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TECHNOLOGY UTILIZATION BIBLIOGRAPHY

Technology Utilization Division

Bibliography on ELECTROMECHANICAL TRANSDUCERS

WITH INDEXES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-5036

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Bibliography on ELECTROMECHANICAL TRANSDUCERS

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D.C. February 1966

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FOREWORD

The Administrator of the National Aeronautics and Space Administration has established a technology utilization program for "the rapid dissemination of information. . . .on technological developments. . . .which appear to be useful for general industrial application." From a variety of sources, including NASA Research Centers and NASA contractors, space-related technology is collected and screened; and that which has potential industrial use is made generally available. Information from the nation's space program is thus made available to American industry, including the latest developments in materials, management systems, processes, products, techniques and analytical and design procedures.

This publication is a part of a series of bibliographic publications intended to serve both scientific and technical personnel and the libraries and librarians who support them.

THE DIRECTOR, *Technology Utilization Division*
National Aeronautics and Space Administration

INTRODUCTION

This bibliography is designed to assess and identify the current literature on the applications and uses of electromechanical transducers.

The purpose of this series of publications is to provide industry with summarizing information on innovations contained in NASA and other space technology literature.

The bibliographies are intended to indicate the wealth of new information and new technology available from the collections of the National Aeronautics and Space Administration. It is the purpose of the Technology Utilization Bibliographies to select and list available information of special interest to the industrial user.

The format for this series has therefore been designed to permit a variety of forms of utilization. The bound volume provides for circulation among personnel who would be most likely to benefit from the material. At the same time, it serves as a permanent record for library filing and reference.

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Abbreviations that frequently appear in the citations describing the references are listed below:

Abbreviation	Full Meaning
CFSTI	Clearinghouse for Federal Scientific and Technical Information
OTS	Office of Technical Services
ph	Photostat. Full size copies of the document are available in photostatic form
mi	Microfiche. Copies of the document are available in microfilm form
MF	Microfiche. See mi
HC	Hardcopy. See ph

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Bibliography on ELECTROMECHANICAL TRANSDUCERS

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TPA ENTRIES

N62-10071 Guggenheim Labs. for the Aerospace Propulsion Sciences, Princeton U., N. J.
TRANSIENT PRESSURE MEASURING METHODS; EFFECTS OF TUBING CONNECTION ON TRANSDUCER RESPONSE.
Howland B. Jones, Jr. Jan. 1962, 18 p. 4 refs. (Aeronautical Engineering Report 595a) (NASA Contract NASr-36)

Previously, the study of liquid propellant combustion instability has required the use of flush-mounted transducers to measure transient pressure fluctuations, particularly important in rocket-chamber combustion.

Flush-mounted transducers available at present however, are large in size, have poorer accuracy and are poor in dependability when subjected to high heat flux densities.

The feasibility of using tubing of various lengths to link the transducer to the chamber was studied as well as how the collected data would be influenced by the use of tubing.

The validity of using several inches or more of tubing between transducer and chamber is shown to depend upon the frequency range required, which is related to the size of the chamber and the mode of instability being measured.

N62-10591 New York U., Coll. of Engineering, N. Y.
MEASUREMENT OF TORSIONAL RIGIDITY OF STIFFENED PLATES.
Herbert Becker and George Gerard. Oct. 1961. 28 [8] p. 12 refs. (Tech. Rept. SM 61-14) (NASA Grant NsG-17-59)
OTS: ph $3.60, mi $1.28

A torsion testing machine was developed to measure torsional rigidity of stiffened plates and the data obtained with it is compared to the predictions of theory. The agreement of theory and experiment for two structures tested, flat and ribbed plates, revealed the reliability of the apparatus. Data measurements should apply with reasonable accuracy to thin shells as well as plates.

Basically, the torsion testing machine consists of a twist measuring system, and a loading machine. The twist measuring system measures the twist in plates by a differential normal motion over fixed lever arms using capacitor sensors connected electrically in pairs so that the signal is proportional to the rotation of the calibration bar. The loading machine uses a twisted trunnion that lies in a ball bearing. Friction is kept to a minimum by periodic cleaning and measurements reveal that starting friction torque can be kept below 0.002 in/lb.

Experimental errors may be generated in the model, the twist measuring system, the loading system, and possibly in interaction of the model with the loading system. Since torsional rigidity is proportional to the fourth power of the cross section dimension, slight errors in scaling from prototype to model would be reflected in inaccurate values of $J_i = G(\Delta\theta/\Delta X$. Loading system errors were found to be chargeable to the radius arm and dead weight. In 10 measurements, radius arm variations were found to be 0.002 in. in an average arm length of 2.0175 in., and each load weight variation was found to be 2×10^{-5} lb per dead weight of 0.16 lb. Errors due to interaction of the model with the loading system were traced to frictional resistance that could generate warping restrain in the model. (J.R.C.)

