired to center the sector, this could be graduated 0 to 250 psi only and thereby reduce the dial arc to approximately 160 angular degrees. The Bourdon element used would be the same as for the Phase II model.

(b) The dials for both the spiral and helical Bourdon designs are identical except reversed in direction.

4. <u>Fail Safe Devices</u> - The USAF proposed at the conclusion of Phase I, that two Fail Safe Devices be developed. Both of these are included in the Phase II prototypes for evaluation purposes. It was agreed only one of these would be incorporated in the final design. The selection of the particular fail safe device to be used is dependent on whether it would be acceptable to "push to read" the tire gauge. With this design the filter would not be necessary. On the other hand, if "push to read" is objectionable, then the filter would be required. Definition of the two devices follow:

<u>(a) Push to Read Valving</u> (Ref. Figure 17 of this report)

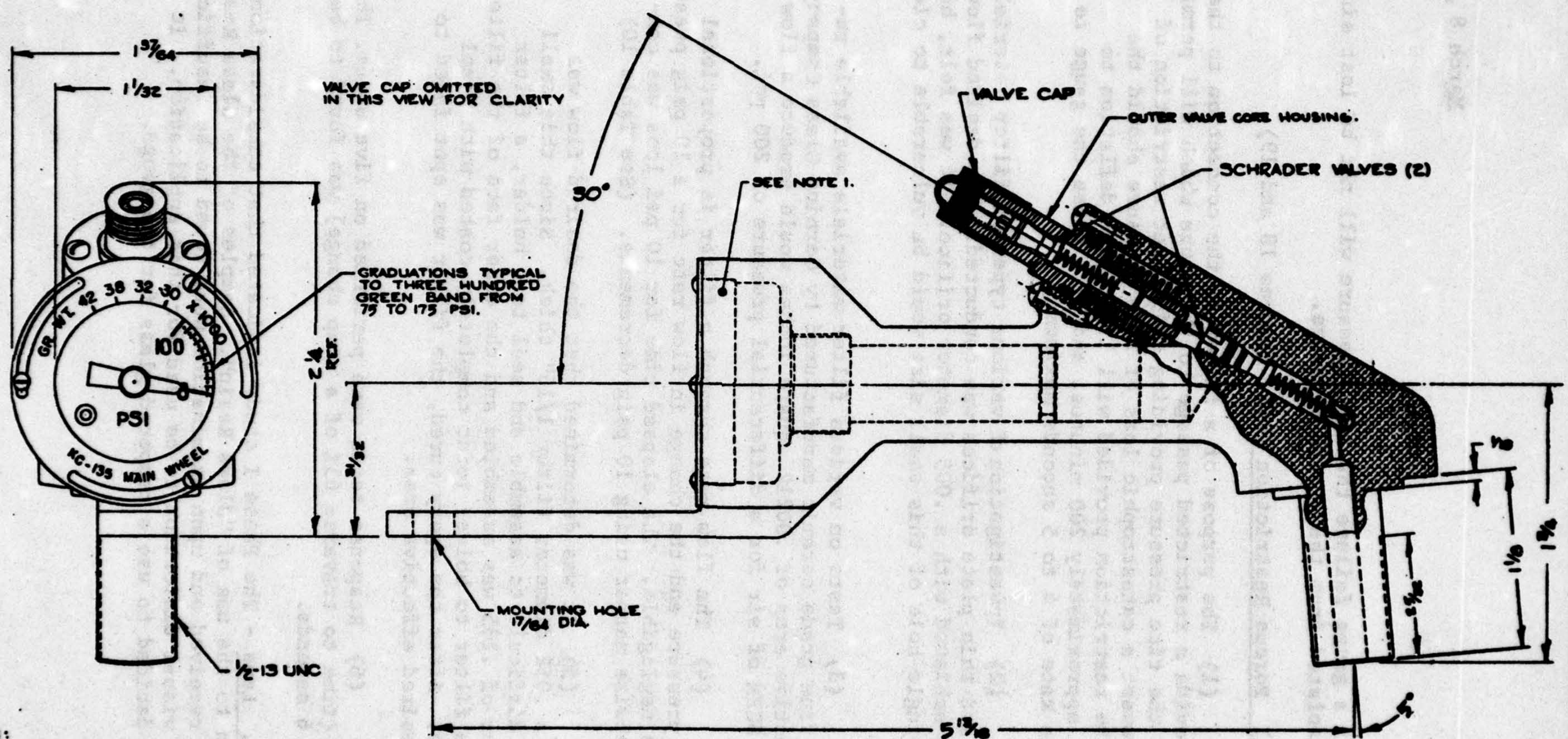
(1) This design isolates the gauge from the tire. During ground inspection, it would be necessary to depress the outer valve stem housing which actuates the inner valve core, thereby opening the gauge to the stored pressure chamber. During this inspection check, the outer valve core would retain the pressure in the tire. This pressure can be allowed to remain in the gauge or can be exhausted by depressing the pin of the outer valve core.

(2) In the event that the tire would require inflation, the inspector need only apply the standard filling manifold to the outer valve stem housing with sufficient force to overcome the force of the return spring and pressure forces against the piston. This will simultaneously open both valves, thereby subjecting the gauge and the tire chamber to the filling pressure. The device is equipped with a locking means to avoid the necessity of manually holding the valve open during fill. Locking is accomplished by pushing and turning the outer valve housing.

(3) This design, due to the isolation of the stored pressure, would eliminate the need for the gauge to withstand the overpressure pulse encountered during landing of the aircraft. Furthermore,

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-640-A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



NOTES:

1. FOR PURPOSES OF GAUGE MOUNTING DETAIL, HELICAL BOURDON DESIGN GAUGE IS SHOWN ASSEMBLED INTO HOUSING. SPIRAL BOURDON DESIGN IS INTERCHANGEABLE EXCEPT DIAL MARKINGS ARE REVERSED.
2. SIZES & POSITIONS OF WHEEL MOUNTING DETAIL ARE FOR KC-135 AIRCRAFT.
3. VALVE FUNCTION–
   A. TO PRESSURE GAUGE, DEPRESS OUTER VALVE CORE HOUSING.
   B. TO BLEED GAUGE, DEPRESS OUTER VALVE CORE.
   C. FOR TIRE FILLING & BLEEDING PURPOSES, OUTER VALVE CORE HOUSING CAN BE LOCKED TO "IN" POSITION BY DEPRESSING & ROTATING. TO RELEASE, ROTATE VALVE CORE HOUSING.

Fig. 17

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		DATE
	DRAWN C.B	5-7-65
	TRACED	
	CHECKED J. D. FULMER	5-10-65
MATERIAL	APPROVED R. D.W.	5-8-65
	USED ON	
	NEXT ASS'Y	
	SUPERSEDES	
SPECIFICATION		
TREATMENT		
FINISH		

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE
OUTLINE DRAWING
TIRE INFLATION INDICATOR

CODE IDENT. NO.	SIZE	DWG. NO.	
61349	0	CSK-9426-H	
SCALE 2:1			SHEET

[redacted]

in the event of a gauge failure the tire pressure will not be lost since the gauge is isolated from the stored pressure.

(b) Porous Restriction (Ref. Figures 18 and 19)

(1) The purpose of a filter in the connection to the gauge is to provide a restricted passage to the gauge which will permit it to indicate the tire pressure providing sufficient restriction of air flow to prevent a catastrophic loss of tire pressure should the gauge fail. The restriction provided will limit tire deflation to 10 psi loss in approximately 200 minutes, and will cause the gauge to have a response rate of 4 to 5 seconds maximum.

(2) Investigation of various types of filter materials and densities and thin plate orifices was conducted. The desired flow rates could be achieved with a .005 diameter orifice. It was felt, however, that a single hole of this small size would be vulnerable to clogging.

(3) Tests on various filter materials available revealed that a fine grade ceramic manufactured by Corning Glass Company having an effective area of .00212 square inches would produce a flow rate of .0355 SCFM of air for a differential pressure of 200 psi.

(4) The flow rate through a filter is proportional to the supply pressure and the change in flow rate for a 10 psig pressure change is negligible. The elapsed time for 10 psi loss was computed in a stepwise manner using 10 psig decrements. (See Table 10)

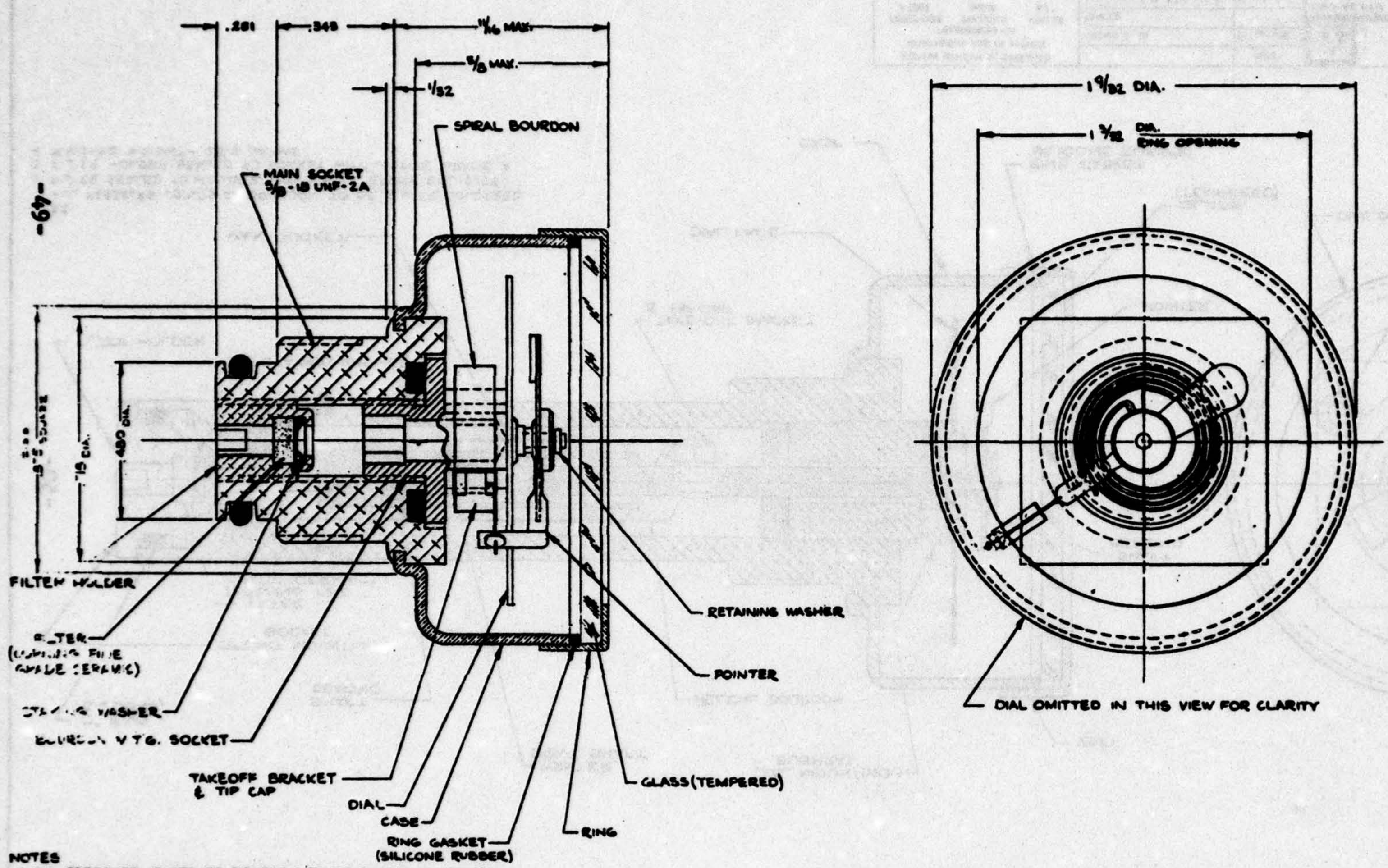
(5) It was determined that the desired flow was obtained with a .052 diameter filter 1/16" thick. Since this small size would be difficult to assemble and seal to a holder, a filter with a diameter of .135 was assembled and the outer face of the filter and around the filter to holder joint completely coated with Hysol ERL-2795 epoxy. After the epoxy cured, the filter was spot faced to produce the desired effective area.

(6) Response tests were performed on five units. The response time (time to traverse 63% of a step change) was found to be between 4 and 6 seconds.

5. Lens - The Phase I study indicated that consideration would be given to the use of "Glass Resin". Samples of the Glass Resin material were received and upon examination were found to be insufficiently free of visual distortion to be used for this application. It was therefore decided to use a tempered glass for the gauge.

LIMITS OF ACCEPTABLE W... ...SHIP ARE DEFINED IN MS-005A

REVISIONS				
SYM		DESCRIPTION	DATE	APPROVED
1		ADDED OUTLINE DIMS.	8/7/65	J.D. FULMER



NOTES
1. ALL PRESSURE JOINTS OF BOURDON TO BE SILVER SOLDERED.
2. FILTER SEALED TO HOLDER WITH HYSOL EPOXY, ERL-2795.
3. FILTER HOLDER SEALED TO MAIN SOCKET WITH LOCTITE, GRADE A.
4. FINISHED WEIGHT - 17 GRAMS

Fig. 18

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH ... MAX.		DATE
	DRAWN C.B.	5-10-65
	TRACED	
	CHECKED J.D. FULMER	5-10-65
	APPROVED R.D.W.	5-13-65
MATERIAL	USED ON	
	NEXT ASS'Y	
	SUPERSEDES	
SPECIFICATION		
TREATMENT		
FINISH		

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

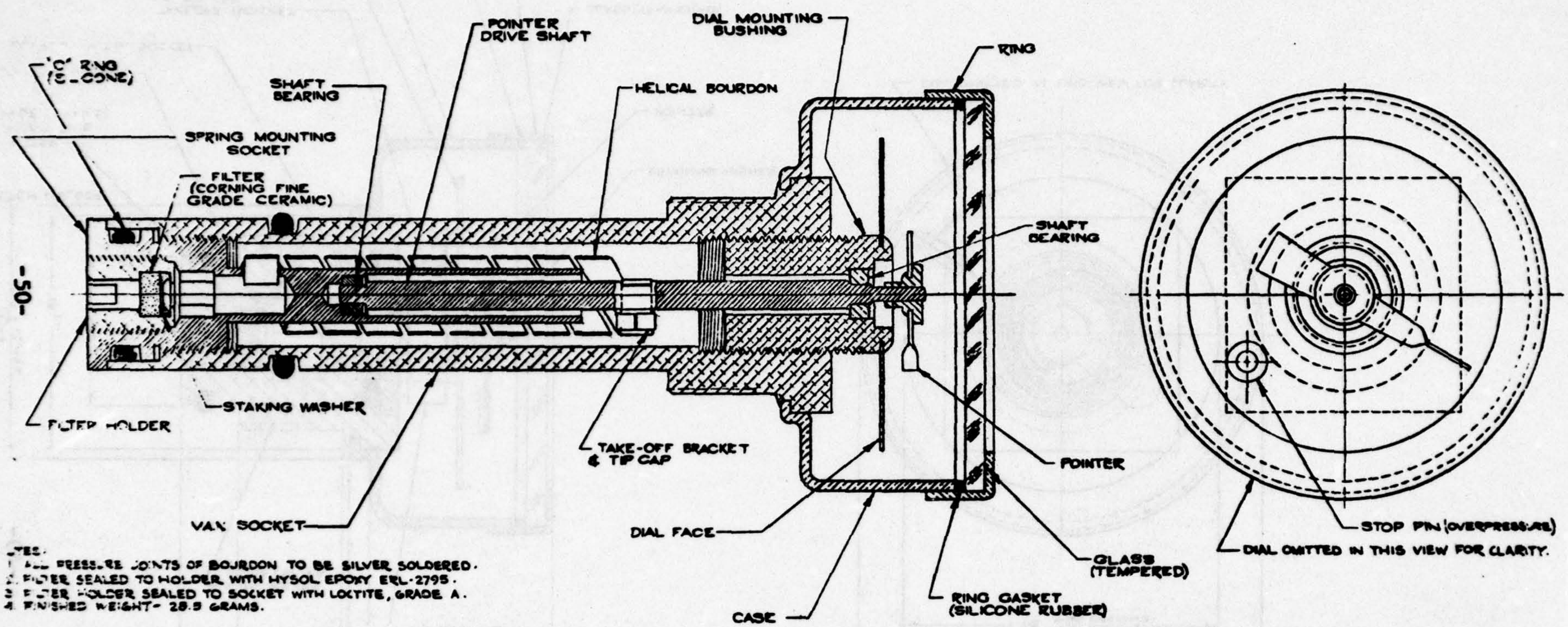
DRAWING TITLE
ASSEMBLY - SPIRAL BOURDON DESIGN
TIRE INFLATION INDICATOR

CODE IDENT. NO.	SIZE	DWG. NO.
61349	C	CSK-9426-I
SCALE 4:1	DRAW ...	SHEET

[redacted]

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-648-A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



NOTES:
1. ALL PRESSURE JOINTS OF BOURDON TO BE SILVER SOLDERED.
2. FILTER SEALED TO HOLDER WITH HYSOL EPOXY ERL-2795.
3. FILTER HOLDER SEALED TO SOCKET WITH LOCTITE, GRADE A.
4. FINISHED WEIGHT - 28.5 GRAMS.

Fig. 19

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.			DATE
	DRAWN C. B.		5-10-65
	TRACED		
	CHECKED J. D. FULMER		5-10-65
MATERIAL	APPROVED R.D.W.		5-13-65
	USED ON		
	NEXT ASS'Y		
	SUPERSEDES		
SPECIFICATION			
TREATMENT			
FINISH			

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE
ASSEMBLY-HELICAL BOURDON DESIGN
TIRE INFLATION INDICATOR

CODE IDENT. NO.	SIZE	DWG. NO.
61349	0	CSK-9426-J
SCALE 4:1		SHEET

TABLE 10

ELAPSED TIME FOR 10 PSI PRESSURE LOSS THROUGH POROUS RESTRICTION

1	2	3	4	5	6	7	
PSIG INPUT	ROTAMETER READING	FLOW SCFM	LB. MIN	INITIAL WT. OF AIR AT PRESSURE	Δt (MIN.) PER 10 PSI DEC.	ELAPSED TIME MIN.	HRS.
200	8	.0355	.00266	11.20	211.0	211.0	3.5
190	7.8	.0340	.00255	10.65	220.0	431.0	7.2
180	7.6	.0325	.00244	10.09	230.0	661.0	11.0
170	7.3	.0305	.00229	9.53	244.0	905.0	15.1
160	7.0	.0285	.00214	8.96	262.0	1167.0	19.5
150	6.7	.0260	.00195	8.40	287.0	1454.0	24.2
140	6.3	.0235	.00176	7.84	313.0	1772.0	29.6
130	6.0	.0210	.001575	7.29	355.0	2127.0	35.5
120	5.7	.0190	.001425	6.73	393.0	2520.0	42.0
110	5.4	.0175	.00131	6.16	427.0	2947.0	49.2
100	5.1	.0160	.00120	5.60	466.0	3413.0	57.0
90	4.8	.0140	.00105	5.04	533.0	3946.0	66.0

The foregoing table was computed based on the following information:

Temperature of air in tire is constant $T = 77°F = 537°R$

Estimated Tire volume $V = 9.53\ ft^3$

Gas constant $R = 53.3\ ft.lb/lb°F$

Density of air at standard condition $D = \frac{.075\ lbm}{ft^3}$

Column 1 - Determined from assigned pressure decrements.
Column 2 - Determined from actual experimental tests.
Column 3 - Determined from associated calibration curve of rotameter.
Column 4 - Determined from relationship $\frac{SCF}{Min.}$ Density $= \frac{lbm}{Min.}$
Column 5 - Determined from formula Weight $= \frac{PV}{RT}$
Column 6 - Determined from relationship $\Delta t = \frac{\Delta P\ (.056)}{lbm/min.}$

Where ΔP = Pressure decrement
$.056 = \frac{V}{RT}$

D. TEST REQUIREMENTS FOR DEVELOPMENTAL MODELS

1. Test Specification (TS-701)

(a) Tentative Test Specification, TS-701, was proposed and submitted to the USAF Project Engineer. In addition to the requirements set forth at that time, Paragraph 5.5 "Pulse Amplitude Test" was added. (See paragraph E of Section II of this report for detail.)

(b) All tests on Phase II prototypes were conducted according to the requirements set forth in this specification.

2. Test Program

(a) Specimen Number	Tests
1	TS-701, paragraphs 3.1, 3.2, 3.3, 5.3, 3.2, 3.3, 5.2, 3.2, 3.3
2 and 3	TS-701, paragraphs 3.1, 3.2, 3.3, 4.2, 4.3, 3.2, 3.3, 4.4, 3.2, 3.3, 4.5, 3.2, 3.3, 4.6, 3.2, 3.3, 4.8, 3.2, 3.3, 5.1, 3.2, 3.3, 5.5, 3.2, 3.3
4 and 5	TS-701, paragraphs 3.2, 3.3, 25 cycles of 5.4, 3.2, 3.3, 75 cycles of 5.4, 3.2, 3.3, 125 cycles of 5.4, 3.2, 3.3, 200 cycles of 5.4, 3.2, 3.3, 300 cycles of 5.4, 3.2, 3.3, 400 cycles of 5.4, 3.2, 3.3

(b) Specimen Number	Description
1	Housing with Spiral Bourdon Internals
2 and 4	Spiral Bourdon Internals
3 and 5	Helical Bourdon Internals

Note on Specimen 1: - The acceleration equipment did not have sufficient capacity to handle this relatively large mass, as it was designed for evaluating the gauge only. The salt spray tests could be performed but sand and dust test equipment was not available at USG. As the salt spray tests should be the last performed on the unit, USAF agreed that these tests would be conducted at Wright Field.

3. <u>Environmental and Reliability Test Equipment</u>

Test Req., TS-701	Description of Equipment
Vibration Error, Para. 4.6	MB Model C10VB Vibration System
Mechanical Shock, Para. 4.8	Barry Drop Tester, Type 20 VI
Acceleration Test, Para.5.4	Built by USG for contract AF33(657)12491

(a) Acceleration Machine - In order to apply the required centrifugal acceleration of 3000 g's, and tangential acceleration of 50 g's to the specimens, it was necessary to design and build a machine capable of producing these g forces. Centrifugal accelerations were obtained by rotation and the tangential accelerations by angular deceleration of the machine and specimen (braking). The machine used for these tests is described below.

(1) The braking mechanism in the machine is made from a standard Chevrolet clutch-fly wheel assembly. In order to reduce the braking mass, the function of the clutch is reversed. The heavy fly wheel is mounted on a stationary upright member. The clutch plate disc is driven by the shaft to which the specimen plate is mounted. The shaft is driven by a variable speed (0-1800 rpm) electric motor from a 10" diameter pulley. The shaft is equipped with a 3-step pulley with 3", 3-3/4", and 4" diameter steps. This gives the machine the capability of being rotated at an angular velocity of up to approximately 6000 rpm. When the clutch is disengaged, the shaft is allowed to rotate freely. Upon reaching the predetermined speed, the clutch is engaged to reduce the angular velocity to zero within the time required to achieve 50 g tangential deceleration.

(2) Machine Design Computations - A 6" radius for the specimen was first selected as a convenient dimension, hence:

Let A_T = tangential acceleration in ft/sec^2

A_R = radial acceleration in ft/sec^2

ω = angular velocity in radians/sec

α = angular acceleration in radians/sec^2

t = time in seconds

Given:

$$A_T = (50 \text{ g's})\ (32.17 \text{ ft/sec}^2) = 1610 \text{ ft/sec}^2$$

$$A_R = (3000 \text{ g's})(32.17 \text{ ft/sec}^2) = 96{,}500 \text{ ft/sec}^2$$

$$r = 0.5 \text{ ft.}$$

To find the angular velocity necessary to obtain a radial acceleration of 3000 g's

$$A_R = \omega^2 r$$

Transposing $\omega = \sqrt{\dfrac{A_R}{r}}$

$$= \sqrt{\frac{96{,}500 \text{ ft}}{\text{sec}^2} \times \frac{1}{0.5 \text{ ft.}}}$$

$$= \sqrt{\frac{1.93 \times 10^5 \text{ radians}}{\text{sec}^2}}$$

$$\omega = \frac{438 \text{ radians}}{\text{sec.}} = 4180 \text{ rpm}$$

To find the angular deceleration necessary to obtain a tangential deceleration of 50 g's

$$A_T = r\alpha$$

Transposing $\alpha = \dfrac{A_T}{r}$

$$\alpha = \frac{1610 \text{ ft.}}{\text{sec}^2} \times \frac{1}{0.5 \text{ ft.}}$$

$$\alpha = \frac{3220 \text{ radians}}{\text{sec}^2}$$

To find the braking time necessary to obtain a tangential deceleration of 50 g's

$$= \frac{d}{dt}$$

$$dt = d$$

$$dt = \frac{438 \text{ radians}}{\text{sec.}} \times \frac{\text{sec}^2}{3220 \text{ radians}}$$

$$t = .141 \text{ seconds to change from}$$

$$\frac{3220 \text{ radians}}{\text{sec}^2} \quad \text{to} \quad \frac{0 \text{ radians}}{\text{sec}^2}$$

(3) Radial acceleration was easily determined by measurement of the rpm rate of the specimen plate using a strobe light. Tangential acceleration was more difficult to measure. To verify whether the machine would generate a 50 g tangential component it was equipped with a #2213 Endevco Accelerometer. This accelerometer's performance was marginal at the low frequency (approximately 1 cps) signal generated by the tangential accelerations. This accelerometer and other low frequency accelerometers commercially available all have crosstalk errors. When a load of 3000 g's is exerted transverse to the sensitive axis of these transducers, the error at the output is so high as to render the readings unusable. It was decided to use the #2213 Endevco, together with high speed motion pictures to determine whether a correlation between the values of acceleration obtained by both means could be made. The sensitive axis of the accelerometer was oriented in the direction of the tangential acceleration. The accelerometer signal was commutated and fed into a #2614 Endevco Amplifier. The output of the amplifier was recorded on a Hughes Aircraft Mem-Scope #104 thereby displaying the acceleration pattern.

(4) Test cycles were conducted by braking to zero from speeds of 2500 and 3500 rpm. High speed film was analized by noting the change in position in degrees rotation of the specimen plate for each two frames of film.

(5) Assuming the time intervals between frames to be constant, the angular displacement for each two frames is proportional to the angular velocity. This velocity was plotted in Figures 20 and 21 which clearly show the constant velocity before braking and the average deceleration as a line sloping down to the right. Average decelerations of 79.4 and 107.2 for initial speeds of 2500 rpm and 3500 rpm were noted.

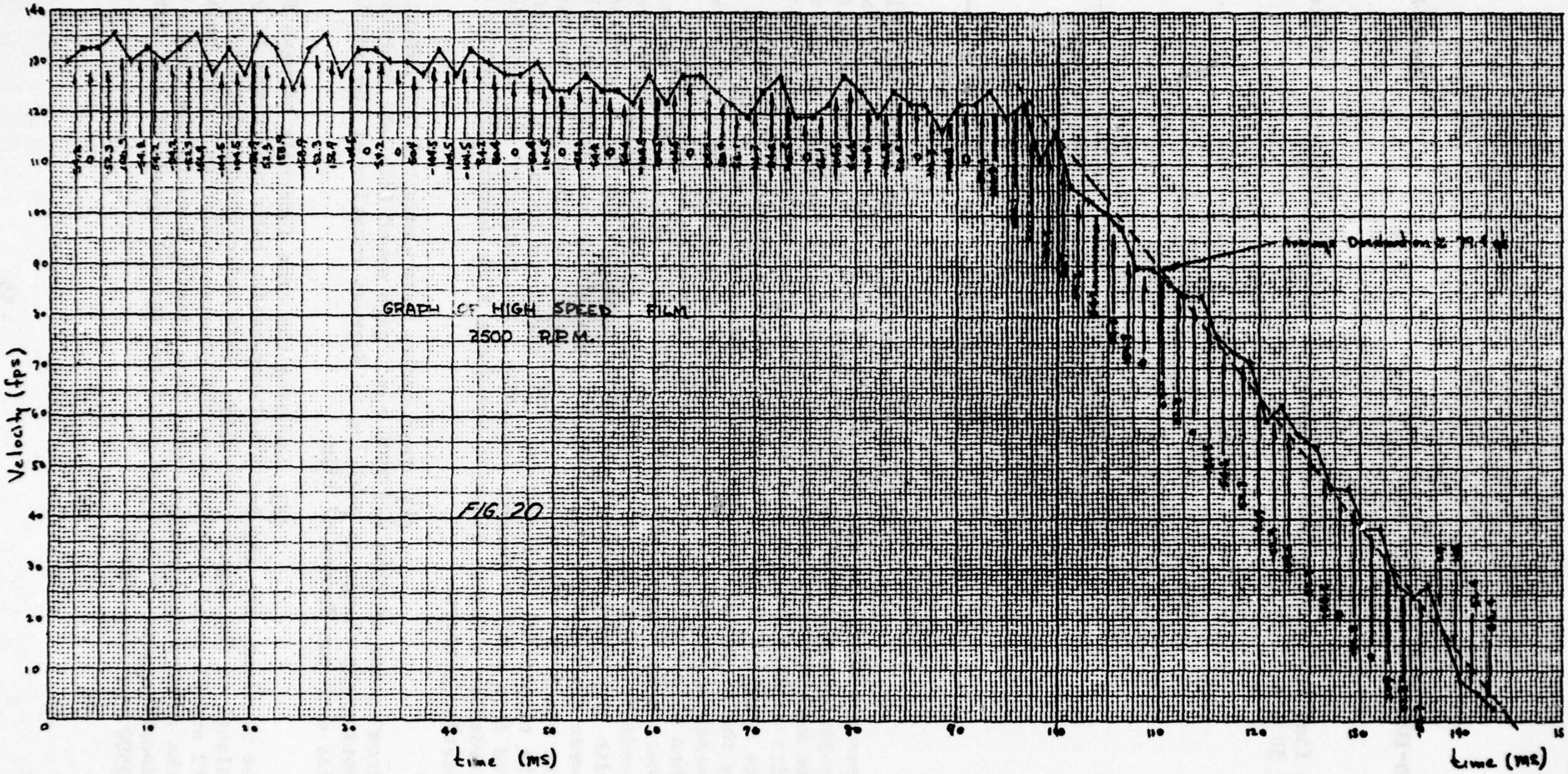
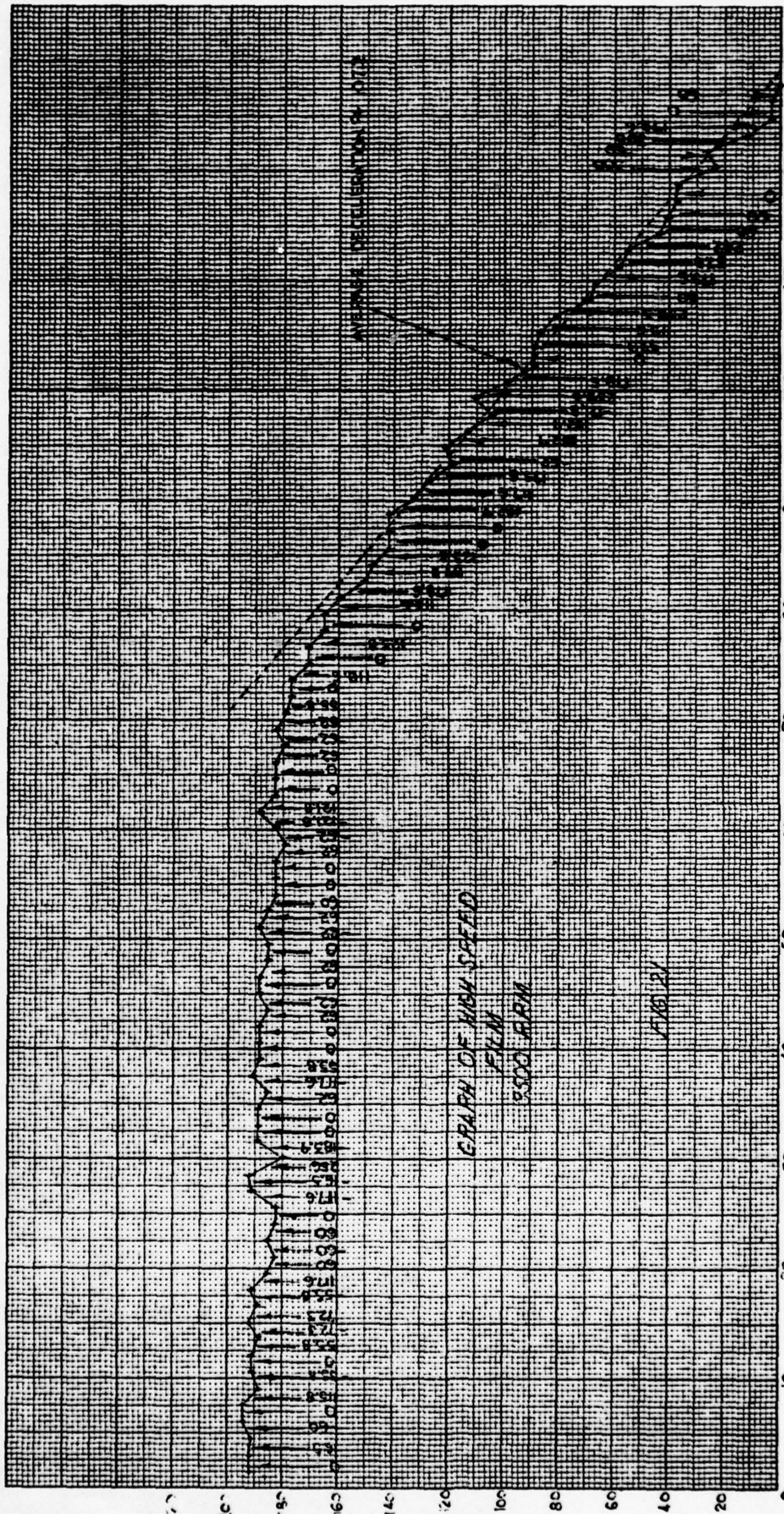


FIG. 20


GRAPH OF HIGH SPEED
FILM
9500 RPM
FIG 21
TIME (MS)
VELOCITY (FPS)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
20
40
60
80
100
120
140
160
180
200

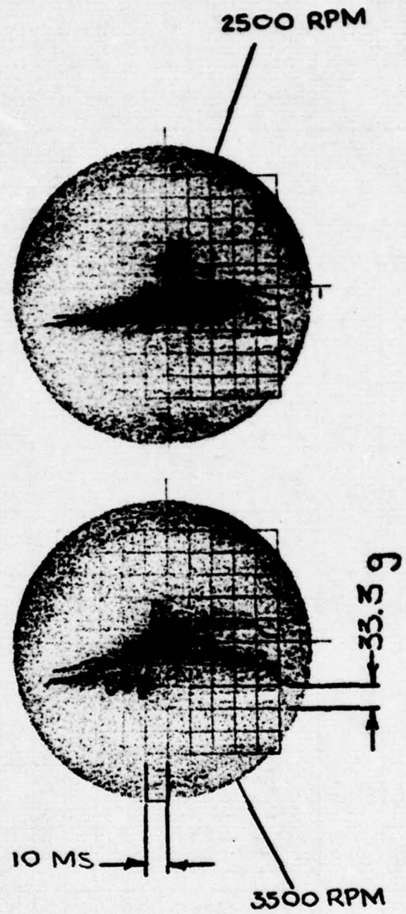


Fig. 22

(6) Figure 22 shows the Memo-Scope traces made concurrent with the high speed film graphs.

(7) It can be seen from the Memo-Scope films that the acceleration magnitudes (reading from start of trace) are approximately 116 g's for the 2500 rpm trace, and 113 g's for the 3500 rpm trace.

(8) The following values of amplitude on the Memo-Scope traces were observed: 2.25 spaces for 2500 rpm run and 2.75 spaces for the 3500 rpm run. The corresponding average deceleration taken from the high speed film plots is 79.4 g's and 107 g's.

Therefore: $\frac{79.4}{2.25} = 35$ g/space $\frac{107}{2.75} = 39$ g/space

Both these values are somewhat higher than the calibrated value of 33 g's/space for the accelerometer. Even assuming the lowest value of 33 g's/space, the tangential deceleration is in excess of the required 50 g's when braked from any speed higher than 2500 rpm.

(9) The machine as checked out above, was not capable of rotating at 4180 rpm (3000 g's radial acceleration at 6" radius). A more powerful motor (1 HP, 6500 rpm) was purchased and assembled to the machine. With the new motor the machine was capable of achieving speeds in excess of 5000 rpm (4300 g's at 6" radius).

(10) The final form of the spiral and helical designs dictated a new specimen plate mounting arrangement. As a result of this requirement the moment arm was changed from 6" to 5-9/16", which increases the rpm requirement to 4500 in order to achieve 3000 g's radial acceleration. This change in the moment arm reduced the applied tangential deceleration by 7%. However, a 7% reduction of even the lowest observed value still assures that the machine will generate a tangential component in excess of 50 g's.

E. TEST RESULTS - Tables 2 thru 32 show the results obtained of the testing performed in accordance with Paragraph II B. All test results are satisfactory and in accordance with TS-701 except for the following.

1. Vibration Error (Units 2 and 3)

(a) Spiral Bourdon (Unit 2) - After exposure to vibration endurance, this unit was intact but showed excessive friction as shown in Table 22. The pointer bearing was polished and Molykote applied to the bushing. The gauge was then retested for vibration endurance. After approximately 2/3 of the second vibration endurance test had elapsed, a fatigue break was noted in the Bourdon tube. The gauge was tested for friction and was satisfactory. The conclusion was that no increase in friction would be caused by the endurance vibration exposure.

(b) Helical Bourdon (Unit 3) - During exposure to vibration endurance, the Bourdon fractured causing a pressure leak. The unit also indicated excessive friction. In analyzing the unit, it was determined that excessive length of Bourdon was allowed to remain beyond the take off wire, causing a concentrated flexing near the point of take off. The excess material was removed and the unit resealed. The bearings were also polished and Molykote added to reduce the friction. The vibration endurance test was repeated. The unit passed all of the requirements. Tables 23 and 26 show the scale error and friction after the two vibration exposures.

2. Acceleration Test(Units 4 and 5)

(a) Spiral Bourdon (Unit 4) - After exposure of 400 simulated takeoffs and landings, the unit functioned within the requirements.

(b) Helical Bourdon (Unit 5) - The initial scale error (Table 13) indicates that the unit has excessive friction; however, since the internals and the filter assembly were already sealed to the housing it was decided to conduct acceleration without correcting the friction. The decision to waive repair at that time was in the interest of expediting the program. It was felt that incorporating a finer bearing finish and a lubricant (the need for which was evidenced on Units 2 and 3 after vibration), would have no influence on the ability of the units to withstand the high acceleration forces. The objective in conducting the acceleration was to uncover any defect that would cause a permanent shift in scale calibration or a permanent deformation to the unit. As shown in Tables 27 thru 32, the gauge calibration and function was not affected by the acceleration forces. It is therefore concluded that the helical Bourdon design is capable of passing this test.

F. ANALYSIS OF TEST RESULTS AND EVALUATION OF DESIGNS

1. The Phase II study and evaluation of prototypes has demonstrated the feasibility of a permanently attached tire inflation indicator.

2. Although difficulty with friction on both the spiral and helical designs was encountered, it has been proven that by more precise bearing finish control and lubrication, the units are capable of meeting the required performance.

3. Time did not allow a detailed study of the costs of the two designs; however, an analysis of the components and assemblies indicated the helical design would be the more costly in a ratio of approximately 5:4.

TABLE 11

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE

TEST DATA (SPECIMEN 1 THRU 5)

TEST POINT	SPIRAL #2 BEFORE TAP	SPIRAL #2 AFTER TAP	SPIRAL #2 FRICTION	HELICAL #3 BEFORE TAP	HELICAL #3 AFTER TAP	HELICAL #3 FRICTION
0		-4			-6	
25	-2	-1	1	-6	-4	2
50	-1	+1	2	-5	-3	2
75	+2	+2	0	-4	-2	2
100	+4	+6	2	-3	-1	2
125	+4	+5	1	-1	+1	2
150	+4	+5	1	-1	+1	2
175	+4	+4	0	-1	+1	2
200	+3	+4	1	-1	+1	2
225	+3	+4	1	0	+1	1
250	+3	+4	1	+2	+2	0
275	+4	+5	1	+2	+2	0
300	+4	+5	1	+2	+3	1
500	-	-	-	-	-	-
300	+6	+6	0	+4	+3	1
275	+5	+4	1	+4	+3	1
250	+5	+4	1	+3	+2	1
225	+5	+4	1	+2	+1	1
200	+4	+4	0	+3	+2	1
175	+5	+4	1	+1	+1	0
150	+5	+5	0	+2	+1	1
125	+4	+4	0	+2	+1	1
100	+6	+5	1	0	-1	1
75	+3	+2	1	0	-3	3
50	+2	+1	1	-2	-4	2
25	+1	0	1	-2	-4	2
0	0	-1	1	-3	-5	2

TABLE 11-A

TEST POINT	SPIRAL #1 BEFORE TAP	AFTER TAP	FRICTION
0		-5	
25	-4	-4	0
50	-1	-1	0
75	0	0	0
100	+1	+1	0
125	0	0	0
150	+1	+1	0
175	-1	-1	0
200	-1	-1	0
225	-2	-2	0
250	-2	-2	0
275	-2	-2	0
300	0	0	0
500	-	-	-
300	0	0	0
275	-1	-1	0
250	-1	-1	0
225	0	0	0
200	0	0	0
175	+1	+1	0
150	+2	+2	0
125	+2	+2	0
100	+2	+2	0
75	+1	+1	0
50	-1	-1	0
25	-3	-3	0
0	-4	-4	0

40

TABLE 11-B

TEST POINT	SPIRAL #4 BEFORE TAP	SPIRAL #4 AFTER TAP	SPIRAL #4 FRICTION	HELICAL #5 BEFORE TAP	HELICAL #5 AFTER TAP	HELICAL #5 FRICTION
0		0			+6	
25	0	+1	1	+2	+5	3
50	+1	+1	0	+2	+5	3
75	+2	+2	0	+2	+5	3
100	+4	+4	0	+2	+4	2
125	+5	+5	0	+2	+4	2
150	+3	+3	0	+2	+3	1
175	+2	+3	1	-1	+1	2
200	+1	+2	1	-2	-1	1
225	+1	+1	0	-3	-2	1
250	0	+1	1	-4	-2	2
275	0	+1	1	-4	-3	1
300	+1	+2	1	-5	-4	1
500	-	-	-	-	-	-
300	+4	+3	1	-1	-3	2
275	+4	+3	1	-1	-3	2
250	+4	+3	1	0	-2	2
225	+3	+3	0	+2	-1	3
200	+3	+3	0	+3	0	3
175	+4	+4	0	+3	+1	2
150	+4	+4	0	+6	+3	3
125	+6	+6	0	+8	+5	3
100	+6	+6	0	+10	+6	4
75	+5	+4	1	+10	+6	4
50	+3	+3	0	+11	+7	4
25	+4	+3	1	+13	+9	4
0	+2	+1	1	+15	+9	6

TABLE 11-C

TEST POINT	SPIRAL #2 BEFORE TAP	SPIRAL #2 AFTER TAP	SPIRAL #2 FRICTION	HELICAL #3 BEFORE TAP	HELICAL #3 AFTER TAP	HELICAL #3 FRICTION
0		-4			-3	
25	-4	-4	0	-4	-3	1
50	-2	-2	0	-3	-2	1
75	-2	-1	1	-3	0	3
100	-2	-1	1	-3	-3	0
125	-3	-3	0	-1	0	1
150	-4	-4	0	-2	-1	1
175	-7	-7	0	-3	-1	2
200	-10	-10	0	-3	-3	0
225	-10	-10	0	-4	-2	2
250	-11	-10	1	-4	-2	2
275	-12	-11	1	-5	-3	2
300	-12	-11	1	-5	-3	2
500	-	-	-	-	-	-
300	-12	-12	0	-4	-4	0
275	-12	-12	0	-3	-2	1
250	-10	-10	0	-1	-2	1
225	-10	-10	0	0	-1	1
200	-7	-6	1	0	0	0
175	-6	-6	0	+3	0	3
150	-6	-6	0	+2	0	2
125	-4	-5	1	+3	+1	2
100	-2	-2	0	+3	+1	2
75	-2	-2	0	0	-1	1
50	-3	-3	0	+1	0	1
25	-4	-4	0	+1	-1	2
0	0	-2	2	-1	-2	1

TABLE 12

CALIBRATION AND FRICTION ERROR AT -65°F

ROOM TEMPERATURE +160°F, AND ROOM TEMPERATURE

TEST DATA (SPECIMEN 2 & 3)

AT ROOM TEMPERATURE

TEST POINT	SPIRAL #2			HELICAL #3		
	BEFORE TAP	AFTER TAP	FRICTION	BEFORE TAP	AFTER TAP	FRICTION
0		-4			-5	
25	-4	-1	3	-6	-5	1
50	0	+1	1	-5	-3	2
75	+2	+3	1	-3	-1	2
100	+4	+4	0	-2	-1	1
125	+4	+4	0	0	+2	2
150	+4	+5	1	0	+1	1
175	+4	+4	0	0	+2	2
200	+4	+4	0	0	+1	1
225	+4	+4	0	-1	+1	2
250	+4	+4	0	0	+2	2
275	+4	+4	0	-1	+1	2
300	+5	+5	0	0	+2	2
500	-	-	-	-	-	-
300	+6	+5	1	+3	+1	2
275	+4	+4	0	+2	+1	1
250	+4	+4	0	+4	+3	1
225	+4	+4	0	+3	+1	2
200	+4	+4	0	+4	+1	3
175	+4	+4	0	+4	+2	2
150	+5	+4	1	+5	+3	2
125	+5	+4	1	+4	+3	1
100	+4	+4	0	+4	+2	2
75	+3	+3	0	+3	0	3
50	+3	+2	1	-1	-3	2
25	+2	-1	3	0	-2	2
0	0	-2	2	-2	-4	2

TABLE 12-A

AT +160°F

TEST POINT	SPIRAL #2 BEFORE TAP	SPIRAL #2 AFTER TAP	SPIRAL #2 FRICTION	HELICAL #3 BEFORE TAP	HELICAL #3 AFTER TAP	HELICAL #3 FRICTION
0		+2			-3	
25	+2	+3	1	-5	-3	2
50	+3	+3	0	-3	0	3
75	+4	+4	0	-2	+2	4
100	+5	+5	0	0	+2	2
125	+5	+5	0	+2	+4	2
150	+5	+5	0	+2	+4	2
175	+5	+5	0	+3	+4	1
200	+5	+5	0	+2	+4	2
225	+5	+5	0	+1	+3	2
250	+5	+6	1	+4	+5	1
275	+6	+6	0	+4	+5	1
300	+6	+8	2	+5	+5	0
500	-	-	-	-	-	-
300	+12	+10	2	+7	+7	0
275	+11	+9	2	+7	+5	2
250	+9	+8	1	+8	+6	2
225	+7	+7	0	+7	+5	2
200	+7	+7	0	+7	+5	2
175	+8	+8	0	+8	+5	3
150	+9	+8	1	+8	+5	3
125	+8	+8	0	+7	+4	3
100	+9	+9	0	+6	+4	2
75	+9	+9	0	+5	+3	2
50	+8	+8	0	+2	0	2
25	+5	+5	0	0	-2	2
0	+5	+4	1	-2	-4	2

TABLE 12-B

AT +160°F

TEST POINT	SPIRAL #2 BEFORE TAP	AFTER TAP	FRICTION	HELICAL #3 BEFORE TAP	AFTER TAP	FRICTION
0		+2			03	
25	+2	+3	1	-5	-3	2
50	+3	+3	0	-3	0	3
75	+4	+4	0	-2	+2	4
100	+5	+5	0	0	+2	2
125	+5	+5	0	+2	+4	2
150	+5	+5	0	+2	+4	2
175	+5	+5	0	+3	+4	1
200	+5	+5	0	+2	+4	2
225	+5	+5	0	+1	+3	2
250	+5	+6	1	+4	+5	1
275	+6	+6	0	+4	+5	1
300	+6	+8	2	+5	+5	0
500	-	-	-	-	-	-
300	+12	+10	2	+7	+7	0
275	+11	+9	2	+7	+5	2
250	+9	+8	1	+8	+6	2
225	+7	+7	0	+7	+5	2
200	+7	+7	0	+7	+5	2
175	+8	+8	0	+8	+5	3
150	+9	+8	1	+8	+5	3
125	+8	+8	0	+7	+4	3
100	+9	+9	0	+6	+4	2
75	+9	+9	0	+5	+3	2
50	+8	+8	0	+2	0	2
25	+5	+5	0	0	-2	2
0	+5	+4	1	-2	-4	2

TABLE 13

POSITION ERROR AND OVERPRESSURE TEST DATA

(SPECIMEN 2 & 3)

TEST POINT	SPIRAL #2 POSITION NORMAL	90°CW	180°CW	270°CW	NORMAL	HELICAL #3 POSITION NORMAL	90°CW	180°CW	270°CW	NORMAL
150	+6	+7	+7	+6	+7	-3	-2	-3	-4	-3

OVERPRESSURE TEST

SCALE ERROR AND FRICTION ERROR AFTER 500 PSI FOR TEN MINUTES.