N62-10687 Corbin-Farnsworth, Inc., Palo Alto, Calif.
STUDY PROGRAM FOR THE DEVELOPMENT OF A BLOOD PRESSURE MEASURING AND MONITORING SYSTEM FOR REMOTE USE ON MAN IN FLIGHT.
Final Report.
Thomas Corbin. Mar. 15, 1962. 29 p. 16 refs.
(NASA Contract NASr-35) OTS: ph $2.60, mi $1.07

The purpose was to study the problem of measuring arterial blood pressure. The measurement was to be made without discomfort to the subject and with no interference of his normal movements. Ideally this would be a continuous measurement, displaying the pressure waveform with absolute calibration. A survey was made of the various blood pressure measuring methods described in the literature, as well as commercially available apparatus for continuous automatic measurement. The choice of employing ear's opacity pulse techniques in the development of a blood pressure transducer was influenced by the results of this survey. Pulse waves of blood passing through the capillary bed of the ear pinna cause slight variations in the ear's opacity to infrared. Several transducers were designed and built deploying a photo conductor and an infrared source to measure these variations. Much work went into the refinement of this technique to provide the best signal available under all conditions. Tests were conducted to determine the existence of any quantitative relationship between this blood flow indicator and actual blood pressure. If any such relationship does exist, it is indeed evasive and therefore the transducer output was treated as purely qualitative information. A system for obtaining pressure measurements is described and a laboratory model built and tested. An improvement on this system and a second system for obtaining dynamic blood pressure measurements is described and proposed for further study. (Author Abstract)

N62-11007 Therm Inc., Ithaca, N. Y.
A FEASIBILITY STUDY ON THE MEASUREMENT OF THE TIME-DEPENDENT SHROUD PRESSURE OF A DUCTED PROPELLER.
Gary R. Hough. Aug. 1961. v, 24 p. 18 refs.
(TAR-TR-612) (Contract Nonr-2859(00))

Results of a limited study on the measurement of the instantaneous incremental shroud pressure on a ducted propeller by means of a piezoelectric transducer are given. The instrumentation is described and

photographs of the observed pressure pattern presented. The feasibility of such measurements, the reproducibility and quality of the signal, and the magnitude and decay of the higher harmonics over a range of advance ratios are examined. Recommendations for future tests are outlined. (Author Abstract)

N62-11123 Engineering Physics Co., Rockville, Md.
INDUCTION FLOWMETER FOR DIELECTRIC FLUIDS—OPERATIONAL MODEL.
First Quarterly Report.
Vincent Cushing, Dean Reily, and T. R. Schein. Mar. 30, 1962. iii 29 p. 5 refs.
(NASA Contract NASw-381; EPCO Proj. 105)
OTS: ph $3.60, mi $1.16.

A research program is under way to develop an electromagnetic flowmeter suitable for operational use with hydrogen (capable of passing one pps of liquid hydrogen) and suitable for calibration tests at the NASA Lewis Research Center. Unlike commercially available magnetic flowmeters which make use of electrically conducting liquids, the flowmeter under development will make use of the polarization currents in dielectric fluids to provide power for actuating an electronic voltage detector. Since polarization currents induced in a dielectric are proportional to the frequency of induction, it was necessary to employ a high frequency magnetic field in the flowmeter for use with dielectric liquids. Primarily because an accurate quantitive voltage measurement is limited by the state of the art to the audio frequency range, an induction frequency of 10 kcs was chosen, which should easily permit 100 or 200 cps resolution of flow oscillation.

The design requires a flow rate of one pps of liquid hydrogen and a pipe diameter of 1.5 in. (both for compatibility with Lewis Research Center facility), vacuum insulation wherever possible, and explosive proof construction.

Work completed during the first quarter involved the design, assembly, or testing of the following items: housing and fittings, magnet coil, magnetic circuit, pipe transducer, liquid nitrogen test circuit, amplifier, magnet power generator, and phase sensitive detector. (V.D.S.)

N62-11126 Guggenheim Labs. for the Aerospace Propulsion Sciences, Princeton U., N. J.
TRANSIENT PRESSURE MEASURING METHODS; TRANSIENT PRESSURE TRANSDUCER DESIGN AND EVALUATION.
Howland B. Jones, Jr. Feb. 1962. 76, 5 p. 14 refs.
(Aeronautical Engineering Rept. 595b) (NASA Contract NASr-36)
OTS: ph $8.10, mi $2.66.

Owing to the need for improved dynamic pressure measurements in the combustion instability program at Princeton, consideration is given to transducer design, including the vibratory system, heat transfer characteristics, application to rocket chambers, and a description of a static and dynamic calibration system. Such shortcomings of present transducers as the lack of heat transferability and limited frequency response are discussed and are the targets of tests described. Details to be derived from the methods, procedures, and apparatus described will be used to report full details on several available transient pressure transducers. (V.D.S.)