TEST POINT	SPIRAL #2 BEFORE TAP	AFTER TAP	FRICTION	HELICAL #3 BEFORE TAP	AFTER TAP	FRICTION
0		+4			-4	
25	+4	+5	1	-4	-2	2
50	+6	+6	0	-4	-2	2
75	+5	+5	0	-3	0	3
100	+7	+7	0	-2	+1	3
125	+5	+6	1	-1	+1	2
150	+7	+7	0	-2	+1	3
175	+5	+5	0	0	+1	1
200	+5	+6	1	-2	0	2
225	+4	+4	0	0	+2	2
250	+5	+5	0	+2	+3	1
275	+4	+5	1	+1	+3	2
300	+4	+4	0	+2	+3	1
500	-	-	-	-	-	-
300	+7	+5	2	+5	+3	2
275	+8	+7	1	+4	+3	1
250	+7	+6	1	+5	+3	2
225	+5	+4	1	+4	+2	2
200	+5	+5	0	+6	+3	3
175	+5	+5	0	+6	+3	3
150	+6	+6	0	+7	+4	3
125	+6	+5	1	+6	+3	3
100	+8	+7	1	+8	+4	4
75	+9	+6	3	+6	+4	2
50	+7	+5	2	+6	+2	4
25	+5	+5	0	+4	+1	3
0	+5	+5	0	0	-2	2

TABLE 14

CALIBRATION AND FRICTION ERROR AFTER HIGH TEMPERATURE EXPOSURE TEST DATA

(SPECIMEN 2 & 3)

TEST POINT	SPIRAL #2 BEFORE TAP	SPIRAL #2 AFTER TAP	SPIRAL #2 FRICTION	HELICAL #3 BEFORE TAP	HELICAL #3 AFTER TAP	HELICAL #3 FRICTION
0		-2			-4	
25	-2	-2	0	-7	-4	3
50	+0	0	0	-5	-4	1
75	+4	+4	0	-1	0	1
100	+4	+4	0	-2	-1	1
125	+5	+5	0	+1	+2	1
150	+5	+5	0	0	-2	2
175	+4	+5	1	0	+1	1
200	+3	+5	2	-2	+1	3
225	+2	+4	2	-1	+1	2
250	+3	+5	2	0	+2	2
275	+2	+5	3	0	+1	1
300	+3	+5	2	0	+2	2
500	-	-	-	-	-	-
300	+7	+5	2	+4	+3	1
275	+9	+5	4	+6	+4	2
250	+6	+5	1	+6	+4	2
225	+4	+4	0	+2	0	2
200	+5	+5	0	+6	+4	2
175	+6	+5	1	+6	+4	2
150	+5	+5	0	+7	+5	2
125	+5	+5	0	+8	+5	3
100	+6	+5	1	+6	+5	1
75	+8	+6	2	+6	+4	2
50	+6	+5	1	+6	+4	2
25	+4	+4	0	+7	+4	3
0	+4	+1	3	+6	+2	4

TABLE 15

CALIBRATION AND FRICTION ERROR AFTER MECHANICAL SHOCK TEST DATA

(SPECIMEN 2 & 3)

TEST POINT	SPIRAL #2 BEFORE TAP	SPIRAL #2 AFTER TAP	SPIRAL #2 FRICTION	HELICAL #3 BEFORE TAP	HELICAL #3 AFTER TAP	HELICAL #3 FRICTION
0		+2			-3	
25	+2	+2	0	-4	-3	1
50	+2	+2	0	-3	-2	1
75	+3	+3	0	-2	0	2
100	+3	+3	0	-2	-1	1
125	+3	+4	1	-3	-1	2
150	+4	+5	1	-3	-1	2
175	+4	+5	1	-4	-3	1
200	+4	+5	1	-4	-2	2
225	+4	+4	0	-3	-1	2
250	+3	+4	1	-2	0	2
275	+4	+5	1	-1	+1	2
300	+5	+7	2	+2	+3	1
500	-	-	-	-	-	-
300	+8	+8	0	+5	+4	1
275	+5	+5	0	+4	+3	1
250	+5	+4	1	+3	+2	1
225	+5	+5	0	+3	+1	2
200	+6	+5	1	+3	+1	2
175	+6	+5	1	-1	-2	1
150	+8	+6	2	+3	0	3
125	+8	+5	3	+2	0	2
100	+8	+6	2	+2	-1	3
75	+5	+4	1	+2	0	2
50	+5	+4	1	0	-1	1
25	+3	+3	0	-1	-2	1
0	+3	+3	0	-1	-2	1

TABLE 16

CALIBRATION AND FRICTION ERROR AFTER PULSE AMPLITUDE TEST DATA

(SPECIMENS 2 & 3)

TEST POINT	SPIRAL #2 BEFORE TAP	SPIRAL #2 AFTER TAP	SPIRAL #2 FRICTION	HELICAL #3 BEFORE TAP	HELICAL #3 AFTER TAP	HELICAL #3 FRICTION
0		+2			-4	
25	+2	+2	0	-4	-2	2
50	+2	+2	0	-4	-2	2
75	+2	+3	1	-3	-2	1
100	+3	+4	1	-3	-2	1
125	+4	+5	1	-2	-2	0
150	+4	+5	1	-3	-2	1
175	+3	+3	0	-3	-2	1
200	+4	+4	0	-3	-2	1
225	+4	+4	0	-4	-2	2
250	+3	+3	0	-2	0	2
275	+3	+3	0	-2	0	2
300	+4	+5	1	+2	+2	0
500	--	--	-	--	--	-
300	+7	+6	1	+5	+4	1
275	+6	+5	1	+4	+2	2
250	+5	+5	0	+4	+2	2
225	+4	+4	0	+2	0	2
200	+4	+4	0	+1	-1	2
175	+5	+4	1	+1	-2	3
150	+6	+4	2	+1	-2	3
125	+6	+5	1	+2	-1	3
100	+6	+6	0	+1	-2	3
75	+5	+4	1	+1	-1	2
50	+6	+4	2	0	-2	2
25	+4	+3	1	-1	-2	1
0	+3	+2	1	-2	-3	1

TABLE 17

CALIBRATION AND FRICTION ERROR AFTER VIBRATION ENDURANCE TEST DATA

(SPECIMEN 2 & 3)

Vibration Schedule
Gauge Face Vertical
Resonance 180 cps, 15g
Vibrated 1/2 hour at resonance, 2-1/2 hours cycling

Gauge Face Horizontal - Normal Readout Position
Resonance 115 cps, 15g
Vibrated 1/2 hour at resonance, 2-1/2 hours cycling

Gauge Face Horizontal - 90° from Normal Readout Position
Resonance 110 cps, 15 g
Vibrated 1/2 hour at resonance, 2-1/2 hours cycling

ROOM SCALE ERROR & FRICTION ERROR AFTER VIBRATION

TEST	SPIRAL #2		
POINT	BEFORE TAP	AFTER TAP	FRICTION
0		+2	
25	+2	+4	2
50	+2	+5	3
75	+3	+5	2
100	0	+6	6
125	0	+6	6
150	-1	+5	6
175	+3	+4	1
200	+2	+4	2
225	-2	+3	5
250	-4	+3	7
275	-2	+3	5
300	-2	+5	7
500	--	--	-
300	+20	+7	13
275	+12	+6	6
250	+8	+5	3
225	+6	+4	2
200	+10	+5	5
175	+11	+5	6
150	+20	+7	13
125	+20	+6	14
100	+20	+6	14
75	+20	+6	14
50	+16	+6	10
25	+10	+5	5
0	+7	+3	4

TABLE 17-A

Vibration Schedule

Gauge Face Horizontal - Normal Readout Position
Resonance 490 cps, 15g
Vibrated 1/2 hour at resonance, 2-1/2 hours cycling

Gauge Face Horizontal - 90° From Normal Readout Position
Resonance 325 cps, 15g and 490 cps, 15g
Vibrated 1/2 hour at each resonance, 2 hours cycling

Gauge Face Vertical
Resonance 300 cps, 15g
Vibrated 1/2 hour at resonance, 2-1/2 hours cycling

ROOM SCALE ERROR & FRICTION ERROR AFTER VIBRATION

No tests conducted due to leak in Bourdon tube.
See paragraph IV D for explanation.
See Figure for vibration error results after repair and rerun vibration.

TABLE 18

CALIBRATION AND FRICTION ERROR AFTER REPAIR OF VIBRATION FAILURE TEST DATA

(SPECIMENS 2 & 3)

TEST POINT	SPIRAL #2 BEFORE TAP	SPIRAL #2 AFTER TAP	SPIRAL #2 FRICTION	HELICAL #3 BEFORE TAP	HELICAL #3 AFTER TAP	HELICAL #3 FRICTION
0		+3			-3	
25	+4	+4	0	-3	-2	1
50	+4	+5	1	-3	-1	2
75	+4	+5	1	-2	-1	1
100	+5	+7	2	-3	-1	2
125	+4	+6	2	-2	-1	1
150	+4	+5	1	-3	-1	2
175	+4	+4	0	-2	-1	1
200	+3	+4	1	-2	0	2
225	+3	+4	1	-2	+1	3
250	+3	+4	1	-1	+2	3
275	+4	+4	0	-1	+2	3
300	+4	+4	0	+2	+5	3
500	--	--	-	--	--	-
300	+5	+5	0	+8	+6	2
275	+5	+5	0	+4	+3	1
250	+5	+5	0	+5	+3	2
225	+5	+4	1	+4	+2	2
200	+6	+5	1	+3	+2	1
175	+6	+5	1	+3	+1	2
150	+7	+6	1	+2	+1	1
125	+8	+7	1	+3	+1	2
100	+8	+8	0	+2	0	2
75	+7	+6	1	+2	0	2
50	+7	+6	1	+1	-1	2
25	+5	+4	1	0	-2	2
0	+4	+3	1	-1	-2	1

TABLE 19

CALIBRATION AND FRICTION ERROR AFTER VIBRATION ENDURANCE TEST DATA

(SPECIMENS 2 & 3)

Vibration Schedule

Gauge Face Horizontal - Normal Readout Position
Resonance 105 cps, 15g
Vibrated 1/2 hour at resonance, 2-1/2 hours cycling

Gauge Face Horizontal - 90° From Normal Readout Position
Resonance 98 cps, 15g
Vibrated 1/2 hour at resonance, 2-1/2 hours cycling

Gauge Face Vertical
Resonance
Vibrated

ROOM SCALE ERROR AND FRICTION ERROR AFTER VIBRATION

Due to leak in Bourdon tube, scale error could not be conducted. Sufficient friction analysis was conducted to prove friction error within requirements.

TABLE 19-A

VIBRATION SCHEDULE

Gauge Face Horizontal - Normal Readout Position
Resonance - 380 CPS, 15g
Vibrated - 1/2 hour at resonance, 2-1/2 hours at cycling

Gauge Face Horizontal - 90° from Normal Readout Position
Resonance - 340 CPS, 15g
Vibrated - 1/2 hour at resonance, 2-1/2 hours cycling

Gauge Face Vertical
Resonance - 270 CPS, 15g
Vibrated - 1/2 hour at resonance, 2-1/2 hours cycling

ROOM SCALE ERROR & FRICTION ERROR AFTER VIBRATION

TEST POINT	HELICAL # 3 BEFORE TAP	AFTER TAP	FRICTION
0		+4	
25	+2	+5	3
50	+3	+5	2
75	+3	26	3
100	+2	+5	3
125	+3	+6	3
150	+3	+5	2
175	+3	+5	2
200	+3	+4	1
225	+2	+4	2
250	+4	+4	0
275	+4	+6	2
300	+6	+7	1
500	--	--	-
300	+9	+8	1
275	+9	+8	1
250	+8	+6	2
225	+8	+7	1
200	+8	+6	2
175	+7	+6	1
150	+8	+6	2
125	+9	+7	2
100	+9	+7	2
75	+8	+6	2
50	+7	+6	1
25	+7	+5	2
0	+7	+5	2

TABLE 20

CALIBRATION AND FRICTION ERROR AFTER ACCELERATION ENDURANCE TEST DATA

(SPECIMEN 4 and 5)

TEST POINT	SPIRAL #4 BEFORE TAP	SPIRAL #4 AFTER TAP	SPIRAL #4 FRICTION	HELICAL #5 BEFORE TAP	HELICAL #5 AFTER TAP	HELICAL #5 FRICTION
0		+2			+9	
25	+2	+3	1	+2	+7	5
50	+2	+2	0	+2	+6	4
75	+3	+4	1	+2	+5	3
100	+4	+4	0	+4	+5	1
125	+5	+5	0	+3	+4	1
150	+3	+4	1	+2	+3	1
175	+2	+3	1	-1	0	1
200	+1	+2	1	-3	-1	2
225	+2	+2	0	-3	-2	1
250	+1	+2	1	-4	-3	1
275	+2	+2	0	-4	-3	1
300	+2	+3	1	-5	-4	1
500	--	--	-	--	--	-
300	+5	+3	2	-1	-3	2
275	+4	+4	0	-1	-3	2
250	+4	+3	1	0	-2	2
225	+4	+4	0	-2	-2	0
200	+4	+4	0	+1	-1	2
175	+5	+5	0	+2	+1	1
150	+5	+5	0	+5	+3	2
125	+6	+6	0	+7	+5	2
100	+6	+6	0	+8	+6	2
75	+6	+5	1	+9	+7	2
50	+9	+4	0	+11	+8	3
25	+3	+3	0	+13	+8	5
0	+4	+4	0	+17	+10	7

TABLE 20-A

AFTER 75 CYCLES

TEST POINT	SPIRAL #4 BEFORE TAP	SPIRAL #4 AFTER TAP	SPIRAL #4 FRICTION	HELICAL #5 BEFORE TAP	HELICAL #5 AFTER TAP	HELICAL #5 FRICTION
0		+3			+10	
25	+1	+2	1	+1	+8	7
50	+2	+2	0	+2	+7	5
75	+3	+4	1	+2	+7	5
100	+4	+5	1	+2	+5	3
125	+4	+5	1	+2	+4	2
150	+4	+4	0	+1	+3	2
175	+3	+4	1	0	+2	2
200	+2	+2	0	-3	-1	2
225	+1	+1	0	-4	-3	1
250	0	+0	0	-4	-3	1
275	0	+0	0	-5	-4	1
300	+1	+2	1	-4	-4	0
500	--	--	-	--	--	-
300	+4	+3	1	-2	-3	1
275	+4	+4	0	-2	-4	2
250	+4	+3	1	-1	-2	1
225	+4	+3	1	-1	-2	1
200	+4	+4	0	+2	-1	3
175	+4	+4	0	+3	+1	2
150	+6	+6	0	+4	+2	2
125	+6	+6	0	+6	+4	2
100	+7	+6	1	+9	+6	3
75	+6	+5	1	+9	+7	2
50	+5	+4	1	+11	+7	4
25	+4	+3	1	+13	+9	4
0	+3	+3	0	+17	+10	7

TABLE 20-B

AFTER 125 CYCLES

TEST POINT	SPIRAL #4 BEFORE TAP	SPIRAL #4 AFTER TAP	SPIRAL #4 FRICTION	HELICAL #5 BEFORE TAP	HELICAL #5 AFTER TAP	HELICAL #5 FRICTION
0		+2			+9	
25	0	+2	2	+2	+7	5
50	+1	+2	1	+3	+6	3
75	+3	+4	1	+3	+6	3
100	+3	+4	1	+3	+5	2
125	+4	+5	1	+2	+3	1
150	+3	+4	1	+1	+2	1
175	+3	+3	0	-1	+1	2
200	+2	+2	0	-2	-1	1
225	-1	+0	1	-3	-2	1
250	0	0	0	-3	-2	1
275	0	+1	1	-5	-3	2
300	+2	+2	0	-5	-4	1
500	--	--	-	--	--	-
300	+3	+3	0	-2	-3	1
275	+4	+3	1	-2	-3	1
250	+3	+3	0	-1	-2	1
225	+3	+3	0	-1	-2	1
200	+4	+4	0	+1	-2	3
175	+5	+5	0	+2	+1	1
150	+6	+6	0	+4	+3	1
125	+6	+6	0	+7	+4	3
100	+6	+5	1	+8	+6	2
75	+6	+5	1	+8	+7	1
50	+4	+4	0	+10	+7	3
25	+3	+3	0	+13	+8	5
0	+3	+2	1	+15	+10	5

TABLE 20-C

TEST POINT	SPIRAL #4 BEFORE TAP	SPIRAL #4 AFTER TAP	SPIRAL #4 FRICTION	HELICAL # 5 BEFORE TAP	HELICAL # 5 AFTER TAP	HELICAL # 5 FRICTION
0		+1			+9	
25	+2	+2	0	+2	+7	5
50	+2	+3	1	+3	+6	3
75	+3	+3	0	+3	+5	2
100	+4	+5	1	+3	+4	1
125	+4	+5	1	+2	+3	1
150	+4	+4	0	+2	+3	1
175	+4	+4	0	-1	+1	2
200	+3	+3	0	-1	+1	2
225	+2	+2	0	-3	-2	1
250	+2	+3	1	-1	-2	1
275	+2	+2	0	-3	-2	1
300	+2	+2	0	-4	-3	1
500	--	--	-	--	--	-
300	+4	+3	1	-1	-2	1
275	+4	+4	0	-1	-1	0
250	+4	+4	0	+0	-2	2
225	+4	+4	0	+2	-1	3
200	+4	+4	0	+3	1	2
175	+6	+5	1	+4	2	2
150	+7	+6	1	+7	5	2
125	+6	+6	0	+5	4	1
100	+7	+6	1	+9	6	3
75	+6	+5	1	+9	7	2
50	+4	+4	0	+10	7	3
25	+4	+3	1	+13	8	5
0	+2	+2	0	+16	10	6

TABLE 20-D
AFTER 300 CYCLES

TEST POINT	SPIRAL #4 BEFORE TAP	SPIRAL #4 AFTER TAP	SPIRAL #4 FRICTION	HELICAL #5 BEFORE TAP	HELICAL #5 AFTER TAP	HELICAL #5 FRICTION
0		+1			+9	
25	+1	+2	1	+3	+8	5
50	+2	+2	0	+3	+7	4
75	+2	+3	1	+3	+6	3
100	+3	+4	1	+3	+5	2
125	+4	+5	1	+3	+6	3
150	+3	+4	1	+2	+4	2
175	+4	+4	0	+1	+2	1
200	+2	+3	1	-2	-1	1
225	+1	+2	1	-3	-2	1
250	+1	+1	0	-3	-2	1
275	+2	+2	0	-3	-2	1
300	+2	+2	0	-3	-2	1
500	--	--	-	--	--	-
300	+4	+3	1	-1	-2	1
275	+4	+4	0	0	-1	1
250	+3	+3	0	0	-1	1
225	+4	+3	1	0	-2	2
200	+4	+4	0	+1	-1	2
175	+6	+6	0	+3	+2	1
150	+6	+6	0	+4	+4	0
125	+7	+7	0	+6	+5	1
100	+6	+6	0	+8	+6	2
75	+5	+4	1	+9	+7	2
50	+4	+3	1	+11	+7	4
25	+3	+3	0	+13	+8	5
0	+3	+2	1	+16	+10	6

TABLE 20-E
AFTER 400 CYCLES

TEST POINT	SPRIAL #4 BEFORE TAP	AFTER TAP	FRICTION	HELICAL #5 BEFORE TAP	AFTER TAP	FRICTION
0		+2			+8	
25	+2	+2	0	+2	+7	5
50	+2	+2	0	+2	+5	3
75	+3	+3	0	+2	+4	2
100	+3	+4	1	+2	+4	2
125	+4	+4	1	+2	+3	1
150	+3	+4	0	+1	+2	1
175	+3	+3	0	-2	0	2
200	+3	+4	1	-3	-2	1
225	+2	+2	0	-3	-2	1
250	+1	+2	1	-3	-2	1
275	+2	+2	0	-5	-4	1
300	+2	+2	0	-5	-4	1
500	--	--	-	--	--	-
300	+5	+4	1	-2	-3	1
275	+4	+4	0	-2	-3	1
250	+4	+4	0	-1	-2	1
225	+4	+3	1	-1	-2	1
200	+5	+5	0	+1	-1	2
175	+5	+4	1	+2	0	2
150	+6	+5	1	+4	+2	2
125	+6	+5	1	+5	+3	2
100	+6	+5	1	+7	+5	2
75	+5	+4	1	+8	+6	2
50	+4	+3	1	+8	+6	2
25	+4	+3	1	+11	+8	3
0	+3	+3	0	+16	+10	6

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THE DESIGN AND DEVELOPMENT OF A WHEEL MOUNTED AIRCRAFT TIRE INF--ETC(U)
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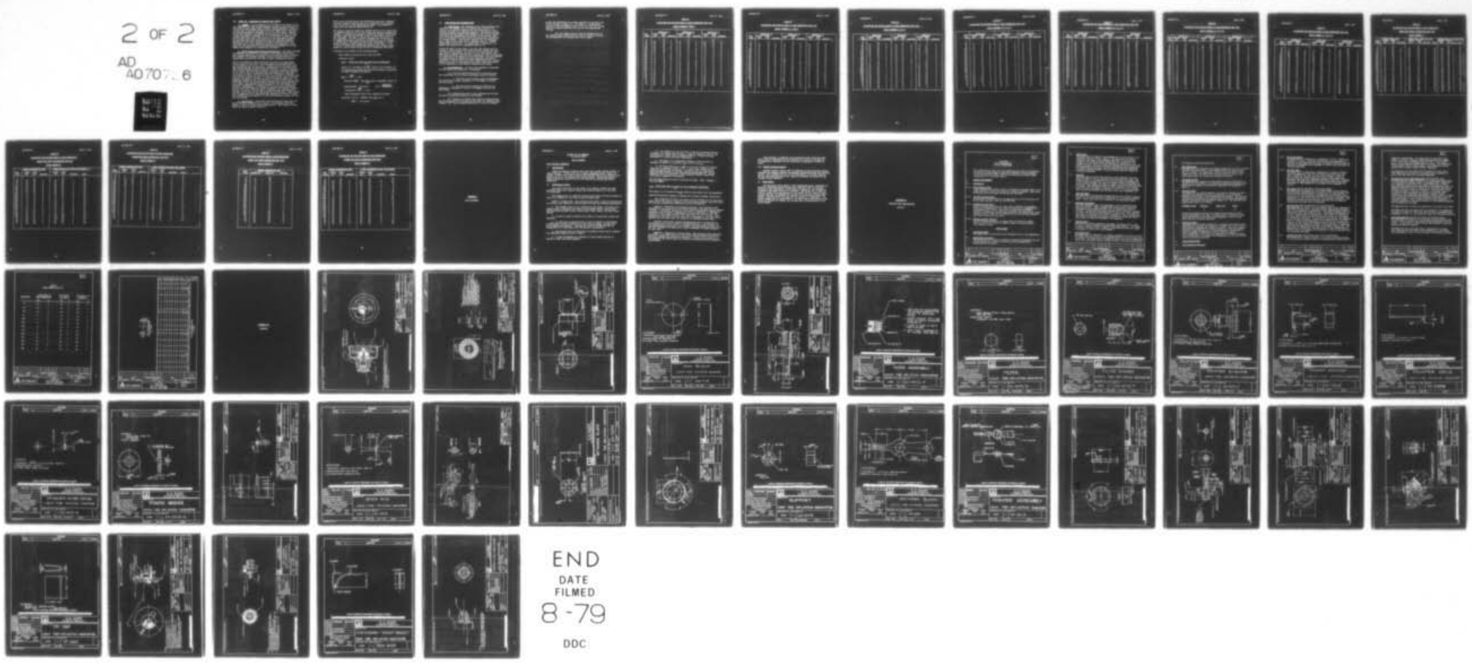

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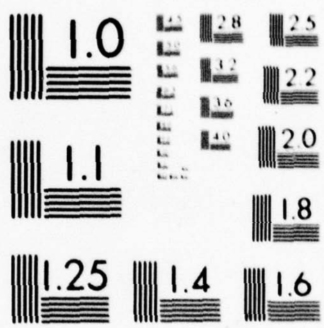


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

III. PHASE III - PRODUCTION OF SERVICE TEST MODELS

A. GENERAL - At the completion of the Phase II, evaluation of the test results by the USAF Project Engineer resulted in the selection of the spiral Bourdon design shown on layout drawing CSK-9426-I, Figure 18. At this time, a decision was made to use the ceramic filter type fail safe device described in paragraph II.C.4.b of this report. However, it was also decided to provide for the incorporation of the fail safe valving described in paragraph II c.4.a in the event it might be desired at some later date. This portion of the development program was directed toward the fabrication of 25 Tire Inflation Indicator Systems; 20 to be field tested by the USAF at Wright-Patterson Air Force Base; and 5 to be reliability tested by the contractor. This phase was also concerned with providing detailed drawings of the components and assemblies for competitive procurement.

B. Final Design, Description and Discussions - The detail drawings of components and assemblies contained in this report describe the final design selected by and submitted to the USAF for field evaluation. The component and assembly drawings include all modifications in the design which resulted from the Phase II model building and testing.

Phase II Acceleration Testing indicated the need for an improvement in the crystal to case seal. The lens gasket was dislodged from its seat and thrown over the dial face. During the Phase III model building, several methods of sealing were investigated. It was determined that "Loctitè Plastic Gasket" applied to the case lip prior to assembly of the crystal and bezel would provide a waterproof seal when immersed in one foot of water. Additional tests were conducted to determine the pressure at which the seal would fail in the event of a Bourdon tube leak and case pressure buildup. It was found that the joint could seal pressures in excess of the fracture point of the glass (200 psi). An additional difficulty with the sealed case was that a small Bourdon leak would cause a low, erroneous pressure reading since the Bourdon would be sensing a differential pressure between the tire and internal case pressure. Furthermore, the fracture of the glass could be hazardous for an operator who might be viewing the gauge at the instant of glass failure. In order to rectify this, a small hole was incorporated in the back of the case and was then sealed with teflon tape. Tests proved that the gauge was still waterproof when immersed in one foot of water, but relieved the case pressure at 10-12 psi providing a sealed, but fail safe case design.

C. Test Results - Scale Error and Friction Error Tests were conducted on serial numbered units 1 thru 21, in accordance with paragraphs 3.2 and 3.3 of Test Specification TS-701. The results of these tests are shown in Tables 21 thru 27.

Scale error, friction error, and reliability tests were conducted on serial numbered units 22 thru 26 in accordance with paragraphs 3.2, 3.3 and 5.4 of Test Specification TS-701. The results of these tests are shown in Tables 28 thru 32.

The contract requires a Mean Time Between Failure of 172 cycles with a confidence factor of 0.9 (a cycle being one simulated takeoff and landing). According to Bazovski's "Reliability Theory and Practice" the total test time shall be 400 cycles, or 80 cycles on each of five specimens. In order to better determine the reliability of the gauge under severe conditions of acceleration, it was planned to perform up to 400 cycles on each of the five gauges. As indicated in Table 31, serial number 25 failed at 275 cycles. Also, in order to balance the acceleration machine while testing serial number 26, serial number 22 was run for an additional 400 cycles.

Following is an analysis of the foregoing tests:

Total number of cycles for all units of 2,275.

Therefore, since

$$\text{MTBF} = \frac{\text{Total test time or cycles for all equipments}}{2.3}$$

Where 2.3 is obtained from $\frac{4.61}{2}$ based on the constant for the Poisson/chi squared distribution assuming an exponential (2 degree freedom) distribution.

$$\text{MTBF} = \frac{2275}{2.3} = 988$$

Therefore MTBF $>$ 988 cycles with a confidence factor of 0.90

Assuming MTBF - 172 cycles $\quad 172 = \frac{(2275)(2)}{\text{Poisson/chi}}$

$$\text{Poisson/chi} = \frac{4550}{172} = 26.4$$

From Poisson/chi tables for 2 degrees of freedom

Confidence level $>$ .9999999 that gauge has a

MTBF = 172 cycles

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions - The foregoing study, the preparation and testing of two designs and the production and testing of 26 service test models has demonstrated the feasibility of a permanently attached tire inflation indicator. Reliability testing (simulated aircraft takeoff and landing) on five of the 26 field test models has demonstrated the ability of the pressure indicator to withstand the severe shock and acceleration encountered by aircraft wheels. They further revealed that the indicators have a MTBF of 172 cycles with a confidence level of .9999999 during their service life. Or another way of stating it, is a MTBF of 985 cycles with a confidence factor of .9.

During the Phase II work effort, two fail safe devices were developed to assure against tire failure should a gauge leak occur. (For detailed description, see para. II 4 of this report) The USAF Project Engineer selected one of these, the filter restriction, for inclusion in the Phase III Field Test Models. He also required the gauge housing to provide the valve type fail safe device. Production of the 25 field test models demonstrated that a porous restriction could be incorporated with normal production methods with no impairment to the pressure response of the gauge.

B. Recommendations - In view of the findings as presented in this report, the following is recommended:

(1) The Test Specification TS-701 be adopted as the test requirement for all future procurement except as follows:

a. The scale error tolerance after environmental and reliability testing, paragraph 3.2, be changed to ±5% for all test points.

b. The scale error tolerance at high and low temperature, paragraph 4.3 and 4.4, be changed to ±7% for all test points.

(2) Eliminate the push to test provision and use only the porous restriction feature for fail safety.

(3) Separate the filling valve from the gauge housing. The filling valve can be attached to the wheel as a separate valve assembly, 180° from the gauge permitting it to act as a counter-

weight and eliminating the complex machining of the valve seat in the housing (or wheel rim - see item 4). An additional benefit of this arrangement would be the fact that the filling hose and operator's hand would not obscure the gauge during filling.

(4) The gauge housing be made an integral part of the aircraft wheel eliminating the need for seperate mounting and sealing means and reducing total wheel weight.

TABLE 21

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE TEST DATA

SERIAL NUMBERS 1 THRU 3

TEST POINT	SERIAL NO. I BEFORE TAP	AFTER TAP	FRICTION	SERIAL NO. 2 BEFORE TAP	AFTER TAP	FRICTION	SERIAL No. 3 BEFORE TAP	AFTER TAP	FRICTION
0		+5			-3			+5	
25	+2	+3	1	-5	-4	1	+5	+5	0
50	+3	+4	1	-6	-4	2	+4	+4	0
75	+3	+4	1	-7	-6	1	+3	+3	0
100	+3	+3	0	-5	-4	1	+1	+1	0
125	+2	+2	0	-6	-4	2	-2	-1	0
150	+1	+2	1	-7	-5	2	-3	-3	0
175	+2	+3	1	-8	-7	1	-3	-3	0
200	-1	-1	0	-8	-7	1	-5	-5	0
225	-2	-2	0	-7	-7	0	-5	-5	0
250	-3	-3	0	-7	-7	-	-4	-4	0
275	-4	-4	0	-5	-5	0	-3	-2	1
300	-6	-5	1	-4	-4	0	0	0	0
275	-2	-3	1	-5	-5	0	-3	-3	0
250	-3	-3	0	-6	-6	0	-3	-4	1
225	-2	-3	1	-6	-6	0	-4	-4	0
200	-1	-1	0	-5	-6	1	-5	-5	0
175	+1	0	1	-5	-6	1	-3	-3	0
150	+2	+1	1	-3	-4	1	-2	-2	0
125	+2	+1	1	-3	-4	1	-1	-1	0
100	+3	+3	1	-2	-3	1	+2	+1	1
75	+2	+1	1	-3	-4	1	+3	+3	0
50	+4	+3	1	-2	-3	1	+4	+4	0
25	+5	+4	1	-3	-3	0	+5	+5	0
0	+6	+5	1	-3	-3	0	+5	+5	0

TABLE 22

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE TEST DATA

SERIAL NUMBERS 4, 5 AND 6

TEST POINT	SERIAL NO. 4 BEFORE TAP	SERIAL NO. 4 AFTER TAP	SERIAL NO. 4 FRICTION	SERIAL NO. 5 BEFORE TAP	SERIAL NO. 5 AFTER TAP	SERIAL NO. 5 FRICTION	SERIAL NO. 6 BEFORE TAP	SERIAL NO. 6 AFTER TAP	SERIAL NO. 6 FRICTION
0		-6			0			-4	
25	-5	-5	0	0	0	0	-4	-4	0
50	-6	-6	0	0	0	0	-3	-3	0
75	-5	-5	0	0	+1	1	-5	-4	1
100	-4	-3	1	-1	0	1	-3	-3	0
125	-4	-4	0	-1	0	1	-4	-3	1
150	-5	-5	0	-3	-2	1	-3	-3	0
175	-5	-5	0	-4	-3	1	-4	-4	0
200	-6	-6	0	-7	-6	1	-5	-5	0
225	-5	-5	0	-8	-7	1	-5	-5	0
250	-6	-6	0	-10	-9	1	-4	-4	0
275	-5	-5	0	-6	-6	0	-4	-4	0
300	-5	-5	0	-6	-6	0	-3	-3	0
275	-5	-5	0	-5	-6	1	-3	-3	0
250	-5	-6	1	-6	-8	2	-3	-4	1
225	-5	-5	0	-5	-6	1	-4	-5	1
200	-6	-6	0	0	-2	2	-4	-4	0
175	-5	-5	0	-2	-2	0	-3	-3	0
150	-4	-4	0	0	-2	2	-3	-3	0
125	-3	-4	1	-1	-2	1	-2	-2	0
100	-2	-3	1	+2	0	2	0	0	0
75	-5	-5	0	+2	+1	1	-2	-2	0
50	-4	-5	1	0	0	0	0	-2	2
25	-5	-5	0	0	0	0	-3	-4	1
0	-5	-6	1	0	0	0	-3	-4	1

TABLE 23

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE TEST DATA

SERIAL NUMBERS 7, 8 & 9

TEST POINT	SERIAL #7 BEFORE TAP	SERIAL #7 AFTER TAP	SERIAL #7 FRICTION	SERIAL #8 BEFORE TAP	SERIAL #8 AFTER TAP	SERIAL #8 FRICTION	SERIAL #9 BEFORE TAP	SERIAL #9 AFTER TAP	SERIAL #9 FRICTION
0		+2			-3			0	
25	+3	+3	0	-4	-4	0	-2	0	2
50	+2	+3	1	-5	-5	0	0	+1	1
75	+2	+2	0	-5	-5	0	+1	+2	1
100	+1	+2	1	-6	-5	1	+2	+2	0
125	+2	+3	1	-5	-5	0	0	+1	1
150	+1	+2	1	-6	-5	1	0	+2	2
175	+1	+2	1	-6	-5	1	-2	0	2
200	-1	+1	+	-6	-5	1	-3	0	3
225	-2	0	2	-5	-5	0	-5	0	5
250	0	+1	1	-5	-5	0	-1	+1	2
275	+1	+2	1	-5	-5	0	0	+2	2
300	+3	+4	1	-6	-5	1	+2	+3	1
275	+4	+3	1	-2	-4	2	+5	+3	2
250	+3	+2	1	-3	-4	1	+5	+2	3
225	+3	+2	1	-4	-5	1	0	-3	3
200	+4	+3	1	-3	-4	1	+4	+1	3
175	+4	+3	1	-3	-4	1	+4	+2	2
150	+6	+3	3	-3	-4	1	+4	+2	2
125	+5	+4	1	-4	-5	1	+5	+2	3
100	+6	+3	3	- 3	-4	1	+3	+2	1
75	+5	+4	1	-5	-5	0	+4	+2	2
50	+5	+4	1	-4	-5	1	+3	+1	1
25	+5	+4	1	-4	-5	1	+2	0	2
0	+5	+2	3	-2	-3	1	0	-1	1

TABLE 24

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE TEST DATA

SERIAL NUMBERS 10, 11 & 12

	SERIAL #10			SERIAL #11			SERIAL #12		
TEST POINT	BEFORE TAP	AFTER TAP	FRICTION	BEFORE TAP	AFTER TAP	FRICTION	BEFORE TAP	AFTER TAP	FRICTION
0		0			-2			-2	
25	-2	0	2	-3	-3	0	-2	-1	1
50	0	0	0	-2	-2	0	-1	0	1
75	0	0	0	-3	-3	0	-2	-1	1
100	+1	+1	0	-3	-3	0	-1	+1	2
125	0	0	0	-4	-3	1	-1	-1	0
150	0	+1	1	-4	-4	0	-2	-2	0
175	-2	-1	1	-7	-7	0	-4	-4	0
200	-5	-3	2	-8	-7	1	-6	-6	0
225	-6	-5	1	-8	-7	1	-6	-6	0
250	-5	-5	0	-9	-7	2	-6	-6	0
275	-5	-5	0	-8	-7	1	-5	-5	0
300	-3	-3	0	-7	-6	1	-3	-2	1
275	-2	-4	2	-5	-7	2	-4	-4	0
250	-3	-5	2	-5	-6	1	-5	-5	0
225	-2	-4	2	-5	-6	1	-5	-5	0
200	-2	-3	1	-4	-5	1	-4	-4	0
175	-1	-3	2	-4	-6	2	-4	-4	0
150	+1	0	1	-2	-2	0	-3	-3	0
125	+3	+2	1	-1	-2	1	-1	-1	0
100	+4	+2	2	+1	-1	2	0	+1	1
75	+4	+2	2	0	-1	1	0	0	0
50	+3	+1	2	0	-1	1	0	0	0
25	+2	0	2	0	-1	1	-1	-1	0
0	+2	0	2	0	-1	1	-1	-1	0

TABLE 25
CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE TEST DATA

SERIAL NUMBERS 13, 14 & 15

TEST POINT	SERIAL #13 BEFORE TAP	SERIAL #13 AFTER TAP	SERIAL #13 FRICTION	SERIAL #14 BEFORE TAP	SERIAL #14 AFTER TAP	SERIAL #14 FRICTION	SERIAL #15 BEFORE TAP	SERIAL #15 AFTER TAP	SERIAL #15 FRICTION
0		0			-1			+7	
25	+2	+2	0	0	+1	1	+4	+6	2
50	+2	+3	1	0	+1	1	+2	+4	2
75	+3	+4	1	0	+1	1	+1	+3	2
100	+3	+4	1	+1	+2	1	-1	+1	2
125	+4	+5	1	+2	+2	0	-3	-1	2
150	+3	+3	0	0	+1	1	-4	-2	2
175	+1	+2	1	-2	+2	4	-7	-4	3
200	+1	+1	0	+2	+2	0	-7	-4	3
225	-2	-2	0	+2	+2	0	-6	-3	3
250	-3	-2	1	-2	-2	0	-3	-2	1
275	-3	-3	0	-2	-2	0	-2	0	2
300	-2	-2	0	-4	-3	1	-2	+1	3
275	0	-2	2	-2	-1	1	+4	+1	3
250	0	-2	2	0	+1	1	+4	0	4
225	-2	-2	0	-2	+2	4	+4	-1	5
200	+2	+1	1	0	+2	2	+4	-1	5
175	+3	+2	1	+2	+2	0	+4	-1	5
150	+3	+3	0	+2	+1	1	+3	0	3
125	+5	+5	0	+3	+2	1	+6	+2	4
100	+6	+6	0	+3	+2	1	+6	+3	3
75	+6	+5	1	+2	+2	0	+7	+5	2
50	+4	+4	0	+2	+1	1	+9	+7	2
25	+4	+3	1	+2	+2	0	+10	+7	3
0	+2	+1	1	+1	0	1	+10	+8	2

TABLE 26

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE TEST DATA

SERIAL NUMBERS 16, 17 & 18

	SERIAL #16			SERIAL #17			SERIAL #18		
TEST POINT	BEFORE TAP	AFTER TAP	FRICTION	BEFORE TAP	AFTER TAP	FRICTION	BEFORE TAP	AFTER TAP	FRICTION
0		-4			+4			+2	
25	-3	-2	1	+3	+3	0	0	+1	1
50	-1	0	1	+2	+3	1	+1	+2	1
75	+1	+3	2	+1	+2	1	+1	+2	1
100	+3	+4	1	-1	0	1	+2	+3	1
125	+3	+4	1	-2	-1	1	+1	+2	1
150	0	+2	2	-3	-3	0	0	0	0
175	+1	+2	1	-6	-6	0	+3	+3	0
200	-2	-1	1	-7	-7	0	-2	-2	0
225	-3	-2	1	-7	-6	1	-3	-3	0
250	-3	-2	1	-6	-6	0	-3	-3	0
275	-1	-1	0	-4	-2	2	-3	-2	1
300	0	+1	1	-4	-5	1	-2	0	2
275	0	0	0	-6	-6	0	0	-3	3
250	-2	-1	1	-6	-6	0	-2	-3	1
225	-2	-2	0	-5	-5	0	-2	-3	1
200	-1	-1	0	-4	-5	1	-1	-2	1
175	+3	+2	1	-6	-6	0	+2	+2	0
150	+2	+2	0	-2	-2	0	+2	+1	1
125	+4	+3	1	+1	+1	0	+4	+3	1
100	+4	+4	0	+2	+2	0	+3	+3	0
75	+3	+3	0	+4	+3	1	+4	+3	1
50	+1	0	1	+4	+4	0	+3	+3	0
25	0	-1	1	+5	+4	1	+4	+3	1
0	-2	-3	1	+4	+4	0	+3	+2	1

TABLE 27

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE TEST DATA

SERIAL NUMBERS 19, 20 & 21

TEST POINT	SERIAL #19 BEFORE TAP	SERIAL #19 AFTER TAP	SERIAL #19 FRICTION	SERIAL #20 BEFORE TAP	SERIAL #20 AFTER TAP	SERIAL #20 FRICTION	SERIAL #21 BEFORE TAP	SERIAL #21 AFTER TAP	SERIAL #21 FRICTION
0		0			-3			+4	
25	-1	0	1	-3	-3	0	+3	+4	1
50	+1	+1	0	-2	-1	1	+3	+4	1
75	+2	+2	0	0	+1	1	+3	+4	1
100	+2	+2	0	+1	+2	1	+2	+3	1
125	+2	+2	0	+2	+3	1	+1	+2	1
150	0	0	0	+2	+3	1	-1	0	1
175	-2	-2	0	+2	+2	0	-6	-4	2
200	-2	-2	0	+2	+2	0	-6	-4	2
225	-2	-2	0	0	+1	1	-6	-5	1
250	-3	-3	0	0	+1	1	-7	-6	1
275	-3	-3	0	+2	+2	0	-6	-6	0
300	-2	-2	0	-3	0	3	-5	-4	1
275	-2	-2	0	+4	+3	1	-4	-5	1
250	-2	-2	0	+2	+1	1	-5	-5	0
225	-2	-2	0	+2	+2	0	-4	-5	1
200	-2	-2	0	+3	+2	1	-2	-4	2
175	0	-1	1	+4	+3	1	-2	-3	1
150	0	0	0	+4	+3	1	+2	0	2
125	+3	+3	0	+4	+3	1	+4	+3	1
100	+3	+3	0	+3	+3	0	+6	+5	1
75	+3	+3	0	+3	+2	1	+6	+5	1
50	+2	+2	0	+2	0	2	+6	+5	1
25	+2	+1	1	-2	-3	1	+6	+5	1
0	+2	+1	1	-1	-2	1	+6	+5	1

TABLE 28

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE

BEFORE AND AFTER ACCELERATION TEST DATA

SERIAL NUMBER 22

TEST POINT	BEFORE ACCEL. TEST			AFTER ACCEL. TEST (400 CYC)				AFTER ACCEL. TEST (800 CYC.)			
	BEFORE TAP	AFTER TAP	FRICTION	BEFORE TAP	AFTER TAP	FRICTION	SHIFT	BEFORE TAP	AFTER TAP	FRICT.	SHIFT
0		+2			+3			–	+6		+4
25	+2	+3	1	+3	+4	1	+1	+6	+7	1	+4
50	+3	+3	0	+4	+4	0	+1	+6	+7	1	+4
75	+3	+3	0	+4	+4	0	+1	+7	+8	1	+5
100	+3	+4	1	+4	+4	0	0	+7	+8	1	+4
125	+3	+4	1	+4	+5	1	+1	+6	+7	1	+3
150	+2	+2	0	+3	+3	0	+1	+5	+6	1	+4
175	0	0	0	+1	+2	1	+2	+4	+4	0	+4
200	-2	-2	0	-1	0	1	+2	+2	+3	1	+5
225	-4	-2	2	-2	-2	0	0	0	+1	1	+3
250	-4	-4	0	-1	-1	0	+3	+1	+2	1	+6
275	0	0	0	+2	+2	0	+2	+1	+2	1	+2
300	+2	+2	0	+4	+4	0	+2	+5	+6	1	+4
275	+1	+1	0	+3	+3	0	+2	+5	+4	1	+3
250	-1	-1	0	+1	+1	0	+2	+2	+2	0	+3
225	-2	-2	0	-1	-1	0	+1	+3	+2	1	+4
200	-2	-2	0	+2	+1	1	+3	+4	+3	1	+5
175	+2	+1	1	+4	+3	1	+2	+7	+5	2	+4
150	+4	+3	1	+6	+5	1	+2	+7	+7	0	+4
125	+5	+5	0	+7	+6	1	+1	+9	+8	1	+3
100	+7	+6	1	+9	+8	1	+2	+11	+9	2	+3
75	+6	+5	1	+8	+7	1	+2	+11	+9	2	+4
50	+7	+5	2	+7	+6	1	+1	+10	+9	1	+4
25	+5	+4	1	+6	+5	1	+1	+8	+8	0	+4
0	+3	+3	0	+5	+4	1	+1	+8	+7	1	+4

TABLE 29

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE

BEFORE AND AFTER ACCELERATION TEST DATA

SERIAL NUMBER 23

TEST POINT	BEFORE ACCELERATION TEST			AFTER ACCELERATION TEST (400 CYCLES)			
	BEFORE TAP	AFTER TAP	FRICTION	BEFORE TAP	AFTER TAP	FRICTION	SHIFT
0		+3			+6		+3
25	+3	+5	2	+6	+7	1	+2
50	+4	+5	1	+7	+8	1	+3
75	+5	+7	2	+8	+9	1	+2
100	+5	+6	1	+8	+9	1	+3
125	+5	+5	0	+6	+7	1	+2
150	+3	+3	0	+6	+7	1	+4
175	+2	+2	0	+3	+4	1	+2
200	-2	-1	1	+2	+2	0	+3
225	-3	-3	0	+1	+1	0	+4
250	-6	-4	2	-2	0	2	+4
275	-7	-5	2	-2	-1	1	+4
300	-7	-5	2	-2	-1	1	+4
275	-3	-4	1	+2	-1	3	+3
250	-2	-3	1	+2	+1	1	+4
225	-2	-2	0	-2	-2	0	0
200	+2	+1	1	+3	+3	0	+2
175	+3	+3	0	+4	+4	0	+1
150	+4	+4	0	+7	+7	0	+3
125	+5	+5	0	+8	+8	0	+3
100	+8	+7	1	+11	+10	1	+3
75	+8	+7	1	+10	+9	1	+2
50	+6	+5	1	+9	+8	1	+3
25	+5	+5	0	+9	+8	1	+3
0	+4	+3	1	+9	+7	2	+4

TABLE 30

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE

BEFORE AND AFTER ACCELERATION TEST DATA

SERIAL NUMBER 24

TEST POINT	BEFORE ACCELERATION TEST BEFORE TAP	AFTER TAP	FRICTION	AFTER ACCELERATION TEST (400 CYCLES BEFORE TAP	AFTER TAP	FRICTION	SHIFT
0		-2			-2		0
25	0	0	0	-1	0	1	0
50	+1	+2	1	+1	+2	1	0
75	+2	+3	1	+2	+3	1	0
100	+3	+3	0	+3	+3	0	0
125	+3	+3	0	+3	+3	0	0
150	+2	+3	1	+1	+2	1	-1
175	0	0	0	-1	0	1	0
200	-4	-3	1	-5	-3	2	0
225	-5	-4	1	-5	-4	1	0
250	-6	-5	1	-6	-5	1	0
275	-6	-5	1	-7	-5	2	0
300	-9	-5	4	-7	-5	1	0
275	-3	-4	1	-3	-5	2	-1
250	-3	-4	1	-3	-4	1	0
225	-3	-4	1	-4	-4	0	0
200	+1	-1	2	0	-2	2	-1
175	+3	+2	1	+2	0	2	-2
150	+4	+3	1	+4	+3	1	0
125	+5	+4	1	+5	+4	1	0
100	+7	+5	2	+6	+4	2	-1
75	+7	+5	2	+5	+4	1	-1
50	+4	+4	0	+4	+3	1	-1
25	+4	+3	1	+2	+1	1	-2
0	+2	0	2	0	+1	1	+1

TABLE 31

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE

BEFORE AND AFTER ACCELERATION TEST DATA

SERIAL NUMBER 25

TEST POINT	BEFORE ACCELERATION TEST		
	BEFORE TAP	AFTER TAP	FRICTION
0		+2	
25	+1	+2	1
50	0	+1	1
75	-1	0	1
100	-1	+1	2
125	-2	0	2
150	-2	0	2
175	-2	-2	0
200	-5	-3	2
225	-5	-4	1
250	-5	-4	1
275	-4	-4	0
300	-4	-4	0
275	-2	-3	1
250	-3	-4	1
225	-2	-3	1
200	-2	-3	1
175	0	-1	1
150	+2	+1	1
125	+3	+2	1
100	+2	+2	0
75	+2	+2	0
50	+2	+2	0
25	+3	+3	0
0	+2	+2	0

TABLE 32

CALIBRATION AND FRICTION ERROR AT ROOM TEMPERATURE

BEFORE AND AFTER ACCELERATION TEST DATA

SERIAL NUMBER 26

TEST POINT	BEFORE ACCELERATION TEST: BEFORE TAP	AFTER TAP	FRICTION	AFTER ACCELERATION TEST (400 CYCLES): BEFORE TAP	AFTER TAP	FRICTION	SHIFT
0		+4			+7		+3
25	+2	+3	1	+4	+4	0	+1
50	+2	+2	0	+3	+3	0	+1
75	+2	+3	1	+2	+3	1	0
100	+2	+2	0	+2	+2	0	0
125	+2	+3	1	+2	+3	1	0
150	+1	+2	1	+1	+2	1	0
175	-1	+1	+	+2	+2	0	+1
200	-1	+1	2	0	+1	1	0
225	-1	+1	2	+1	+2	1	+1
250	0	+2	+	+3	+3	0	+1
275	+2	+3	1	+3	+4	1	+1
300	+3	+6	3	+4	+6	2	0
275	+6	+4	2	+5	+5	0	+1
250	+5	+3	2	+4	+3	1	0
225	+3	+2	1	+3	+2	1	0
200	+3	+2	1	+3	+2	1	0
175	+3	+2	1	+3	+2	1	0
150	+4	+3	1	+3	+2	1	-1
125	+4	+3	1	+3	+3	0	0
100	+3	+3	0	+3	+3	0	0
75	+5	+4	1	+4	+4	0	0
50	+3	+3	0	+4	+4	0	+1
25	+4	+4	0	+6	+5	1	+1
0	+5	+5	0	+7	+8	1	+3

ADDENDUM I

WORK STATEMENT

EXHIBIT "A" TO CONTRACT
AF 33(657)-12491

WORK STATEMENT

Tire Inflation Indicator

I. Introduction

There are numerous occasions when tires fail on USAF aircraft because of under inflation. A need exists for a simple, dependable device, which will quickly, visually and clearly indicate the inflation status of an aircraft tire without the use of the standard type pressure gauge. The present method of gauge checking for pressure level is too slow for use during walk around inspection.

II. Description of Work

The overall objective of this effort is to develop a device for wheel attachment which will visually display the inflation status of a tire when on an aircraft.

The program shall be conducted in three basic phases and shall include, but need not be limited to, the areas of work outlined below:

PHASE I - Design Study - The Contractor shall make a study of piezoelectric and various other designs for devices which will meet the following requirements:

a. The assembly shall be of a minimum size and weight, and construction rugged enough to withstand the effects of centrifugal forces, runway bumps, retraction and extension forces, thrown water, slush, debris, and other runway hazards.

b. It shall be made of material not subject to electrolytic action with magnesium.

c. It shall be so constructed that it will be capable of withstanding a temperature of 350°F, as much as 500 psi working pressure, and the loads due to spin-up and rotation. (Spin-up will occur on landing and will be accomplished in 2 revolutions, eg o-200 mph in 2 revolutions.)

d. The accuracy must be within ±5% of specified pressure over an ambient air temperature range of -65°F to +160°F.

e. It must be readable at a distance of 6 feet without the use of optical or other assisting equipment.

f. The design is to be such that it need not be removed when air is added to or removed from the tire. It may be designed as part of the pressuring port (valve stem) or separate from it. It must be easily attachable to a wheel and easily replaceable.

g. The gauges to be fabricated in Phases II and III shall be designed to operate in a pressure range of 75 to 175 psi.

h. The device shall have a MTBF of 172 cycles during its service life, with a confidence factor of .90. A cycle shall consist of one simulated take-off and one landing. The device shall be subjected to three thousand (3,000) G normal acceleration during take-off. During landing it shall be subjected to three thousand (3,000) G normal and fifty (50) G tangential acceleration.

The following formula is used to calculate the Mean - Time - Between - Failures (MTBF):

$$\text{MTBF} = \frac{\text{Total test time or cycles for all equipments (operating)}}{2.3}$$

The factor 2.3 is obtained from $\frac{4.61}{2}$ based on the constant for the Poisson/Chi squared distribution assuming an exponential (2 degree freedom) distribution.

Upon completion of Phase I and prior to start of Phase II, the Contractor shall present the various designs to the USAF Project Engineer, who will select the two most promising for fabrication and test in Phase II.

PHASE II - Fabrication and Testing Prototypes - The Contractor shall fabricate and test each of the two designs selected by the USAF Project Engineer in Phase I. The number selected for test shall be sufficient to demonstrate compliance with the detail requirements set forth under Phase I, with the exception of the working pressure range which shall be 75 to 175 psi. Upon completion of the tests, the test data shall be presented to the USAF Project Engineer who will then select the design to be developed in Phase III.

Portions of the above required demonstrations may be accomplished by installation on Air Force Aircraft at Wright-Patterson AF Base, however, if the demonstration on Aircraft is not feasible, the Government will make available Test Equipment for simulation of field conditions, at Wright-Patterson AF Base, Ohio.