N62-11466 Aeronautical Research Labs., Melbourne
MODIFICATIONS TO A HEIGHTLOCK PRESSURE TRANSDUCER FOR FLIGHT TESTS.
D. H. Edwards. July 1961. 5 [6] p.
(Flight Technical Memorandum 13)

Modifications to a "heightlock" pressure transducer, mainly by fitting a high resolution potentiometer, and its applications in flight tests are described. When used in conjunction with a suitable recorder, changes of altitude of 2.5 feet at 10,000 feet can be detected. (Author Abstract)

N62-11541 Engineering-Physics Co., Rockville, Md.
INDUCTION FLOWMETER FOR DIELECTRIC FLUIDS: EXPERIMENTAL VERIFICATION.
Final Report.
Vincent Cushing, Dean Reily, and T. R. Schein. Apr. 16, 1962. iv, 44 p. 9 refs.
(NASA Contract NASr-53; ERCO Proj. 105)

The concept of an electromagnetic flowmeter for use with dielectric fluids, particularly cryogenic propellants, has been experimentally verified and found to be practicable. The test set-up and the individual components of the flowmeter are described in detail. The description of component parts includes the following: housing and fittings, magnetic circuit, pipe/transducer, amplifier, hum compensator, and associated electronic equipment. (J.R.C.)

N62-11666 National Aeronautics and Space Administration. Lewis Research Center, Cleveland
MEASUREMENTS OF FLOW DURATION IN A LOW-PRESSURE SHOCK TUBE.
Virgil A. Sandborn. May 1962. 15 p. 5 refs.
(NASA TN D-1218)
OTS: $0.50.

Hot-wire signals were used to evaluate the duration of uniform flow in a shock tube. The measurements were in good agreement with similar measurements of Roshko. The similarity correlation derived by Roshko from a boundary-layer analysis was a good first-order representation of the data; however, at the extreme low pressures a systematic deviation from the correlation was noted. (Author Abstract)

N62-12133 Westinghouse Electric Corp., Elmira, N.Y.
RESEARCH ON OPTICAL AMPLIFICATION EMPLOYING ELECTRONIC SCANNING TECHNIQUES.
James A. Hall and Harry Shabanowitz. Wright-Patterson AFB, Ohio, Aeronautical Research Lab., Dec. 1961. 265 p. 27 refs.
(ARL-154) (Contract AF 33(616)-3254; Proj. 7027)
OTS: $4.00.

The objective of the investigation was to determine a basis for subsequent development of a highly sensitive optical to electrical transducer or television camera tube for obtaining useful images at extremely low levels of illumination. (Author Abstract)

N62-12249 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
DYNAMIC TESTING OF PRESSURE TRANSDUCERS—A PROGRESS REPORT.
Jon Inskeep. Dec. 6, 1961. 21 p. 12 refs.
(JPL-TR-32-268) (NASA Contract NASw-6)

Testing methods and results are described for frequency response testing of pressure transducers and associated coupling tubing as part of a current program of dynamic testing of pressure measurement systems. A shock tube, low frequency tank, acoustic siren, and commercial testing equipment are used to excite pressure transducers. Results are analyzed either graphically or with a flying spot scanner/wave analyzer. Types of equipment are described in detail along with advantages of their use and problems encountered in their development and operation. Results of a test program to obtain maximum frequency response from a commonly used strain gauge pressure transducer are given along with general rules for selection of transducer types and coupling configurations. (Author Abstract)

N62-12358 National Aeronautics and Space Administration. Lewis Research Center, Cleveland.
APPLICATION OF THE HOT-WIRE, RESISTANCE-TEMPERATURE TRANSDUCER TO THE MEASUREMENT OF TRANSIENT FLOW QUANTITIES.
V. A. Sandborn. Prepared for the ASME Symposium on Measurements in Unsteady Flow, Worcester, Mass., May 1962. 28 p. 15 refs.
OTS: ph $2.60, mi $1.04.

Properties of metallic conductors, semiconductors, thermistors, and insulators as resistance-temperature materials for use as transducers are investigated. Transient characteristics of resistance-temperature elements are discussed. Also, the use of transducers is outlined for flow fluctuation measurements such as anemometer application, free-molecule heat-transfer probe, hot-wire manometer, ion-beam hot-wire calorimeter, and temperature measurements. It is shown that, as a result of recent developments in heat-transfer correlation and electronic circuitry, resistance-temperature transducers, including semiconductors, can be introduced with good success in many new transient applications. (P.Z.)

N62-12482 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A NEW WIDE-RANGE PRESSURE TRANSDUCER.
John Dimeff, James W. Lane, and Grant W. Coon. [1962] 26 p. 7 refs. Paper for Publication in The Review of Scientific Instruments.
OTS: $2.60 ph, $0.98 mf.

A new transducer has been developed that will measure pressure over a wide range by sensing the damping of a vibrating diaphragm immersed in the gas whose pressure is being measured. It is capable of measuring pressures from approximately 10^{-5} to 200 mm Hg with an accuracy of about 1 percent over a large portion of the range. The device overcomes many of the shortcomings characteristic of other gages; it is small and rugged, with a fast response time at low pressures, and lends itself well to automatic operation. (Author Abstract)

N62-12659 Naval Ordnance Lab., White Oak, Md.
A PRESSURE-SENSITIVE DETECTOR FOR USE IN SHOCK-VELOCITY MEASUREMENTS IN SHOCKTUBES AND TUNNELS.
John M. Marshall. Feb. 14, 1962. 19 p.
(NOL Tech. Rept. 61-117; Ballistics Res. Rept. 53.)

The pressure-sensitive detector described in this report was designed to overcome various difficulties outlined herein. Two novel features of the design are absence of soldered connections to the transducer and quick-change components of working parts. The latter feature enables one to select the type of material and the thickness of the diaphragm to suit the pressure and temperature ranges expected. (Author Abstract)

N62-12666 Naval Ordnance Lab., White Oak, Md.
PITOT PRESSURE MEASUREMENTS IN THE NOL 4-IN. HYPERSONIC SHOCK TUNNEL NO. 3.
V. C. D. Dawson and R. H. Waser. Apr. 1962. 26 p. 3 refs.
(NavWeps-7329; Ballistics Res. Rept. 38.)

This report discusses various instruments that have been used in the measurement of pitot pressure in the test section of the NOL 4-in. hypersonic shock tunnel no. 3. (Author Abstract)

N62-12873 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MEASUREMENT OF COOLING WATER TEMPERATURE OF AN ELECTRIC-ARC AIR HEATER.
David Wald. [1962?] 6 p. Prepared for publication in Instr. and Control Sys.
OTS: $1.10 ph, $0.80 mf.

Instrumentation for measuring the temperature of cooling water in the vicinity of electric-arc air heaters encounters an environment of strong electric and magnetic fields, high pressure, and stray electric currents. In the transducer described here, a large signal-to-noise ratio was attained by multiplying tenfold the signal at the source and by extensively shielding against pickup. Recordings taken from the subject instrument show rapid response and large deflection with no visible noise level. (Author Abstract)

N62-12988 Ballistic Research Labs., Aberdeen Proving Ground, Md.
PROPAGATION OF LARGE AMPLITUDE WAVES IN PURE LEAD.
J. Sperrazza. Jan. 1962. 67 p. 21 refs.
(BRL Rept. 1158)

Under the experimental conditions reported herein is demonstrated that basic features of the longitudinal propagation of large amplitude waves in lead (Pb) circular rods (arising from the axial impact of two identical rods) can be predicted from a strain-rate independent theory. The primary measurements include (at different positions on the lateral surface of the rod) determinations of strain-time histories with both diffraction gratings and strain gages. Subsidiary measurements include determinations of time of contact of the two rods; these data are not inconsistent with the strain-rate independent theory.

A theoretically deduced dynamic stress-strain curve is verified experimentally by means of two types of transducer devices. One is a piezoelectric (quartz) transducer which measures the axial stress directly at the impact face of the two identical Pb rods undergoing axial impact. The other transducer consists of nonpermanently deforming rod of hard aluminum on whose lateral surface are mounted strain gages; the aluminum rod is struck by a lead rod, and the axial stress is measured indirectly after the "elastic wave" in the aluminum has traveled a short distance down the rod. (Author Abstract)

N62-13126 Radiation Incorporated, Melbourne, Fla.
TELEMETRY TRANSDUCER HANDBOOK.
H. F. Fisher, Jr. Wright-Patterson AFB, Ohio, Feb. 1962. 369 p. refs.
(Contract AF 33(616)-8309)
(WADD-TR-61-67, Vol. II, Suppl. 1)

A new "Telemetry Transducer Survey" was mailed to over 600 manufacturers. Literature search is continuing to obtain additional pertinent data for inclusion in the Handbook. Supplementary material has been prepared in standard format and is being distributed as supplements 1, 2, and 3 during 1962. The page numbering of each supplement is such that its pages are intended for insertion in Vol II of the Telemetry Transducer Handbook. Volume I will be completely rewritten. It is recognized that information on new transducer techniques developments, and related areas must be distributed rapidly to maintain an up-to-date amount of the state-of-the-art of telemetry transducers. (Author Abstract)

N62-13285 Stanford Research Inst., Menlo Park, Calif.
PRESSURE TRANSDUCER FOR MEASURING SHOCK WAVE PROFILES.
D. Berstein and D. L. Hartill. Dec. 29, 1961. 80 p. 15 refs.
(Contract DA-49-146-XZ-096)
(Poulter Labs. Tech. Rept. 004-61)

Research is underway to develop a transducer for measuring pressure pulses in rocks and soils in the pressure range above 10 kilobars and with a rise time of the order of 0.01 microseconds. Pressures will be determined by recording the change in electrical resistance of the sensitive element of the transducer. The immediate objective of the research program is the selection of materials which can be used in this type of transducer. The resistance of an ideal material would vary smoothly with pressure; while this variation must be large enough to detect changes in pressure of a few kilobars, it must be small enough to permit measurements over a range of a few hundred kilobars. Although the resistance of many insulators (and semiconductors) varies with pressure, this project has been concerned mainly with conductors. Transducers should be easier to construct and calibrate than insulators or semiconductors. Preliminary measurements have been carried out on twelve different alloys, four of which seem suitable for use as transducer elements. (Author Abstract)