PHASE III - Fabrication of Final Design - The Contractor shall fabricate and deliver to the USAF twenty-five (25) of the device selected in Phase II which are suitable for operational evaluation. He shall also prepare a set of drawings of the device which are suitable for manufacturing by competitive reprocurement.

Five (5)units, in addition to the twenty-five (25) called for under Item 3 shall be fabricated by the Contractor and tested for reliability to demonstrate compliance with the reliability requirements of Phase Ib. above.

III. Monthly Progress Reports

Monthly progress reports shall be submitted to the Procuring Activity outlining the progress achieved and problems encountered during the reporting period. Also included shall be a brief description of the work scheduled for the next reporting period and a graph or statement portraying the percentage of work completed.

IV. Final Report

The Contractor shall submit a final engineering report containing all technical information gained through work performed under the contract. Results of test conclusions, in accordance with Phase II, and drawings in accordance with Phase III shall be included. ARDC Manual Nr 5-1 shall be used as a guide in the presentation of the format for the technical report. A draft copy will be submitted for approval by the Procuring Contracting Officer, allowing thirty (30) days for such approval or disapproval. Required changes will be incorporated in the final report which shall be submitted in fifteen (15) copies, one of which shall be reproducible by the ozalid method.

ADDENDUM II

TENTATIVE TEST SPECIFICATION

(TS-701)

TENTATIVE
TEST SPECIFICATION
U.S.A.F. TIRE GAUGE

1. This specification covers the test conditions and tests to be performed on the U.S.A.F. Tire Gauge as specified in Exhibit A (Work Statement) to Contract AF33(657)-12491, (KC-135 Main Wheel) and contract change notification No. 1 (B70 Main Wheel).

2. **GENERAL REQUIREMENTS**

2.1 **Definitions**

2.1.1 **Test Pressure Cycle**
A test pressure cycle shall consist of changing the pressure input to the gauge from zero to full scale and back to zero psi pressure. Full scale is 300 psi for KC-135 wheel and 600 psi for B70 wheel.

2.1.2 **Operable Pressure Range**
The operable pressure range of the gauge shall be 75 to 175 psi for the KC-135 wheel and 350 to 525 for the B70 wheel.

2.1.3 **Atmospheric Conditions**
Unless otherwise specified, all tests shall be made at an atmospheric pressure of approximately 29.92 inches of mercury and a temperature of approximately 25°C (77°F). When tests are made with atmospheric pressure or temperature substantially different from these values, proper allowance shall be made for the difference from the specified condition and noted on each test data sheet.

2.1.4 **Tapping and Test Position**
Unless otherwise specified, the gauge shall be tested in a normal operating position and shall be lightly tapped or vibrated before a test reading is taken.

TEST METHODS

3. **INDIVIDUAL TESTS**
Each gauge shall be subjected to the following tests at room temperature.

3.1 **Examination of Product**
Each gauge shall be visually inspected to determine conformance with the outline drawing with respect to outline and dial configuration, identification and finish.

REV.	WAS	DATE	BY	APP.	REV.	WAS	DATE	BY	APP.

DATE 8/16/65 | DR. BY JDF/pm | CHK. BY J.D.F. | APP BY R.D.W.

U.S. GAUGE — AMETEK — A DIV. OF AMETEK, INC.

NAME: TENTATIVE TEST SPECIFICATION U.S.A.F. TIRE GAUGE

PART & DRAWING NO.: TS-701 Sheet 1

3.2 **Scale Error**

The gauge shall be tested at room temperature for scale error at the pressures listed in Tables I and II. The tests shall be made by subjecting the gauge to the pressures specified to produce these readings, first with pressures increasing, the pressure shall be brought up to but shall not exceed the pressure specified to give the desired reading; and with the pressure decreasing, the pressure shall be brought down to but shall not fall below the pressure specified to give the desired reading. The scale errors shall not exceed the tolerances specified.

3.3 **Friction**

The gauge shall be tested for friction at each alternate test point shown in Tables I and II, beginning with the second test point. The pressure shall be increased so as to bring the pointer approximately to the desired reading, and then held constant while two readings are taken; the first before the gauge is tapped, the second after the gauge is tapped. The difference of any two such readings is the friction error and shall not exceed a tolerance of 1.5% of full scale reading. This test may be combined with the scale error test (Paragraph 3.2)

4. **SAMPLING TESTS**

One gauge shall be selected at random from each lot of 100 or fraction thereof on the order and shall be subjected to the following sampling tests. These tests shall be in addition to the individual tests.

4.1 **Rejection and Retest**

Any gauge failing to meet the requirements of the Individual Tests shall be rejected. When a representative sample fails to meet the requirements of the Sampling Tests, the lot represented shall be rejected. Gauges which have been rejected may be replaced or repaired to correct the defects and resubmitted for acceptance. When this has been done, all specified tests shall be repeated. Before resubmitting, full details concerning the previous rejection and corrective action taken shall be noted and furnished to the Inspector.

4.2 **Position Error**

With midscale pressure applied to the gauge, the gauge shall be held in each of several different positions and tapped lightly. The change in pointer indication with a change in gauge position shall not exceed a tolerance of ±1% of full scale reading.

4.3 **Low Temperature**

The gauge shall be subjected to an ambient temperature of -54°C, (-65°F) and shall have been stored at this temperature for at least 4 hours, prior to testing. The gauge shall be tested for scale error at this temperature and at the test points listed in Tables I and II. The scale errors shall

REV.	WAS	DATE	BY	APP.	REV.	WAS	DATE	BY	APP.

not exceed the tolerances specified.

4.4 **High Temperature**
The gauge shall be subjected to an ambient temperature of +71°C. (+160°F) and shall have been stored at this temperature for at least 4 hours prior to testing. The gauge shall be tested for scale error at this temperature and at the test points listed in Tables I and II. The scale errors shall not exceed the tolerances specified.

4.5 **Overpressure Test**
The gauge shall be subjected to the pressure listed in Table III for a period of ten (10) minutes. Following this overpressure exposure, the gauge shall be capable of meeting the requirements of Paragraphs 3.2 and 3.3.

4.6 **Vibration Error**
The gauge shall be rigidly fastened to a suitable vibration jig while pressurized to midscale and shall be subjected to the following vibration cycling test at room temperature and pressure. The vibration cycling shall be conducted in each of three (3) mutually perpendicular planes in accordance with MIL-STD-810, Method 514. The vibration test nomenclature shall be as follows:

Equipment class	Mounting	Figure 514	Curve
1	A	1	D

During the foregoing cycling, all resonance points shall be noted. At the completion of this test, the gauge shall be checked for scale error and friction in accordance with paragraphs 3.2 and 3.3 and shall meet the tolerances specified.

4.7 **Mechanical Shock**
The gauge shall be rigidly fastened to a suitable shock fixture while pressurized to midscale and subjected to 3 shocks of 15 G's in each of three mutually perpendicular planes (18 shocks). Each shock impulse shallhave a time duration of 11 ±10% milliseconds. The maximum G's shall be reached in approximately 5-1/2 ±10% milliseconds.
At the completion of this test, the gauge shall be checked for scale error and friction in accordance with Paragraphs 3.2 and 3.3 and shall meet the tolerances specified.

5. **QUALIFICATION TESTS**

5.1 **High Temperature Exposure**

5.1.1 KC-135 Main Wheel
The gauge shall be subjected to a temperature of 177°C. (350°F.) for a period of 4 hours. Following this exposure, the gauge shall be returned to room temperature and shall be checked for scale error and friction in accordance with Paragraphs 3.2 and 3.3 and shall meet the tolerance specified.

5.1.2 B70 Main Wheel
The gauge shall be subjected to temperatures as follows: uniformly raise the temperature from 100°F to 360°F in the first hour and hold at 360°F for the next two hours and 20 minutes. Allow to cool to 200°F and conduct scale error tests at this temperature. The gauge shall meet the tolerances specified in Table II. Following this test, the gauge shall meet the scale error and friction error tolerances at room temperature in accordance with Paragraphs 3.2 and 3.3.

5.2 Salt Spray (KC-135 Main Wheel and B70 Main Wheel)
The gauge shall be mounted in a salt spray chamber whose conditions are outlined in MIL-STD-810 for a period not less than 48 hours. At the end of the 48 hour period, the gauge shall be subjected to the scale error at room temperature and friction tests in accordance with Paragraphs 3.2 and 3.3 and shall meet the tolerances specified. Salt deposits resulting from the exposure conditions may be removed by rinsing with tap water prior to operation.

5.3 Sand and Dust (KC-135 Main Wheel and B70 Main Wheel)
The gauge shall be placed in a test chamber equal to that specified in MIL-C-9436 section 3.2.2. The sand and dust composition and density shall be as specified in MIL-STD-810. The relative humidity shall not exceed 30% at any time during the test. The internal temperature of the test chamber shall be maintained at 25°C (77°F) for a period of not less than 2 hours with the air velocity through the test chamber at 100-500 feet per minute. Following the 2-hour period, the temperature shall be raised to and maintained at 71°C (160°F) for not less than 2 hours. At the end of this exposure period, the test item shall be removed from the chamber and cooled to room temperature. Accumulated dust shall be removed from the gauge by brushing or wiping only. The gauge shall be subjected to the scale error at room temperature and friction tests in accordance with Paragraph 3.2 and 3.3 and shall meet the tolerances specified.

5.4 Acceleration Test (KC-135 Main Wheel and B70 Main Wheel)
The gauge shall be rigidly fastened in its normal operating position to an acceleration machine capable of producing 3000 G normal and 50 G

REV.	WAS	DATE	BY	APP.	REV.	WAS	DATE	BY	APP.

DATE 8/16/65	DR. BY JDF/mf	CHK. BY J.D.F.	APP BY R.D.W.
U.S. GAUGE — AMETEK — A DIV. OF AMETEK, INC.	NAME: TENTATIVE TEST SPECIFICATION U.S.A.F. TIRE GAUGE		PART & DRAWING NO.: TS-701 Sheet 4

tangential accelerations. The gauge shall be subjected to the number of cycles to guarantee a Mean Time Between Failure (MTBF) of 172 cycles with a confidence factor of .90. A cycle shall consist of one simulated takeoff and one landing. The acceleration during takeoff shall be 3000 G normal. The acceleration during landing shall be 3000 G normal and 50 G tangential.

Following this test the gauge shall be checked for scale error at room temperature and friction in accordance with Paragraphs 3.2 and 3.3 and shall meet the tolerances specified.

5.5 <u>Acceleration Test, at High Temperature</u> (B70 Main Wheel only)
The gauge shall be rigidly fastened in its normal operating position to an acceleration machine capable of producing 3000 G normal and 50 G tangential accelerations and stored temperatures to 360°F. With the gauge mounted on the spin fixture, the temperature shall be uniformly raised from 100°F to 360°F in the first hour and held at 360°F for the next 2 hours and 20 minutes. Allow the gauge to cool to 200°F and impose a pressure of 550 psi to the gauge. While subjected to this temperature and pressure, impose a normal acceleration load increasing approximately linearily from 0 to 3000 G over a period of 20 to 40 seconds and maintain the 3000 G load for 5 seconds minimum. After 5 seconds apply the brake mechanism causing the machine to decelerate such that a 50 G minimum tangential load is applied to the gauge.

One gauge from each lot shall be subjected to one cycle of this test.

Following this test, the gauge shall be restored at room temperature and shall be tested for scale error and friction in accordance with Paragraphs 3.2 and 3.3. The gauge shall meet the tolerances specified.

5.6 <u>Pulse Amplitude Test</u> (KC-135 Main Wheel and B70 Main Wheel)
The gauge shall be subjected to the average operating pressure and cycled to 10% in excess of the average operating pressure for 1000 cycles. A cycle shall be defined as the time required to apply and release one pulse of pressure.

Following this test, the gauge shall be subjected to the scale error and friction error tests at room temperature in accordance with Paragraphs 3.2 and 3.3 and shall meet the tolerances specified.

TABLE I
SCALE ERROR FOR KC-135

Test Point	Scale Error at Room Temperature		Scale Error at -65° F		Scale Error at +160° F	
	Psi	%	Psi	%	Psi	%
0	15	5	21	7	21	7
25	15	5	21	7	21	7
50	15	5	21	7	21	7
75	9	3	15	5	15	5
100	9	3	15	5	15	5
125	9	3	15	5	15	5
150	9	3	15	5	15	5
175	9	3	15	5	15	5
200	15	5	21	7	21	7
225	15	5	21	7	21	7
250	15	5	21	7	21	7
275	15	5	21	7	21	7
300	15	5	21	7	21	7

REV.	WAS	DATE	BY	APP.	REV.	WAS	DATE	BY	APP.

DATE 8/16/65 | DR. BY JDG/mf | CHK. BY J.D.F | APP BY R.D.W.

U.S. GAUGE
AMETEK A DIV. OF AMETEK, INC.

NAME: TENTATIVE TEST SPECIFICATION U.S.A.F. TIRE GAUGE

PART & DRAWING NO.: TS-701 Sheet 6

TABLE II
SCALE ERROR FOR B70

Test Point	Scale Error at Room Temp.		Scale Error at -65°F		Scale Error at +160°F		Scale Error at +200°F	
	PSI	%	PSI	%	PSI	%	PSI	%
0	30	5	42	7	42	7	54	9
350	18	3	30	5	30	5	42	7
375								
400								
425								
450								
475								
500								
525	18	3	30	5	30	5	42	7
600	30	5	42	7	42	7	54	9

TABLE III
OVERPRESSURE TEST

Test Point	Unit
500	KC-135
650	B70

REV.	WAS	DATE	BY	APP.	REV.	WAS	DATE	BY	APP.

DATE 8/16/65 | DR. BY JDF/mf | CHK. BY J.D.F. | APP BY R.D.W.

U.S. GAUGE
AMETEK A DIV. OF AMETEK, INC.

NAME: TENTATIVE
TEST SPECIFICATION
U.S.A.F TIRE GAUGE

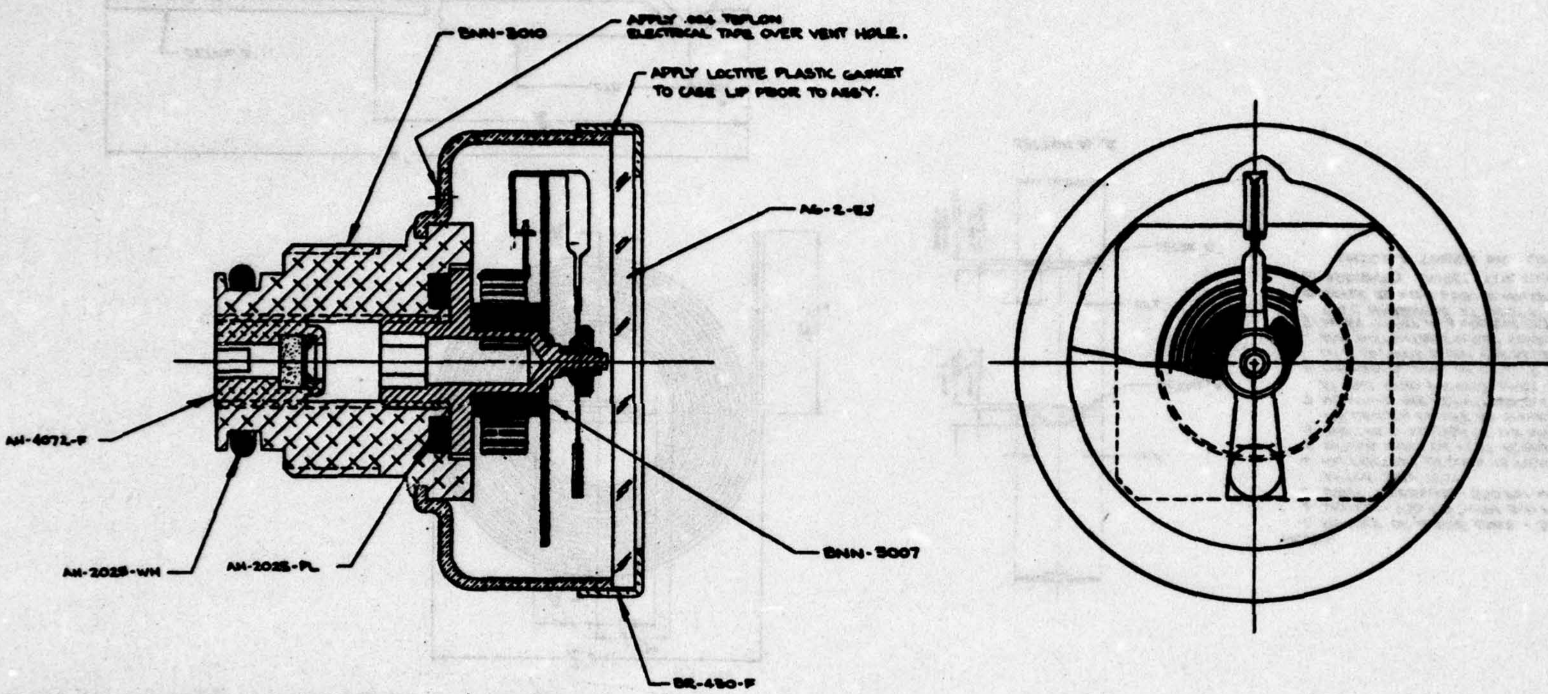
PART & DRAWING NO.: TS-701
Sheet 7

ADDENDUM III

DRAWINGS

LIMITS OF ACCEPTABLE Q, ... ARE DEFINED IN MIL-...

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



NOTES:
1. PRIOR TO ASSEMBLY OF AN-4072-F, LEAK TEST ASSEMBLY BY FILLING CASE WITH WATER & APPLYING 325 PSI DRY NITROGEN FOR 5 MINUTES. THERE SHALL BE NO EVIDENCE OF BUBBLES IN THIS TIME PERIOD.
2. ASSEMBLE AN-4072-F TO WITHIN ONE TURN OF SOCKET AND APPLY LOCTITE GRADE 'E' (2-1). CURE AT 180°F FOR 1 HOUR.
3. TEST IN ACCORDANCE WITH TS-701.

[redacted]

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1°
SURFACE FINISH AA MAX.
MATERIAL
SPECIFICATION
TREATMENT
FINISH

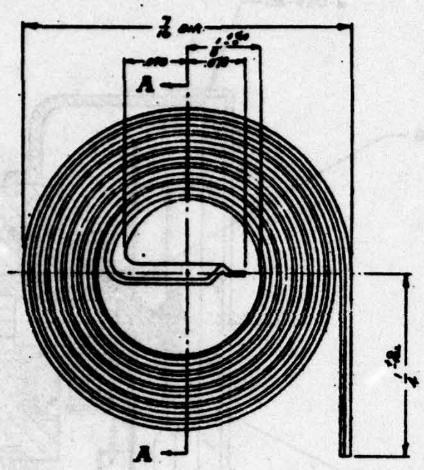
		DATE
DRAWN	C.S.	3-8-65
TRACED		
CHECKED	J. FULMER	11/22/65
APPROVED		
USED ON	CAN-3005	
NEXT ASSY	CAN-3005	
SUPERSEDES		

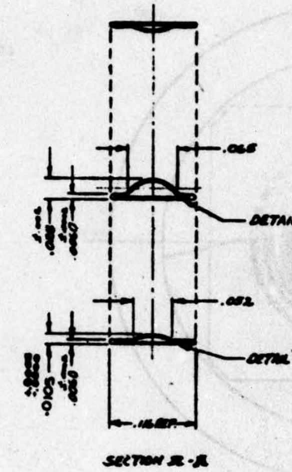
U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

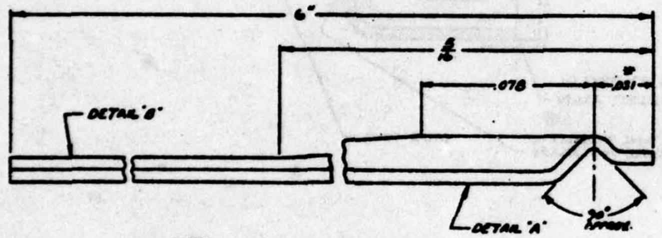
DRAWING TITLE
ASSEMBLY - SPIRAL BOURDON GAUGE
USAF TIRE INFLATION INDICATOR

CODE IDENT. NO.	SIZE	DWG. NO.
61349	C	AW1026BC01

SCALE 4/1 | SHEET







NOTE:
BLEND DETAIL 'A' WITH DETAIL 'B' AS SHOWN.
℄ THE SECTION DEFINED BY THIS DIMENSION SHALL BE CRIMPED TO APPROX. .005 TO EFFECT A SEAL AGAINST SOLDER FLUX & SOLDER.

DETAIL OF DEVELOPED LENGTH
SCALE 20:1

NOTES:
1. NUMBER OF ACTIVE COILS - 5½.
2. MOTION - 230 ±10° WITH 300 PSI INPUT.
3. OVER PRESSURE - 350 PSI WITHOUT LEAKS - SPRING FUNCTIONAL AFTER THIS TEST.
4. NO FRICTION IN COILS IS PERMISSIBLE.
5. SPRING MUST BE FLAT ACROSS COILS WITHIN ±1/32".
6. THE CROSS-SECTION OF THE SPRING MUST BE UNIFORM THROUGHOUT ITS LENGTH EXCEPT AS SHOWN.
7. NO KINKS ARE PERMITTED OVER THE ENTIRE COILED SPRING EXCEPT AT THE BEND & THESE SHALL BE HELD TO A MINIMUM.
8. THE SPRING SHALL BE CAPABLE OF A RESPONSE TIME OF A MINIMUM OF 5 SECONDS WHEN PRESSURIZED WITH A NEATSFOOT OIL MEDIUM AND INSTANTANEOUSLY EXHAUSTED FROM 300 PSI.
9. HEAT TREAT IN A VACUUM RETORT AFTER FORMING TO FULL HARDNESS AT 600°F. FOR 4 HOURS.
10. REFER TO MS-6686 FOR MANUFACTURING SPECIFICATION.
11. APPROVED SOURCE FOR RAW MATERIAL - UNIFORM TUBES INC. COLLEGEVILLE, PA.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±1°. SURFACE FINISH RMS MAX.	DRAWN RKF	DATE 4-29-65
	TRACED	
	CHECKED GRC	5-3-65
MATERIAL .0081 ±.0002 WALL × .0775 O.D. ±.001 BE. CU. TUBING (BERYLCO 25) SEE NOTE 11.	APPROVED W.L.B.	5-11-65
	USED ON AW1041AH01	
	NEXT ASS'Y BWN-2695-A	
	SUP'RSEDES	
SPECIFICATION AMS-203-18		
TREATMENT SEE NOTE 9.		
FINISH		

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE
SPIRAL BOURDON SPRING
1" PRESSURE GAUGE

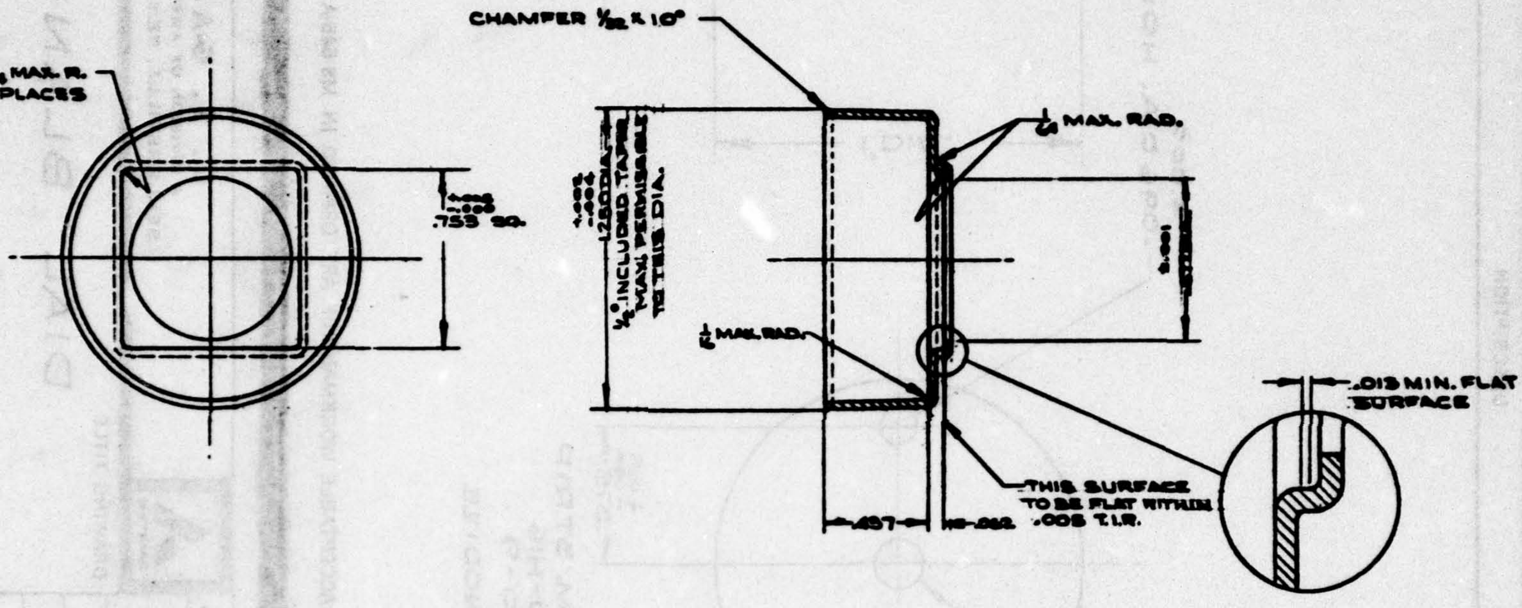
CODE IDENT. NO.	SIZE	DWG. NO.
61349	0	CA-800-G
SCALE 8:1		SHEET 1

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-646-A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		DATE	
	DRAWN Ray R	7-8-65	
MATERIAL 1/32 THK. ALUM. STRIP	TRACED		
	CHECKED		
	APPROVED		
	USED ON AW1026 BC01		
	NEXT ASS'Y BNN-5010		
	SUPERSEDES BSK-9666-AT		
SPECIFICATION MS-200-G			
TREATMENT			
FINISH #86 ANODIZE			

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE

CASE

USAF TIRE INFLATION INDICATOR

CODE IDENT. NO.	SIZE	DWG. NO.
61349	B	BC-618

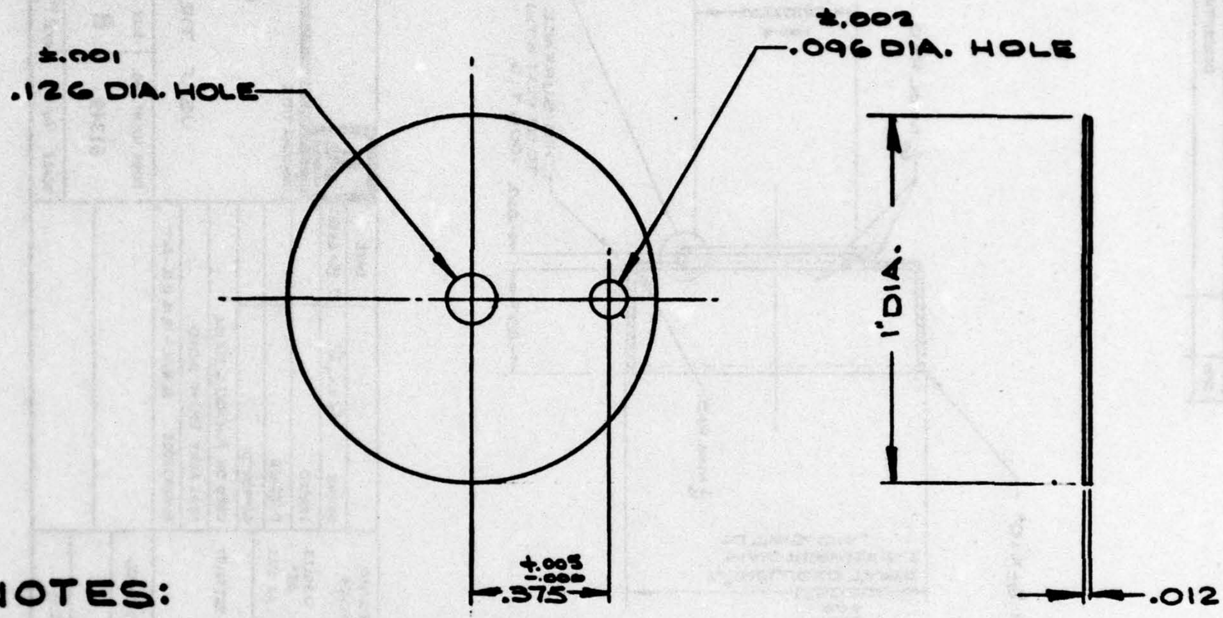
SCALE 2/1 | DATE 11/8 16.5 | SHEET

[redacted]

FORM NO. 104 5 65

REVISIONS

SYM		DESCRIPTION	DATE	APPROVED



NOTES:

1. MATERIAL: .012 THK. ALUM. STRIP 1 1/16 WIDE. 1100-H16
2. SPECIFICATION: MS-200-9.
3. FINISH: #B6 CLEAR ANODIZE

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN	Ray R.	7-8-65
CHECKED		
APPROVED		
USED ON AW1026BC01		
NEXT ASS'Y BNN-3007		
SUPERSEDES ASK-9444-G		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
±1/64	±.005	±1°

SURFACE FINISH AA MAX.

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE

DIAL BLANK

U.S.A.F. TIRE INFLATION INDICATOR

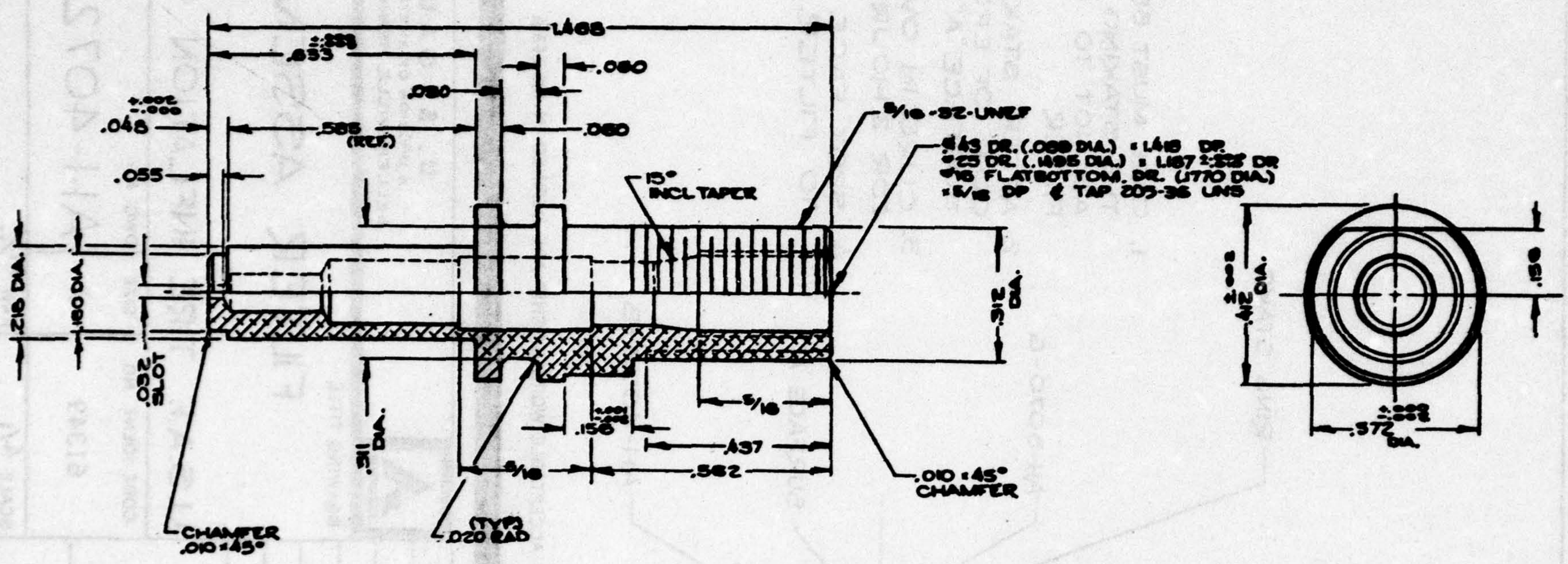
CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AD-11115

SCALE 2/1 | RAW WT/M 1.38 LBS. | SHEET

FORM NO. 934 ALT. 65

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-605-A

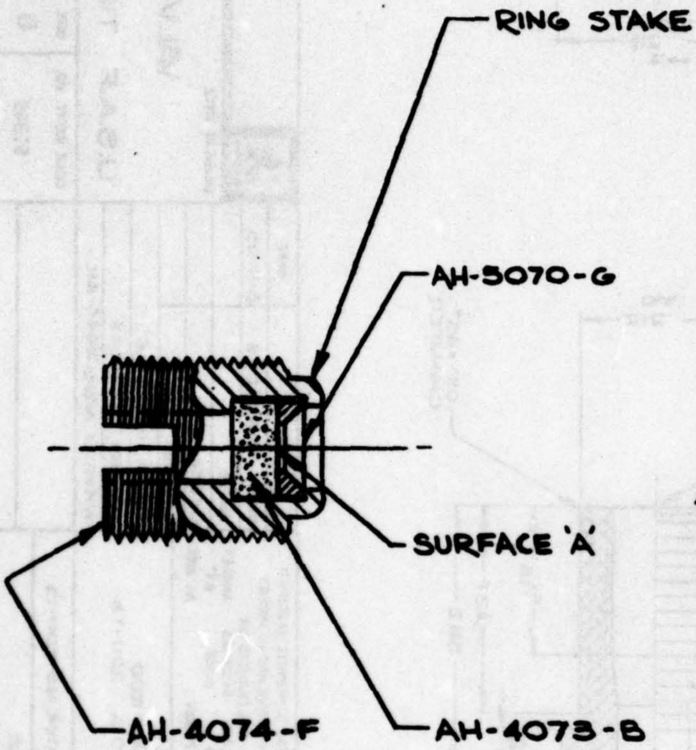
REVISIONS				
SYM		DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		DATE	
TOLERANCES ON FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±1°	DRAWN C. BROOKS	8-11-65	U. S. GAUGE, A DIVISION OF AMETEK, INC., SELLERSVILLE, PENNSYLVANIA
SURFACE FINISH AA MAX.	TRACED		DRAWING TITLE
MATERIAL ALUM. ROD 1/2" DIA 2011-T3	CHECKED		VALVE HOUSING
	APPROVED		U.S.A.F TIRE INFLATION INDICATOR
	USED ON CNN-9005		
	NEXT ASSY CNN-9005		
	SUPERSEDES ASK-8444-AK		
SPECIFICATION MS-200-15			CODE IDENT. NO. 61349 — SIZE B — DWG. NO. BF-873-8
TREATMENT			
FINISH ANODIZE			SCALE 4/1 — SHEET

[redacted]

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



1. CARE MUST BE TAKEN DURING THE STAKING OPERATION. SO AS NOT TO FRACTURE FILTER.
2. AFTER STAKING, APPLY LIGHT COAT OF EPOXY ON ENTIRE SURFACE "A"
3. CURE IN OVEN AT 180°F. FOR 2 HOURS.
4. SPOT FACE SURFACE "A" TO FILTER. .052 $^{+.000}_{-.005}$ DIA.

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

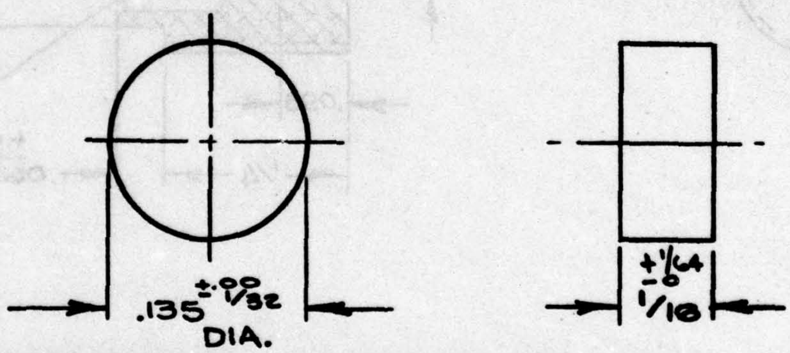
DRAWN C.BROOKS	8-13-65	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA	
CHECKED			
APPROVED			
USED ON AW1026 BC01		DRAWING TITLE FILTER ASSEMBLY U.S.A.F. TIRE INFLATION INDICATOR	
NEXT ASS'Y CNN-3006			
SUPERSEDES ASK-8444-P			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		CODE IDENT. NO. 61349	SIZE A — DWG. NO. AH-4072-F
		SCALE 4/1	RAW WT/M — SHEET

FORM NO. 934 ALT. 65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

MATERIAL:
FINE GRADE #7740 PYREX BRAND FRITTED DISC

PURCHASE FROM:
CORNING GLASS, NEW YORK.



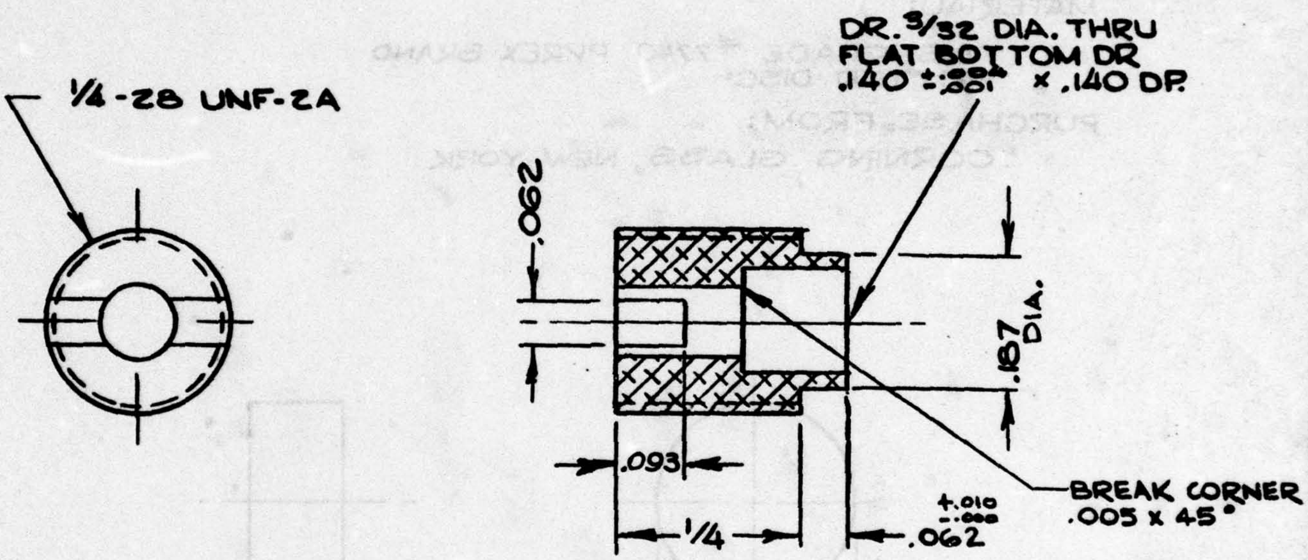
LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN C.BROOKS	8-13-65	AMETEK	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA
CHECKED			
APPROVED			
USED ON AW 1026 B(01		DRAWING TITLE	FILTER U.S.A.F. TIRE INFLATION INDICATOR
NEXT ASS'Y AH-4072-F			
SUPERSEDES ASK-8444-R			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		CODE IDENT. NO. 61349	SIZE A DWG. NO. AH-4073-B
		SCALE 8/1	RAW WT/M PURCHASE SHEET

FORM NO. 934 ALT. 65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN C.BROOKS	8-13-65
CHECKED	
APPROVED	

USED ON AW1026 BC01

NEXT ASS'Y AH-4072-F

SUPERSEDES ASK-9444-Q

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
± 1/64	± .005	± 1°

SURFACE FINISH AA MAX.

MATERIAL - 1/4 DIA. ALUMINUM ROD 2024-T4, MS-200-B
FINISH - ANODIZE

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE

FILTER BUSHING

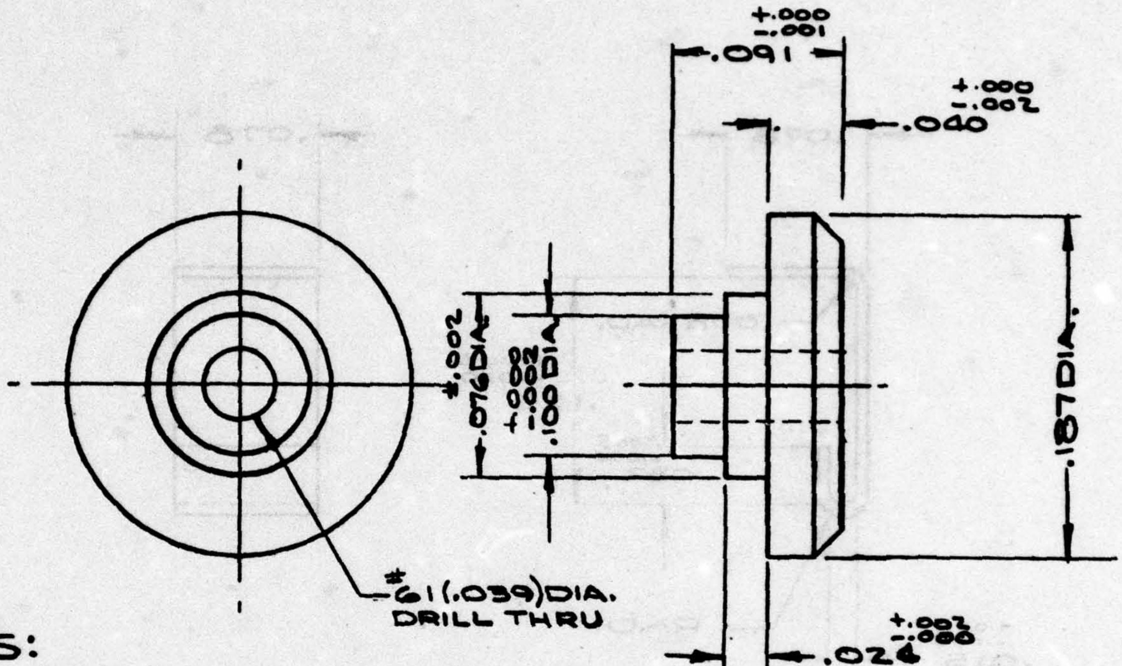
U.S.A.F. TIRE INFLATION INDICATOR

CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AH-4074-F

SCALE 4/1	RAW WT/M 1.9 LBS	SHEET

FORM NO. 334 ALT. 65

REVISIONS				
SYM		DESCRIPTION	DATE	APPROVED



NOTES:

1. MATERIAL: 3/16 DIA. ALUM. ROD 2024-T4
2. SPECIFICATION: MS-200-8
3. FINISH: #86 CLEAR ANODIZE

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN	Ray R.	7-13-65
CHECKED		
APPROVED		
USED ON	AW1026BC01	
NEXT ASS'Y	AP-351-A	
SUPERSEDES	ASK-9444-C	

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE

POINTER BUSHING

U.S.A.F. TIRE INFLATION INDICATOR

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

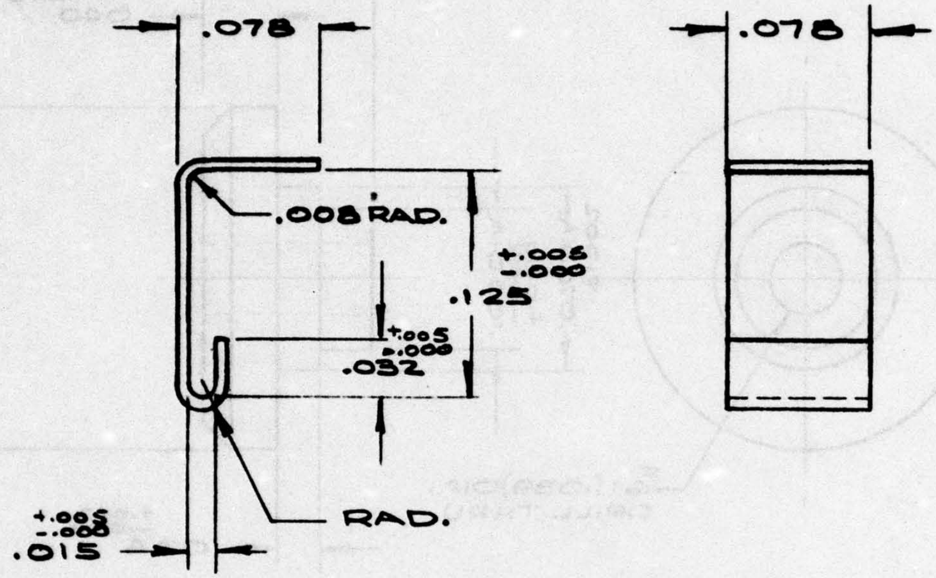
FRACTIONS	DECIMALS	ANGLES
± 1/64	± .005	± 1°
SURFACE FINISH		AA MAX.

CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AH-5210-H

SCALE 10/1	RAW WT/M .38 LB	SHEET

FORM NO. 934 ALT. 65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



NOTES:

1. MATERIAL: .006 THK. PHOS. BRONZE .078 WIDE
2. SPECIFICATIONS: MS - 207 - 14

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN	Ray R	7-13-65
CHECKED		
APPROVED		
USED ON	AW1026 BC01	
NEXT ASS'Y	BNN-3009	
SUPERSEDES	ASK-9444-BJ	

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
± 1/64	± .005	± 1°

SURFACE FINISH AA MAX.

DRAWING TITLE
TAKEOFF BRACKET
U.S.A.F. TIRE INFLATION INDICATOR

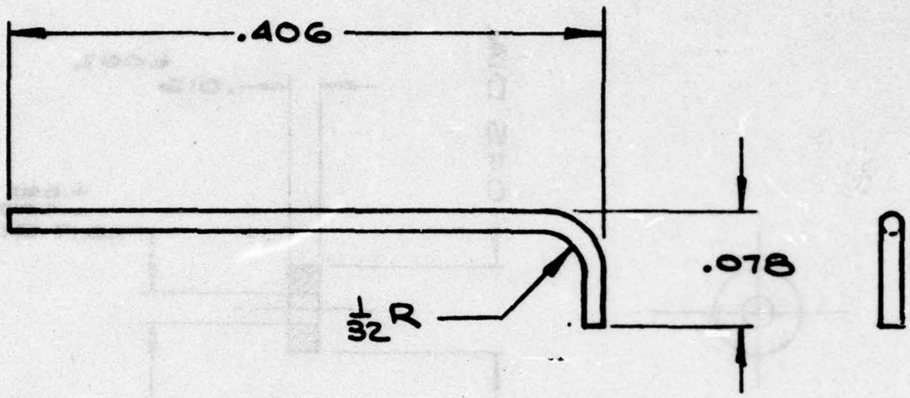
CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AH-5268

SCALE	RAW WT/M	SHEET
10/1	.04 *	

FORM NO 934 ALT 65

REVISIONS

SYM		DESCRIPTION	DATE	APPROVED



NOTES:

1. MATERIAL: .014 DIA. MUSIC WIRE
2. SPECIFICATION: MS-210-11

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN	Ray R	7-13-65
CHECKED		
APPROVED		
USED ON	AW1026BC01	
NEXT ASS'Y	BNN-3009	
SUPERSEDES	ASK-9444-BH	

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE

POINTER DRIVE

U.S.A.F TIRE INFLATION INDICATOR

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
±1/64	±.005	±1°

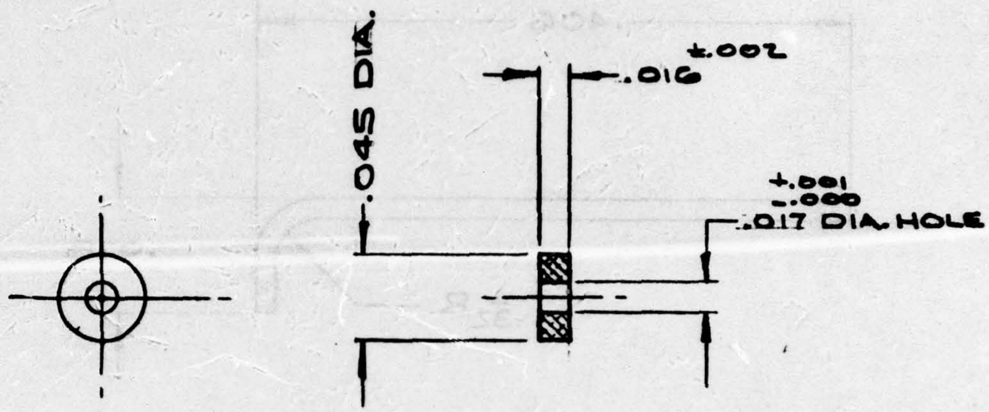
SURFACE FINISH AA MAX.

CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AH-5269

SCALE 8/1 | RAW WT/M | SHEET

FORM NO. 834 ALT. 65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



NOTES:

1. MATERIAL: .016 ±.002 THK ALUM. STRIP 2024-T4
2. SPECIFICATION: MS-200-1
3. FINISH: #86 CLEAR ANODIZE

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN	RayR	7-9-65
CHECKED		
APPROVED		
USED ON AW1026 BC01		
NEXT ASS'Y BNN-3007		
SUPERSEDES ASK-9444-V		

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
±1/64	±.005	±1°
SURFACE FINISH		AA MAX.