N62-13733 Stanford Research Inst., Menlo Park, Calif.
A TRANSDUCER FOR THE CONTINUOUS EXTERNAL MEASUREMENT OF ARTERIAL BLOOD PRESSURE. Final Report.
G. L. Pressman and P. M. Newgard. Dec. 1961. 60 p. 6 refs.
(NASA Contract NAS-2-515; SRI Project 3604)
OTS: $5.60 ph, $2.00 mf.

The objectives of the research described were to develop a transducer that provides a continuous measure of arterial blood pressure, that does not encumber the subject, and that does not require cannulation. Two basic techniques were investigated, both analytically and experimentally: First, an indirect measure of blood pressure based on arterial deflection was attempted, but difficulties of calibration and sensitivity to physiological changes of skin and tissue around the artery resulted in a decision to attempt a more direct measurement of arterial blood pressure. In the second approach, arterial deflection is restrained by the transducer, and the resultant restraining force is measured. A mathematical model of the transducer-artery system was developed and was used as a guide for the design of the experimental prototype transducers. Tests performed on these experimental models show the effects of induced blood pressure changes, motion artifacts, and temperature changes. (Author Abstract)

N62-13814 College of Aeronautics, Cranfield (Gt. Brit.)
TWO-PORT NETWORK REPRESENTATION OF D.C. ELECTRO-MECHANICAL TRANSDUCERS.
R. J. A. Paul. Jan. 1962. 32 p. 3 refs.
(COA-N-121)

Two port network representations are derived for the general linear magnetic and electric field transducers. The constraints imposed by linearity requirements are discussed. It is shown that, for the most general form of transducer, the conversion of energy leads to nonlinear relationships; and a method of solving these equations is suggested. Typical applications are included to illustrate the analysis procedure and, in particular, the case of the d.c. motor is discussed in detail. (Author Abstract)

N62-14557 Watertown Arsenal Labs., Mass.
POINT-CONTACT TRANSDUCERS FOR ULTRASONIC TESTING.
Otto R. Gericke. June 1962. 11 p. 3 refs.
(WAL-TR-143.5/1) OTS: $0.50.

The feasibility of employing point-shaped ultrasonic transducers which directly amplify the detected ultrasonic signal was investigated. Two approaches were considered, one used a semiconductor point with a depletion layer at the very tip produced by a bias voltage, the other employed the variation of contact resistance with contact pressure. The latter method was explored experimentally and found suitable for the detection of ultrasonic energy. In addition, experiments are described in which high-frequency sparks were produced at the specimen surface to generate ultrasonic vibrations. (Author Abstract)

N62-14759 California U., Berkeley. Hydraulic Engineering Lab.
RESEARCH ON ANNULAR NOZZLE TYPE GROUND EFFECT MACHINE: PRESSURE TRANSDUCER.
D. O. Horning and J. D. Cumming. Mar. 1962. 22 p. 4 refs.
(Contract Nonr-222(71))
(IER Ser. 187, Issue 2)

A pressure transducer is described for measuring the base pressure profile of the annular-jet ground effect machine. Design and production criteria are given. Transducer design specifications are as follows: one inch diameter; pressure range, 0 to 6 psig; sensitivity, 0.002 to 0.0007 psig; and frequency response, 170 cps. Response records of five transducers show good reproducibility of results. (R.C.M.)

N62-16174 General Atomic Div., General Dynamics Corp., San Diego, Calif.
TRANSIENT RADIATION EFFECTS IN PRESSURE TRANSDUCERS. [Final Report Nov. 27, 1961-Mar. 30, 1962].
R. A. Poll and V. A. J. van Lint. Kirtland AFB, N. Mex., AF Special Weapons Center, June 1962. 72 p.
(Contract AF 29(601)-4953)
(AFSWC-TDR-62-63)

The performance of two types of pressure transducers in a radiation environment has been evaluated by an experimental program. The devices were (1) a quartz piezoelectric crystal assembly and (2) a strain gauge transducer made by Armour Research Foundation. The most important perturbations of these transducers by a short pulse of radiation are the emission and absorption of secondary electrons by parts of the device and the conductivity of insulating materials, including quartz, cable connectors and cables. The experimentally measured results can be applied to evaluate the spurious signals and the perturbation of pressure-induced signals in a specified pulse radiation environment. (Author Abstract)

N62-17120 Watertown Arsenal Labs., Mass.
DETERMINATION OF THE GEOMETRY OF HIDDEN DEFECTS BY ULTRASONIC PULSE ANALYSIS TESTING
O. R. Gericke *In* Office of the Chief of Research and Development Army Research Office, Washington, D.C. Proc. of the 1962 Army Science Conf., West Point, N.Y., June 20-22, 1962 Vol. I Sept. 19, 1962 p 249-257 (See N62-17113 18-01)

The ultrasonic pulse echo method used in the detection of hidden defects in metals or other materials is investigated. In the ultrasonic pulse echo method, a single ultrasonic transducer acts as transmitter and as receiver of ultrasonic signals. The received echoes are amplified and displayed as vertical indications on a cathode ray tube. Experiments conducted indicate that the effectiveness of ultrasonic pulse echo testing can be greatly enhanced by the introduction of multi-frequency signals and defect echo analysis. The main benefit derived from this innovation is that differences in the configuration or orientation of concealed defects can be determined. J.R.C.