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE

WASHER-WIRE DRIVE

U.S.A.F. TIRE INFLATION INDICATOR

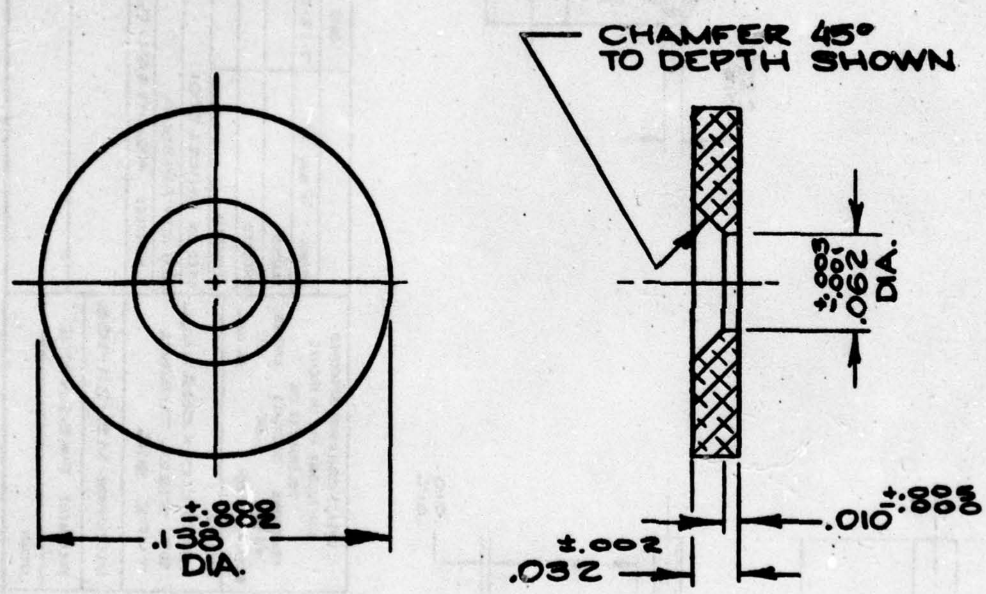
CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AH-5270-B

SCALE	RAW WT/M	SHEET
10/1	0.004 #	

FORM NO. 834 ALT. 65

REVISIONS				
SYM		DESCRIPTION	DATE	APPROVED

MATERIAL:
ALUM. 5/32 2024-T4
MS-200-31
FINISH: ANODIZE



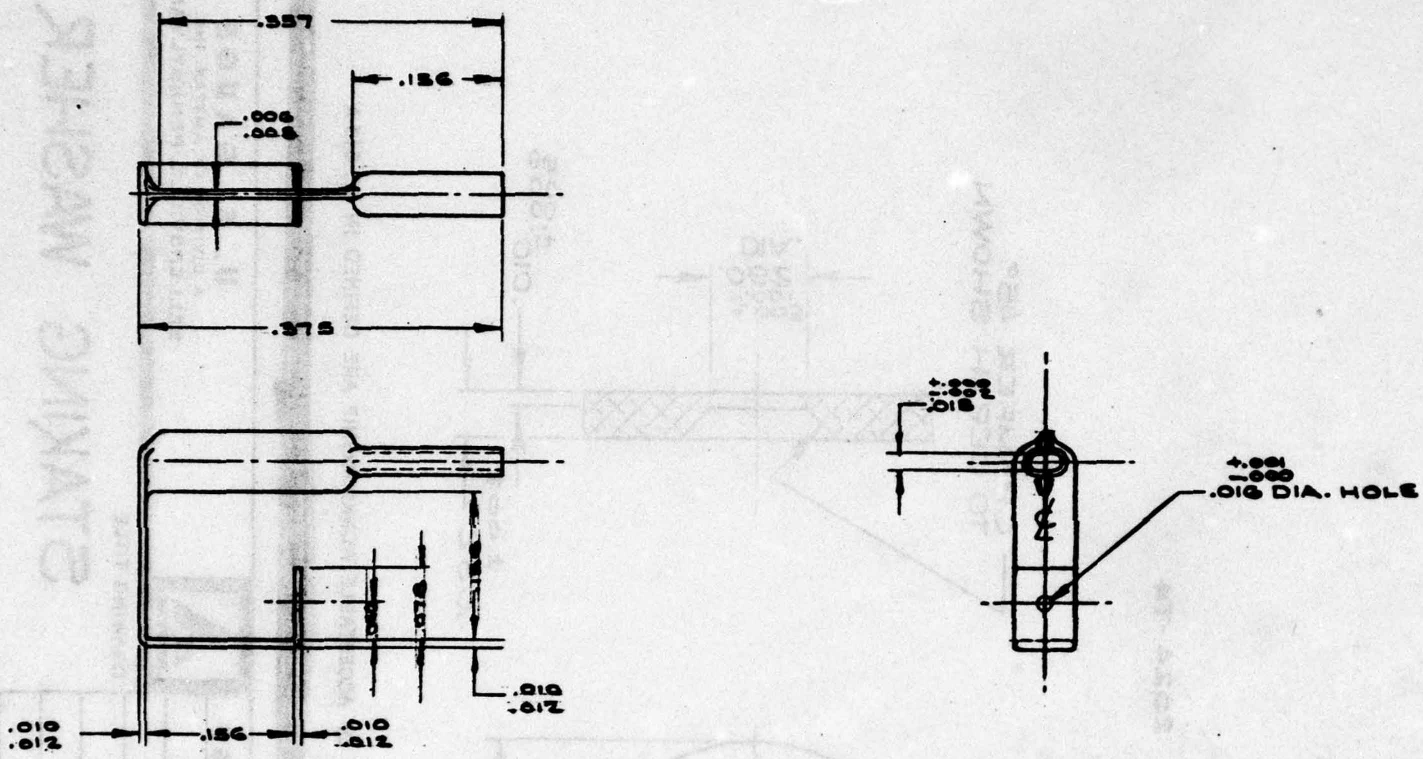
LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN C.BROOKS	8-13-65	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA		
CHECKED				
APPROVED				
USED ON AW 1026 BC01		DRAWING TITLE STAKING WASHER		
NEXT ASS'Y AH-4072-F				
SUPERSEDES ASK-9444-U				
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		U.S.A.F. TIRE INFLATION INDICATOR		
		CODE IDENT. NO. 61349	SIZE A	DWG. NO. AH-5270-G
		SCALE 8/1	RAW WT/M 0.1#	SHEET

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-545-A

REVISIONS				
SYM		DESCRIPTION	DATE	APPROVED

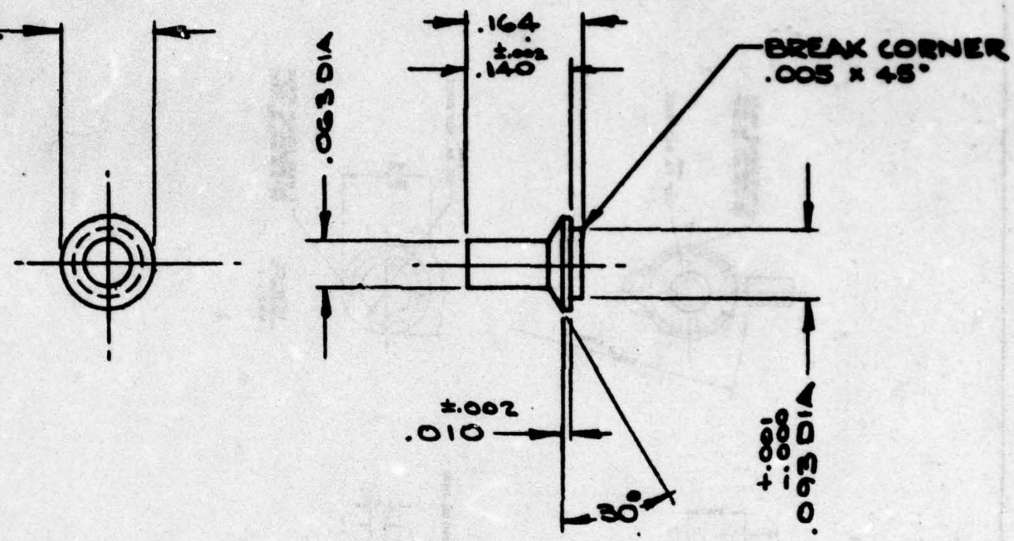


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.	DRAWN Ray R. — DATE 7-12-63	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA	
	TRACED	DRAWING TITLE	
	CHECKED	POINTER EXTENSION	
	APPROVED	U.S.A.F. TIRE INFLATION INDICATOR	
MATERIAL .040 O.D. x .005 WALL ST. STEEL TUBING TYPE 316	USED ON AW1026BK01		
	NEXT ASS'Y AP-351-A		
	SUPERSEDES A3X-9444-BG		
SPECIFICATION MS-211-108		CODE IDENT. NO. 61349	SIZE B — DWG. NO. BH-5272
TREATMENT PASSIVATE			
FINISH		SCALE 8/1	WT. .13 LB — SHEET

[redacted]

FORM NO. 504 8 63

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



NOTES:

1. MATERIAL: 1/8 DIA. ALUM. ROD 2024-T4
2. SPECIFICATION: MS-200-8
3. FINISH: # 86 CLEAR ANODIZE

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN	Roy R.	7-9-65
CHECKED		
APPROVED		
USED ON AW1026 BC01		
NEXT ASS'Y BNN-5007		
SUPERSEDES ASK-9444-W		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
±1/64	±.005	±1°

SURFACE FINISH AA MAX.

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE

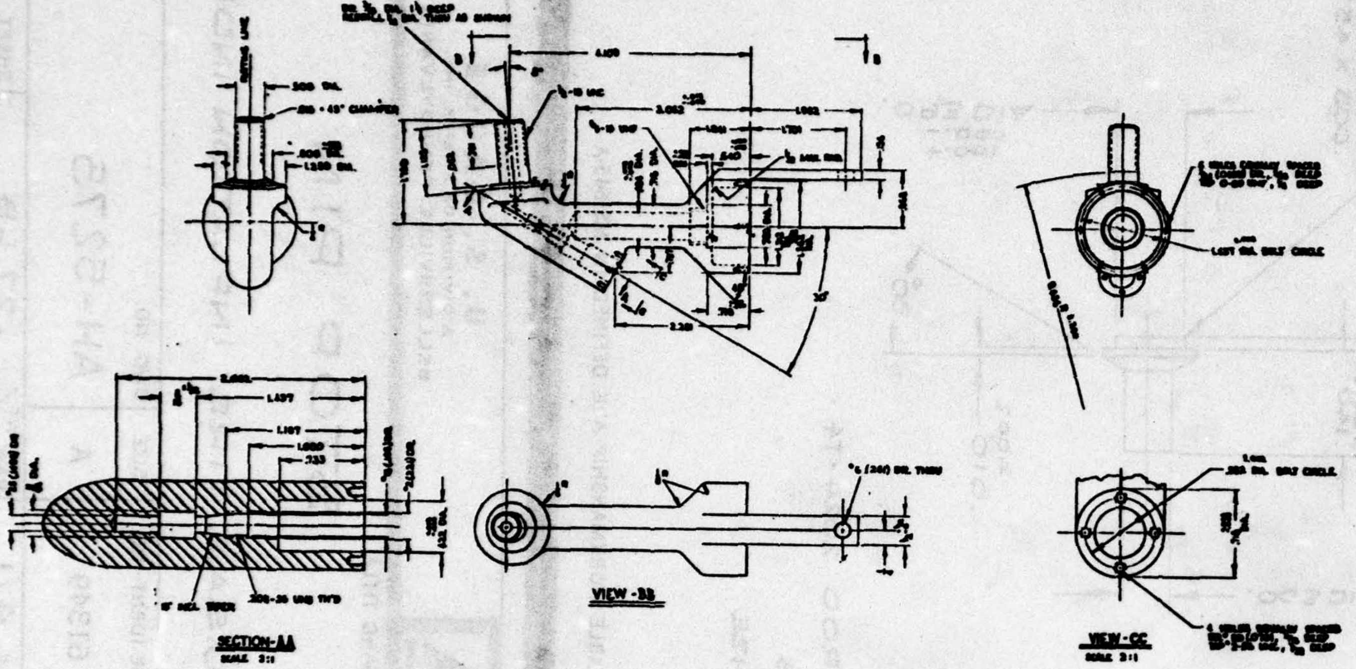
STOP PIN

U.S.A.F. TIRE INFLATION INDICATOR

CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AH-5275

SCALE	RAW WT/M	SHEET
4/1	.27 LB	

FORM NO. 934 ALT. 65



U. S. GAUGE

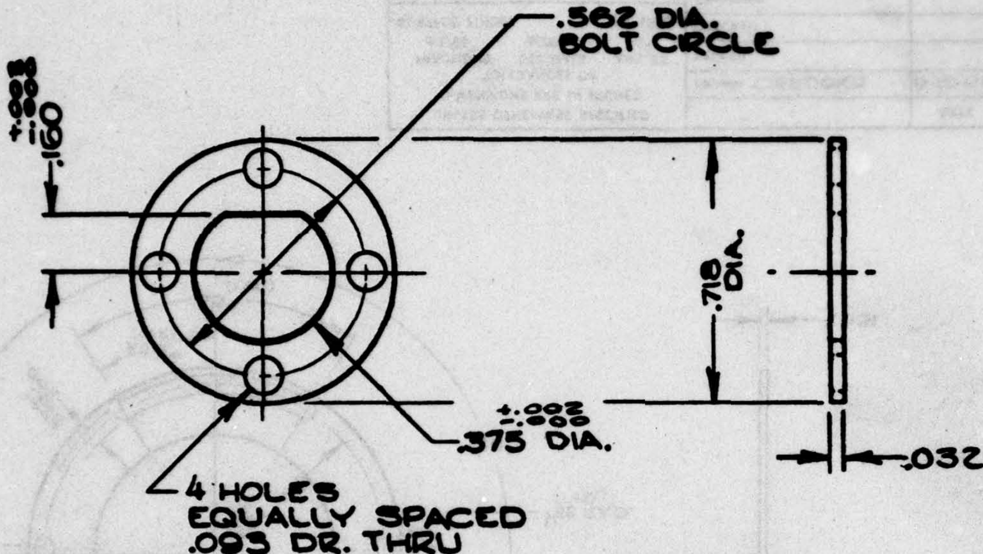
GAUGE HOUSING

U.S. AIR FORCE TIRE PRESSURE GAUGE

D DH-5276

[redacted]

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

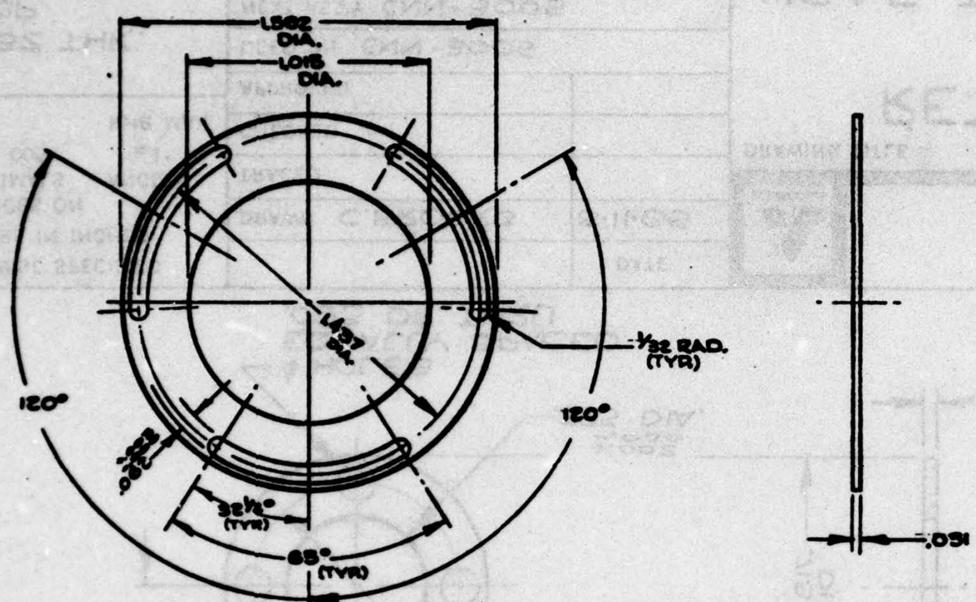


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH RHR MAX.		DATE	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA
	DRAWN C.BROOKS	8-11-65	
	TRACED		DRAWING TITLE
MATERIAL 1" WIDE × .032 THK. ALUM. STRIP 5052-H32	CHECKED		RETAINER PLATE
	APPROVED		
	USED ON CNN-3005		U.S.A.F TIRE INFLATION INDICATOR
	NEXT ASS'Y CNN-3005		
	SUPERSEDES ASK-9444-AQ		
SPECIFICATION MS-200-20			CODE IDENT. NO. 61349 | SIZE A | DWG. NO. AH-5277
TREATMENT			
FINISH ANODIZE			SCALE 2/1 | RAW WT/M 29# | SHEET

FORM NO. 934 A 63

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-646-A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

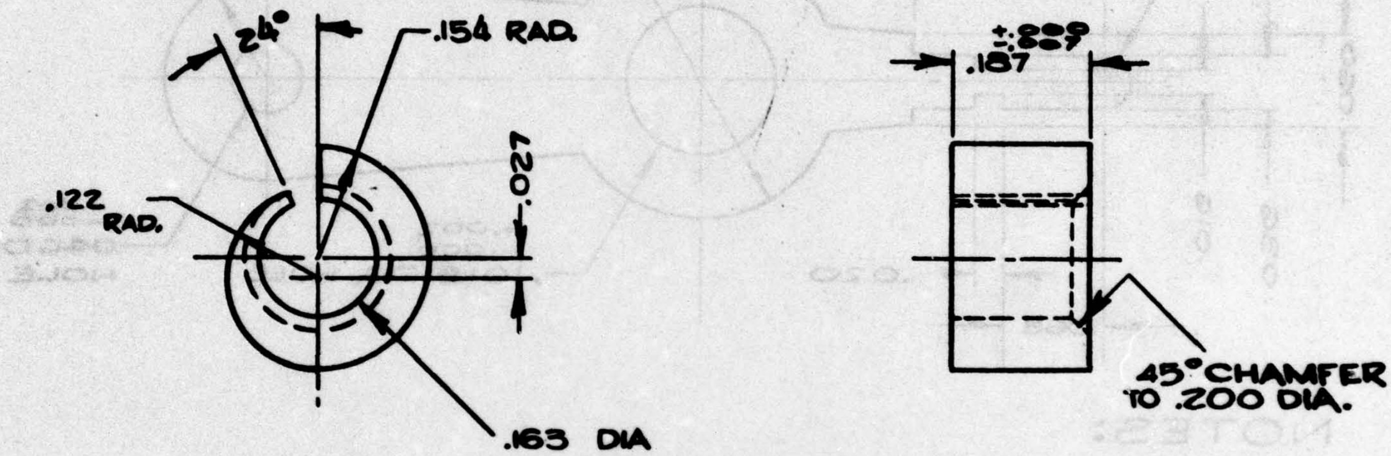


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.	DRAWN C. BROOKS DATE 8-12-65	U. S. GAUGE
	TRACED	DRAWING TITLE DIAL PLATE-GAUGE RETAINER
	CHECKED	U.S.A.F TIRE INFLATION INDICATOR
	APPROVED	
MATERIAL ALUM. STRIP .031 TH. 1100-H16	USED ON CNN-3005	
	NEXT ASSY CNN-3005	
	SUPERSEDES ASK-9444-BC	
SPECIFICATION MS-200-9		CODE IDENT. NO. 61349 · SIZE B · DWG. NO. BH-5278
TREATMENT		
FINISH BLACK ANODIZE		SCALE 2/1 · 9.8 · SHEET

[redacted]

FORM NO. 504 8 65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



MATERIAL:
TEFLON

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN C. BROOKS	9-8-65	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA
CHECKED		
APPROVED		
USED ON AW1026BC01		DRAWING TITLE SUPPORT
NEXT ASS'Y BNN-5007		
SUPERSEDES AGK-9444-B2		USAF TIRE INFLATION INDICATOR

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

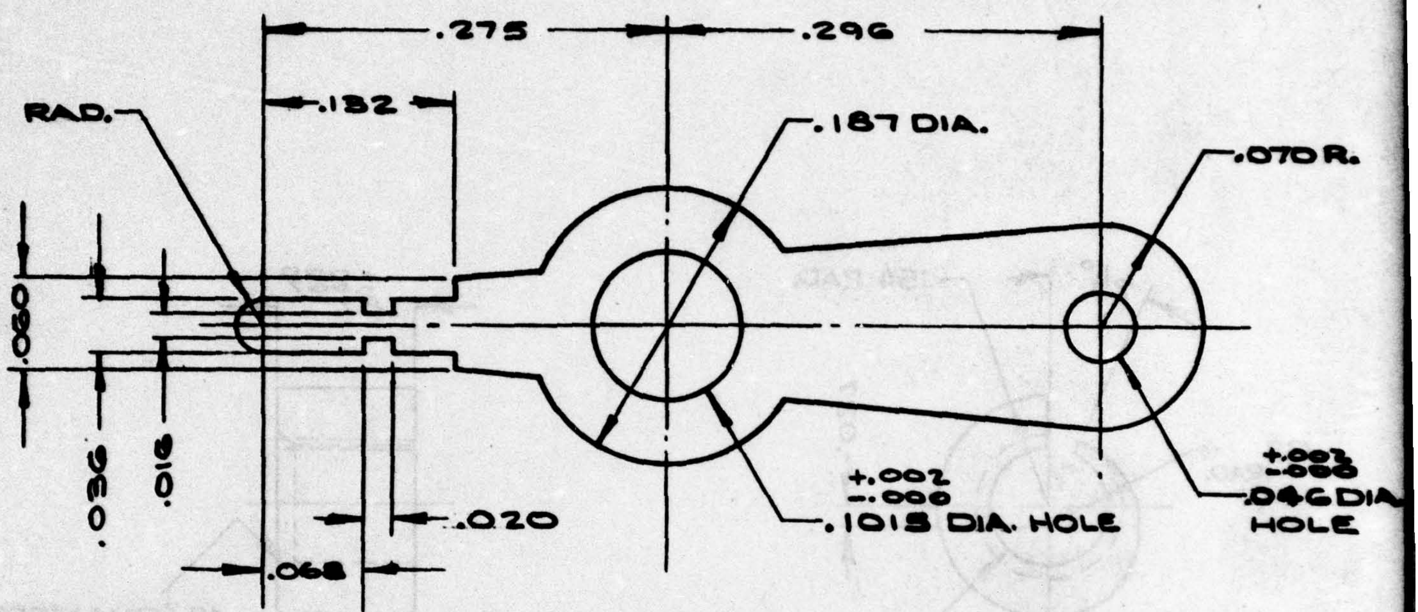
FRACTIONS	DECIMALS	ANGLES
±1/64	±.005	±1°
SURFACE FINISH		AA MAX.

CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AH-5279

SCALE	RAW WT/M PURCHASE	SHEET

FORM NO. 834 ALT. 65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



NOTES:

1. MATERIAL: .012 THK. BRASS STRIP
2. SPECIFICATION: MS-202-27

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

[redacted]

DRAWN	Ray R.	7-13-65
CHECKED		
APPROVED		
USED ON	AW1026BC01	
NEXT ASS'Y	AP-351-A	
SUPERSEDES	ASK-9444-D	

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE

POINTER BLANK

U.S.A.F. TIRE INFLATION INDICATOR

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

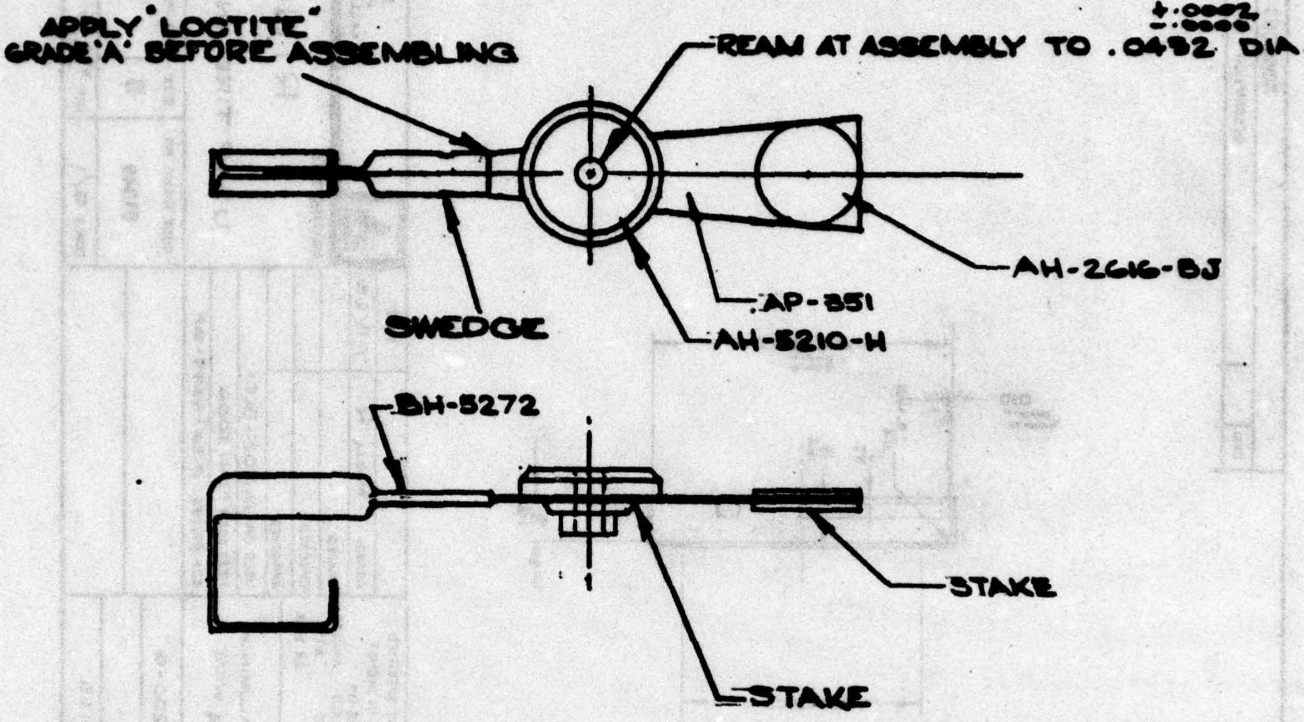
FRACTIONS	DECIMALS	ANGLES
± 1/64	± .005	± 1°
SURFACE FINISH		AA MAX.

CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AP-351

SCALE 8/1 | RAW WT/M 1.0 | SHEET

FORM NO. 834 ALT. 65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-845-A

[redacted]

DRAWN C.BROOKS 9-7-65
CHECKED
APPROVED
USED ON AW1026BC01
NEXT ASS'Y BNN-3007
SUPERSEDES

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON

FRACTIONS	DECIMALS	ANGLES
±1/64	±.005	±1°

SURFACE FINISH AA MAX.