N62-17796 Raytheon Co. Research Div., Waltham, Mass.
PROPERTIES AND APPLICATIONS OF A SENSITIVE MAGNETIC TRANSDUCER
A. P. Schmid and W. Rindner 1962 4 p 2 refs Presented at the 1962 Western Electronic Show and Conv., Los Angeles, Aug. 21-24 Sponsored by Western Electronic Manufacturers Assoc. and Inst. of Radio Engineers
(WESCON Paper-3.2) Available from Western Periodicals Co., 13000 Raymer St., N. Hollywood, Calif.

Magnetic properties of the Bonded NR Diode, whose sensitivity considerably exceeds that of conventional magnetic transducers, are discussed. Measurements of sensitivity have been made as a function of temperature, bias, and frequency. In terms of the figure of merit conventionally applied to Hall-effect devices, values as high as 165 v/amp-k gauss have been obtained at room temperature. Under proper biasing, the devices output is independent of temperature over the range 0° to 70° C. The device is particularly well suited for field probes due to its small size. Packaged units occupying a volume less than 10^{-3} cubic inches have been fabricated. Author

N62-17798 Raytheon Co. Research Div., Waltham, Mass.
A NEW p-n JUNCTION STRAIN TRANSDUCER
W. Rindner and R. Nelson 1962 3 p 2 refs Presented at the 1962 Western Electronic Show and Conv., Los Angeles, Aug. 21-24 Sponsored by Western Electronic Manufacturers Assoc. and Inst. of Radio Engineers
(WESCON Paper-3.4) Available from Western Periodicals Co., 13000 Raymer St., N. Hollywood, Calif.

A new strain transducer is described which is based on the sensitivity of shallow p-n junctions to suitably applied anisotropic stress. With the device subjected to forces of a few thousand dynes, resistance changes in excess of three orders of magnitude have been measured. The device can be operated at various impedance and sensitivity levels, depending on the electrical and mechanical stress biases applied. The fabrication and the results of some measurements of experimental structures serving as microphones are described. Inherently the p-n junction strain transducers can be fabricated in structures comparable in mass and size with present diodes and transistors. Author

1963
STAR ENTRIES

N63-11421 Advanced Technology Labs. Div. of American-Standard, Mountain View, Calif.

DESIGN AND DEVELOPMENT OF 3000°F TEMPERATURE-TRANSDUCER SYSTEM Final Report

D. L. Rall Aug. 15, 1962 143 p 16 refs
(Contracts AF 33(657)-7132 and AF 33(600)-41517; P.O. 2-043005-9153)
(ATL-D-861)

The purpose of this program was to design, develop, and fabricate a transducer system, and method of installation, for measuring the skin temperature of the wing panel and leading edge of the Dyna-Soar vehicle during reentry into the earth's atmosphere. This system was intended for use in making temperature measurements during actual flight, as a means of developing a better understanding of the effect of descent rate, attack angle, and pitchup on aerodynamic heating during reentry. The specifications governing this system design, in general, require that the system be able to withstand skin temperatures up to 3000° F and lead-wire temperatures of up to 2000° F. Author

N63-12272 Academy of Sciences (USSR). G. M. Krzhizhanovsky Inst. of Power Engineering, Moscow

THERMOCOUPLE MEASUREMENT OF THE TEMPERATURE IN A HIGH-VELOCITY GAS FLOW

E. V. Kudryavtsev *In* Israel Program for Scientific Translations, Ltd., Jerusalem Gas Dynamics and Physics of Combustion 1962 p 95-103 5 refs (See N63-12262 05-11) OTS: $1.75

The action of a high-velocity gas flow on a thermocouple is analyzed to determine the criteria for efficient design and use of transducers. Formulas are developed to compensate for the effect of heat conduction and radiation at the transducer. These are then applied to the design of transducers for both longitudinal and transverse measurements. The measurement error due to heat loss from the thermocouple junction is reduced to zero in both transducer designs by directing the thermocouple wires along an isotherm. Radiation transfer is eliminated by means of shields and the recovery factor is compensated for by standard calibration curves. R.C.M.

N63-12288 Advanced Technology Labs. Div. of American-Standard, Mountain View, Calif.

DESIGN AND DEVELOPMENT OF 3000° F TEMPERATURE-TRANSDUCER SYSTEM Program Progress Report [May 1-31, 1962]

D. L. Rall May 1962 6 p 3 refs
(Contract AF 33(657)-7132)
(ATL-D-811)

Preliminary thermal-response tests of 0.012-inch-thick skin-panel assemblies have been completed. Results for skins with 1-inch-thick Q-felt insulation indicate a transient error of approximately 8.5 to 10.5% as compared with 5% predicted from electrical analog studies. These data are in contrast with results for skins with 0.1-inch insulation, which showed reasonable agreement with predicted performance. Design-verification tests have been initiated. Hot- and cold-vibration tests were completed on six panels (four with 0.012-inch skin and two with 0.030-inch skin). Results indicate that sensor performance is unaffected by the vibration environment. Author

N63-12634 France. Office National d'Etudes et de Recherches Aéronautiques, Chatillon-sous-Bagneux

MESURE DES PRESSIONS RAPIDEMENT VARIABLES ET EN PARTICULIER DANS DES ÉCOULEMENTS A HAUTE TEMPÉRATURE (MEASUREMENT OF QUICKLY VARIABLE PRESSURES WITH SPECIAL APPLICATION TO HIGH TEMPERATURE FLOWS)

Jean Girvès Nov. 1962 11 p 4 refs In French; English summary
(ONERA-91)

In this paper are described O.N.E.R.A.-designed pressure pickups which have a broad bandwidth or which are in direct contact with media up to 3700° K. The various types are studied in detail as well as the detecting electronic systems. Besides the specifically aeronautical applications for which they have been developed, these pickups have wide applications in various domains because of their capability to give simultaneously the mean pressure and the fast variations of the instantaneous pressure. The electronic detector which works in conjunction with them allows telemetering over long distances; the practical use of these pickups is particularly simple with the transistorized versions. B.J.C.

N63-12769 Bureau of Mines. Morgantown Petroleum Research Lab., W. Va.

ULTRASONIC PHENOMENA AND METHODS OF MEASUREMENT: A BIBLIOGRAPHY

C[harles A.] Komar and J. Pasini III 1963 35 p 261 refs
(BM-IC-8146)

N63-13424 Aro, Inc., Arnold Air Force Station, Tenn.

THE DESIGN AND DYNAMIC CALIBRATION OF A PRESSURE TRANSDUCER SYSTEM FOR UNSTEADY PRESSURE MEASUREMENTS

R. F. Austin and G. C. Trail, Jr. Arnold Engineering Development Center, Mar. 1963 38 p 9 refs
(Contract AF 40(600)-1000)
(AEDC-TDR-63-29)

A specialized method is discussed for adapting conventional flush-mounted pressure transducers for measurement of unsteady pressures to 1000 cps. Details of the calibration apparatus are presented together with the measured effects of transducer-system geometry and environmental pressure level on the dynamic response of the system. Author

N63-13604 Massachusetts Inst. of Tech. Electronic Systems Lab., Cambridge

CAPACITIVE TRANSDUCERS FOR NARROW-BAND VIBRATORY DISPLACEMENTS

John G. Whitman, Jr. Oct. 1962 40 p 17 refs
(NASA Grant NsG-149-61)
(ESL-R-15) OTS: $3.60 ph, $1.40 mf

A sensitivity figure of merit for an electromechanical transducer is shown to be the energy density in its coupling field, and the special case of the parallel plate capacitive transducer is analyzed in detail. The limitations on the figure of merit for this transducer are calculated using the Paschen's law curve for the breakdown potential difference of an air gap and it is shown that the maximum attainable energy

density in a uniform electric field is on the order of 4.4 x 10^5 ergs/cm^3 under conditions which can be maintained in a transducer application. A comparison of this figure with the energy densities used in existing high-sensitivity capacitive transducers shows that present designs fall short of their ultimate capabilities by approximately a factor of 25, and that their performance can be improved by close to this factor by either evacuating or pressuring the sensor package. The characteristics of electrical discharges in the region to the left of the minimum in the Paschen's law curve are discussed, and a capacitor plate design is proposed which will allow transducers to be operated in this region. An experimental program confirmed the main features of the theoretical analysis despite experimental difficulties encountered in determining accurate breakdown potentials in the region to the left of the minimum. Author

N63-13937 Aerospace Medical Div. Aerospace Medical Research Labs. (6570th), Wright-Patterson AFB, Ohio

ENDORADIOSONDES: A STATE OF THE ART SURVEY [Final Report, June-Sept. 1962]

Michael Mc Cally and George W. Barnard Dec. 1962 13 p 35 refs (AMRL-TDR-62-122) OTS: $0.50