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE

POINTER ASSEMBLY
U.S.A.F. TIRE INFLATION GAUGE

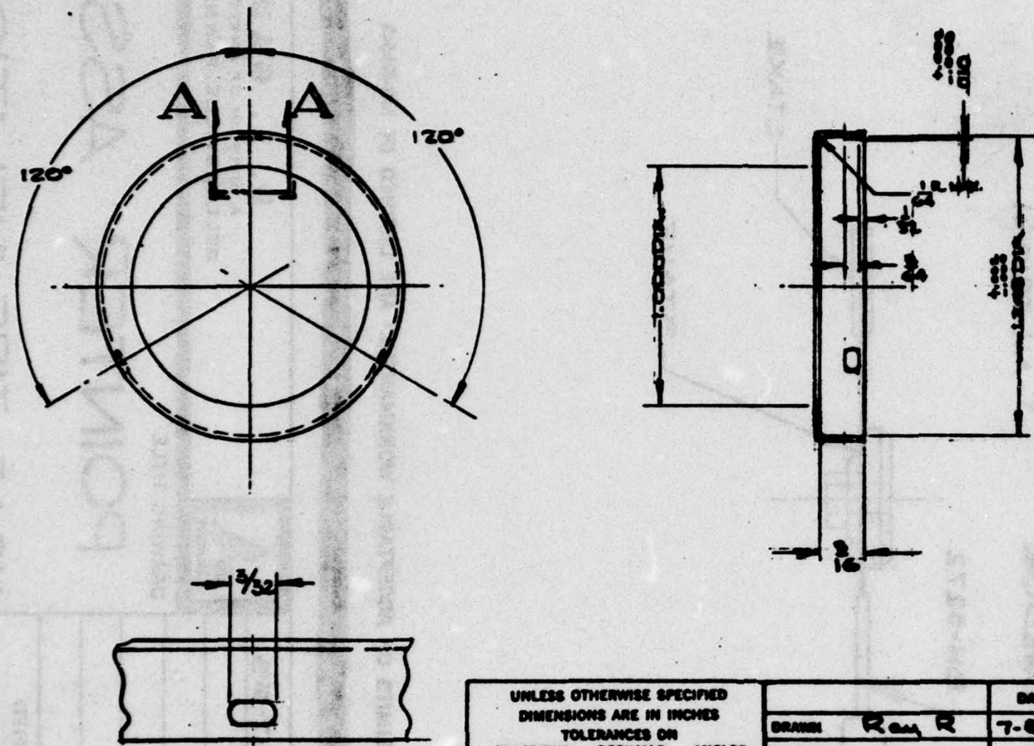
CODE IDENT. NO.	SIZE	DWG. NO.
61349	A	AP-351-A

SCALE 4/1 RAW WT/M SHEET

FORM NO. 834 ALT. 65

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

REVISIONS				
SYM		DESCRIPTION	DATE	APPROVED



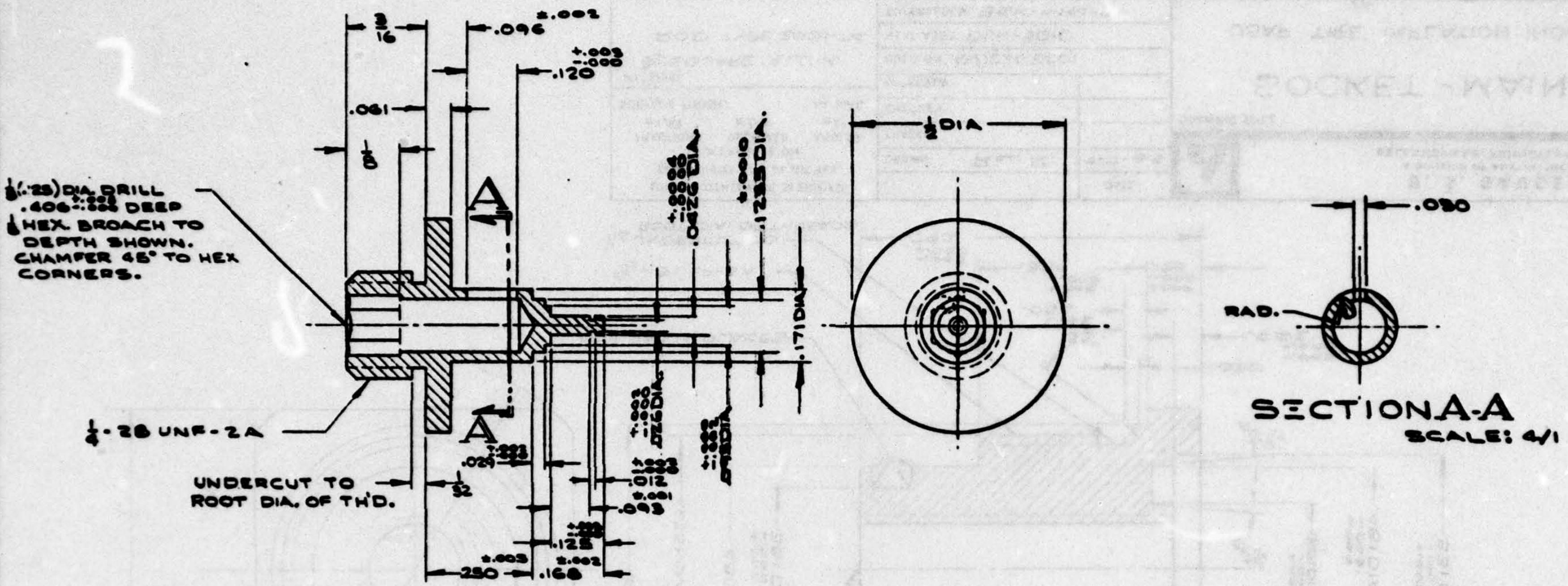
SECTION A-A
SCALE: 4/1

[redacted]

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.	DRAWN Ray R — DATE 7-8-68		U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA
MATERIAL .0179 THK. ALUMINUM STRIP 1 3/4 WIDE	TRACED		DRAWING TITLE RING USAF TIRE INFLATION INDICATOR
	CHECKED		
	APPROVED		
	USED ON AW/1026 BC01		
	NEXT ASSY BHN-3006		
	SUPERSEDES ASK-9444-BF		
SPECIFICATION MS-200-6			CODE IDENT. NO. 61349 — SIZE B — DWG. NO. BR-430-B
TREATMENT			
FINISH ANODIZE			SCALE 2/1 — RAW WT/B 5.2 # — SHEET

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON			DATE
FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1°	DRAWN	RayR	7-7-65
SURFACE FINISH AA MAX.	TRACED		
	CHECKED		
MATERIAL 1/2 DIA. ROD ST. STEEL TYPE 410	APPROVED		
	USED ON	AN10265C01	
	NEXT ASS'Y	BNN-5008	
	SUPERSEDES	ABK-9444-A	
SPECIFICATION MS-211-38			
TREATMENT			
FINISH			

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE
SOCKET - SPRING MTG.

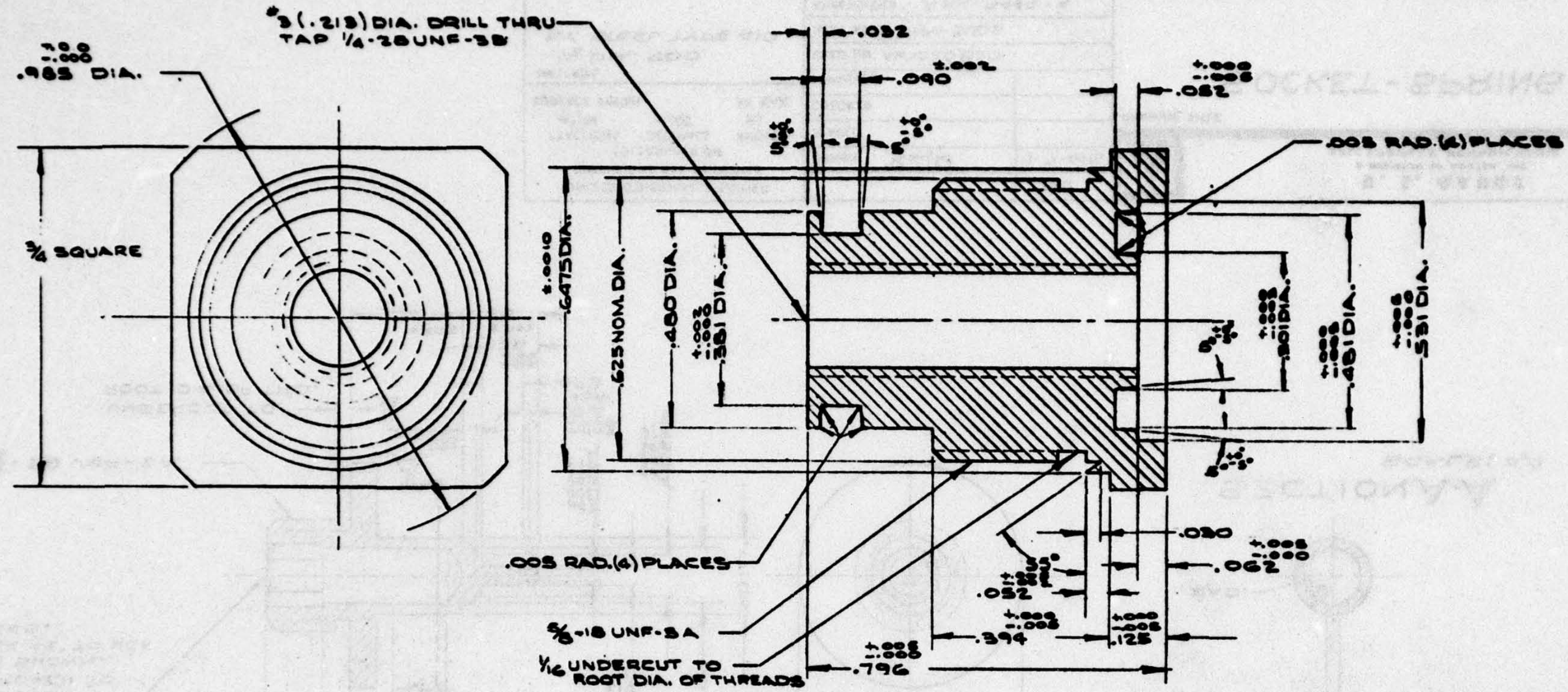
CODE IDENT. NO.	SIZE	DWG. NO.
61349	B	BS-863
SCALE 4/1	RAW WT/M 43 LB	SHEET

[redacted]

FORM NO. 604 8 65

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.	DRAWN Ray R.	DATE 9-7-65
	TRACED	
	CHECKED	
	APPROVED	
MATERIAL 3/4 SQUARE ALUM. ROD TYPE 2024-T4	USED ON AW1026BC01	
	NEXT ASS'Y BNN-3010	
	SUPERSEDES BSK-9444-B	
SPECIFICATION MS-200-B		
TREATMENT		
FINISH #86		

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

DRAWING TITLE
SOCKET - MAIN
USAF TIRE INFLATION INDICATOR

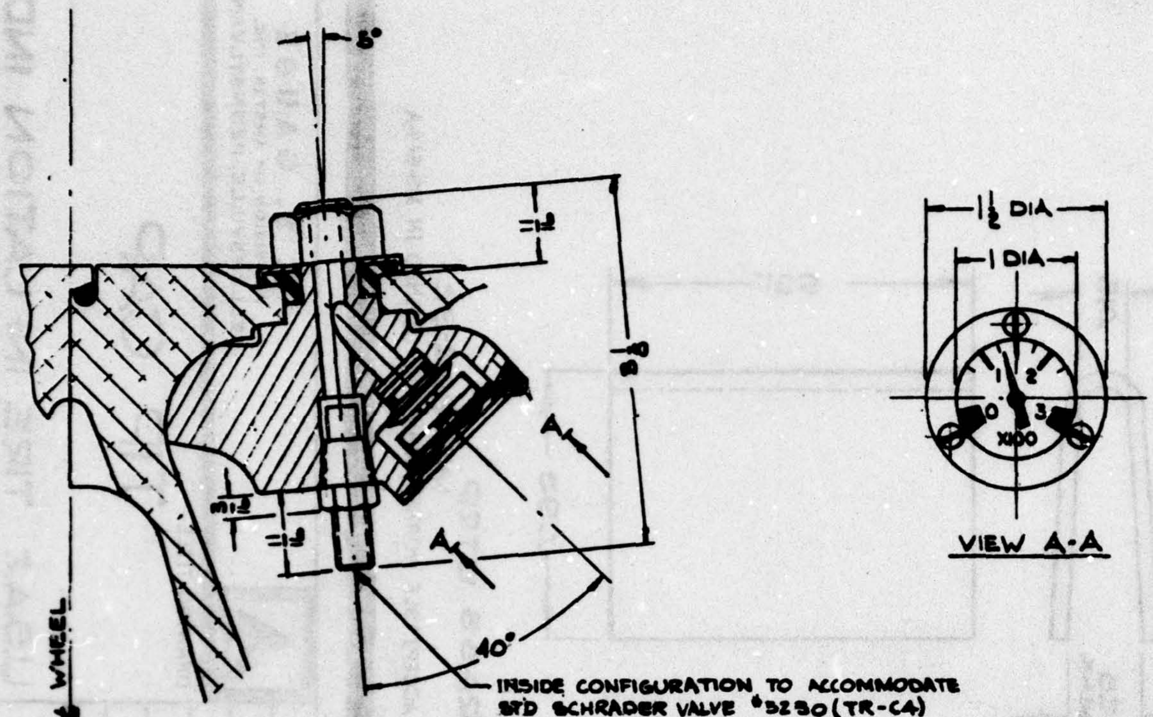
CODE IDENT. NO.	SIZE	DWG. NO.	
61349	B	BS-864	
SCALE: 4/1	RAW WT/M 53 LB		SHEET

[redacted]

FORM NO. 504 D 65

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

REVISIONS				
SYM		DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		DATE
	DRAWN WM HILL	6-26-64
	TRACED	
	CHECKED J. FULMER	6/29/64
MATERIAL	APPROVED R.D.W.	6-30-64
	USED ON	
	NEXT ASS'Y	
	SUPERSEDES	
SPECIFICATION		
TREATMENT		
FINISH		

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

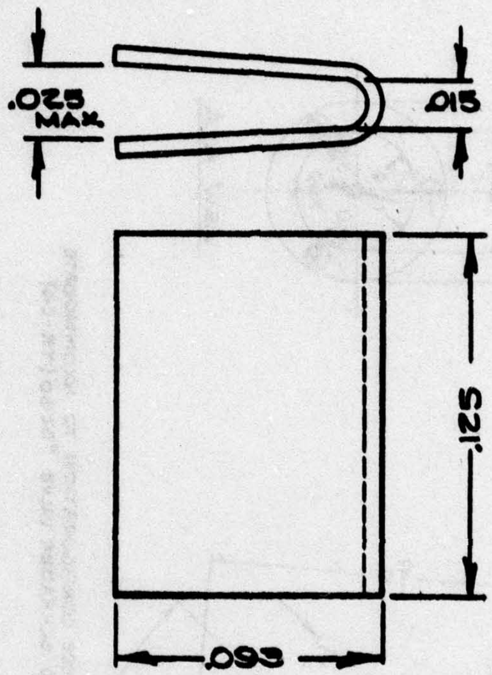
DRAWING TITLE
HOUSING & MOUNTING DESIGN V
USAF TIRE GAUGE

CODE IDENT. NO.	SIZE	DWG. NO.
61349	B	B-SK-9426
SCALE FULL	RAW WT/	SHEET #2

[redacted]

FORM NO. 504 B 90

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



MATERIAL:
70-30 H.H. BRASS STRIP
.006 THK. MS-202:32

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

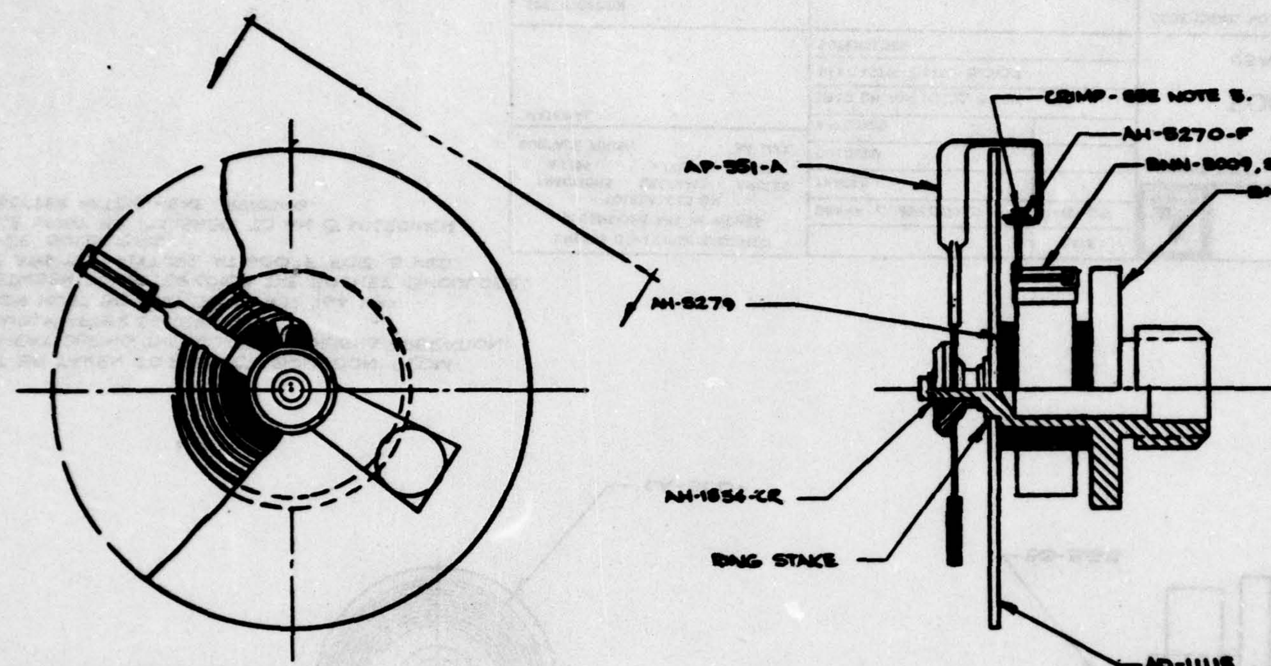
[redacted]

DRAWN C. BROOKS	3-12-65	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA	
CHECKED			
APPROVED			
USED ON AW1026BC01		DRAWING TITLE TIP CAP U.S.A.F. TIRE INFLATION INDICATOR	
NEXT ASS'Y BNN-3008			
SUPERSEDES ASK-9444-AW			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		CODE IDENT. NO. 61349	SIZE A · DWG. NO. AT-260
		SCALE 15/1	RAW WT/M · SHEET

FORM NO. 534 ALT. 66

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-045-A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



NOTES:

1. APPLY LIGHT FILM OF DRY MOLYKOTE PRIOR TO ASS'Y OF POINTER TO SHAFT.
2. TEST FOR SMOOTHNESS OF POINTER ACTION PRIOR TO ASS'Y OF AH-5270-F.
3. AFTER ASS'Y. OF AH-5270-F, CRIMP WIRE AS SHOWN. WHILE CRIMPING, THE BOURDON MUST NOT BE FLEXED SO AS TO CAUSE PRELOAD ON THE POINTER.
4. APPLY 150 PSI PRESSURE AND ROTATE DIAL TO INDICATE 150 PSI.
5. ADJUST TAKEOFF BRACKET TO ACHIEVE 0 & 300 PSI TEST POINTS. CRIMP BRACKET AND APPLY HYSOL EPOXY. CURE EPOXY AT 180°F FOR 1 HOUR.

[redacted]

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±1°
SURFACE FINISH AA MAX.
MATERIAL
SPECIFICATION
TREATMENT
FINISH

		DATE
DRAWN	C BROOKS	9/8/68
TRACED		
CHECKED		
APPROVED		
USED ON	AW1026BC01	
NEXT ASS'Y	AW1026BC01	
SUPERSEDES		

U. S. GAUGE
A DIVISION OF AMETEK, INC.
SELLERSVILLE, PENNSYLVANIA

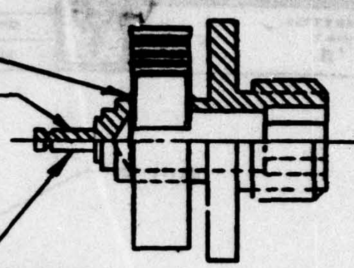
DRAWING TITLE
SUB-ASSEMBLY-GAUGE INTERNALS
USAF TIRE INFLATION INDICATOR

CODE IDENT. NO.	SIZE	DWG. NO.
61349	B	BNN-3007
SCALE 4/1		SHEET

FORM NO. 504 6 68

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-845-A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

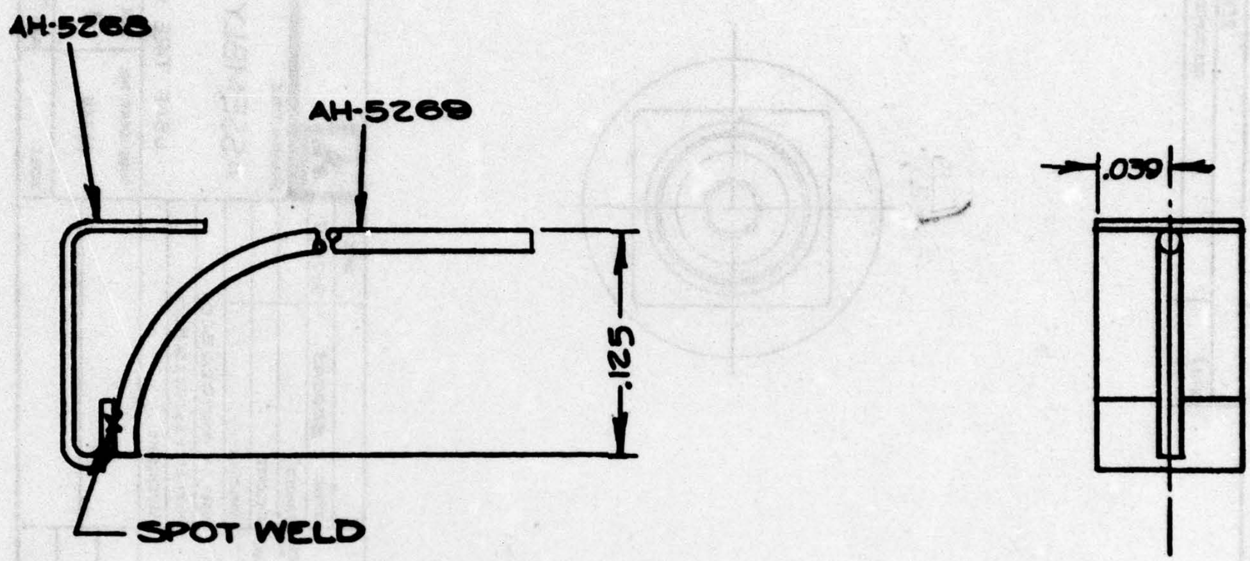


NOTES:
1. CARE MUST BE TAKEN TO PROTECT BOURDON FROM EXCESSIVE HEAT DURING THE SILVER SOLDERING OPERATION.
2. CLEAN ASSEMBLY AFTER SOLDERING
3. THE BOURDON MUST BE FLAT TO WITHIN 1/64 MAX. RUNOUT BETWEEN THE OUTER COIL & THE SOCKET SHOULDER.
4. HEAT TREAT ASS'Y IN FIXTURE AT 600°F. FOR 8 HRS. AFTER SILVER SOLDERING.
5. THIS SURFACE MUST BE POLISHED TO AN 8 MICROINCH FINISH OR BETTER AFTER HEAT TREATING.

[redacted]

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		DATE	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA
MATERIAL	DRAWN C. BROOKS	9-8-65	DRAWING TITLE SUB-ASSEMBLY SOCKET, BOURDON, & TIP USAF TIRE INFLATION INDICATOR
	TRACED		
	CHECKED		
	APPROVED		
	USED ON AW1026 BC01		
	NEXT ASS'Y BNN-3007		
	SUPERSEDES		
SPECIFICATION			CODE IDENT. NO. 61349 · SIZE B · DWG. NO. BNN-3008
TREATMENT			
FINISH			SCALE 4/1 · RAW WT/M · SHEET

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-645-A

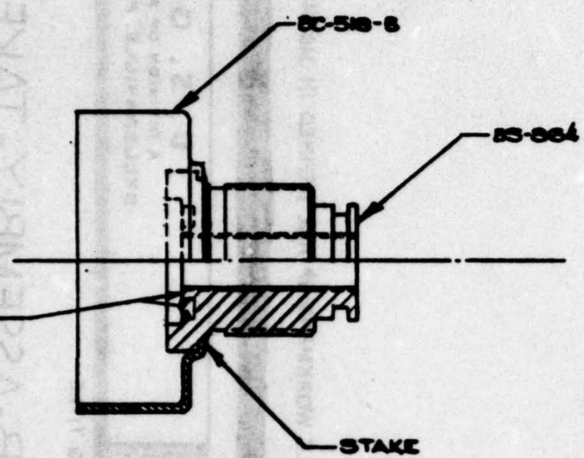
[redacted]

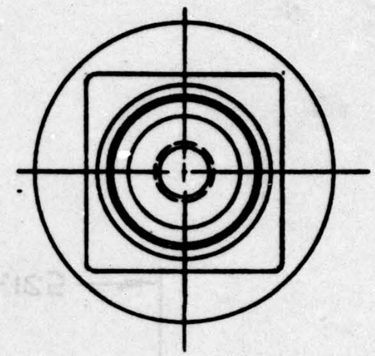
DRAWN C. BROOKS	9-8-65	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA	
CHECKED			
APPROVED			
USED ON AW1026BC01		DRAWING TITLE SUB-ASSEMBLY-TAKEOFF BRACKET USAF TIRE INFLATION INDICATOR	
NEXT ASS'Y BNN-3007			
SUPERSEDES			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		CODE IDENT. NO. 61349	SIZE A / DWG. NO. BNN-3009
		SCALE 10/1 / RAW WT/M	SHEET

FORM NO. 834 ALT. 66

LIMITS OF ACCEPTABLE WORKMANSHIP ARE DEFINED IN MS-646-A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED





NOTES:
1. APPLY LOCTITE GRADE 'A' TO CASE PRIOR TO STAKING
2. THESE SURFACES ARE FOR PRESSURE SEALING. CARE MUST BE TAKEN NOT TO DISTORT MARK DURING THE STAKING OPERATION.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1° SURFACE FINISH AA MAX.		DATE	U. S. GAUGE A DIVISION OF AMETEK, INC. SELLERSVILLE, PENNSYLVANIA
MATERIAL	DRAWN C. BROOKS	9-7-65	DRAWING TITLE ASSEMBLY-CASE & MAIN SOCKET USAF TIRE INFLATION INDICATOR
	TRACED		
	CHECKED		
	APPROVED		
	USED ON AN/1026BC01		
	NEXT ASS'Y AN/1026BC01		
	SUPERSEDES		
SPECIFICATION			CODE IDENT. NO. 61349 — SIZE B — DWG. NO. BNN-3010
TREATMENT			
FINISH			SCALE — DRAWN W/B — SHEET

[redacted]

FORM NO. 300 8 65