Within the last 5 years endoradiosondes or "radio pills," have been developed employing tiny transducers and transmitters which can be swallowed or implanted in man and animals. The present state of the art of these instruments, including design, construction, uses, advantages, and limitations, is reviewed. The literature in this area, to date, consists largely of suggestions for design principles and considerations of circuitry. There is only the barest amount of useful data on equipment performance, reliability, response linearity, frequency response characteristics, and correlation with proven systems. The endoradiosonde promises to be a useful technique in physiological instrumentation, but much basic development remains to be done before this tool can be useful to any but the bioelectronic specialist. Author

N63-14321 National Aero- and Astronautical Research Inst., Amsterdam (Netherlands)

NON-DESTRUCTIVE AND DESTRUCTIVE TESTS ON REDUX BONDED SINGLE AND DOUBLE LAP-JOINTS WITH VARIOUS GLUE LINE THICKNESSES

A. Hartman and J. B. de Jonge Mar. 1962 33 p 12 refs (Supported by Netherlands Aircraft Development Board) (NLR-TN M.2099)

A series of Redux-bonded single and double lap-joints with nonporous glue layers of various glueline thicknesses were tested ultrasonically by means of the Fokker Bond Tester. Tensile shear tests were carried out after completion of the ultrasonic tests. Bond Tester indications were in good agreement with theoretical results, indicating the instrument's ability to detect glueline stiffness. The static strength of double lapjoints turned out to be nearly independent of glueline thickness; for single lapjoints a strong dependence on glueline thickness was found. The analysis of the tensile shear test of adhesive bonded joints is discussed. Author

N63-16606 Rock Island Arsenal, Ill.

INSTRUMENTATION FOR EVALUATION OF ARTILLERY AND ROCKET LAUNCHER PERFORMANCE AT ROCK ISLAND ARSENAL

J. C. Hanson *In* Army Research Office Proc. of the Army Conf. on Dyn. Behavior of Mater. and Structures held at Springfield Armory, Mass., Sept. 26-28, 1962 [1962] p 49-60 (See N63-16603 14-34)

All instrumentation measurements at Rock Island Arsenal under dynamic conditions have been utilized to obtain operating data on performance of research and development prototype weapons and assemblies during proof firing or functioning tests, rather than on a specific material subject to a particular condition of loading. The basic sensing device used for obtaining analogs of dynamic physical phenomena is the electromechanical transducer. Commercial transducers are used for measuring fluid pressure, acceleration, displacement of moving parts, and loads. Special transducers have been designed for measuring artillery recoil displacement, recoil rod, and trunnion loads. Conventional strain gages are used to measure loads and surface strains on various components, movement of parts, and projectile ejection from the barrel. Recording equipment with a frequency response of zero to 600 cps has been found to be adequate for the majority of measurements. Author

N63-17470 Advanced Technology Labs. Div. of American-Standard, Mountain View, Calif.

EXPERIMENTAL EVALUATION OF A DULL-ELEMENT TRANSDUCER FOR HIGH-TEMPERATURE-GAS MEASUREMENTS [Final Technical Report]

J. T. Chambers, D. L. Rall, and W. H. Giedt Wright-Patterson AFB, Ohio, Aeronautical Research Labs., Mar. 1963 55 p (Contract AF 33(657)-8411) (ARL-63-58)

An experimental evaluation was made of a dual-element transducer, in which gas-stream temperatures are inferred from simultaneous temperature-time measurements of two transducers of equal shape but unequal thermal capacity. The major effort was expended on measuring medium-temperature streams to prove the feasibility of the concept. The accuracy of the transducer was within ±6% in measurements from 1950° to 2250° F, which was the best experimental accuracy predicted by an earlier analysis of the concept. A limited number of measurements were made with the transducer directly in an oxyacetylene flame. The indicated flame temperatures were 4700° F and 4789° F, which agree within 5% with measurements made by sodium-line-reversal techniques for equivalent combustion conditions in tests conducted at the University of California. In a third series of tests, the transducer was used to traverse a 2100° F gas stream, and from a single record the temperature profile in the stream was calculated within the accuracy to which the true profile could be established. It is concluded that the dual-element transducer is feasible for all the applications tested. Author

N63-18139 California Inst. of Tech., Pasadena

I. DESIGN AND APPLICATION OF PIEZOCERAMIC TRANSDUCERS TO TRANSIENT PRESSURE MEASUREMENTS. II. SOME MEASUREMENTS OF CURVATURE AND THICKNESS OF REFLECTING NORMAL SHOCKS AT LOW INITIAL PRESSURES Progress Report, Nov. 1, 1961-May 1, 1962

Douglas S. Johnson 1962 97 p 27 refs (NASA Grant NsG-40-60) (NASA CR-50495) OTS: $8.60 ph, $3.11 mf

A small pressure transducer, using the piezoelectric properties of a manufactured ceramic, was designed, constructed, and installed in the end plate of the GALCIT 17-inch shock tube to obtain high-speed measurements of the pressure field behind a reflecting shock. The design problem for piezoceramic pressure transducers, and some possible solutions are discussed in detail. Results of transducer calibration and recommendations for improvement of the instrument are presented. An initial program to determine the curvature of a shock at low initial pressures was run concurrently with calibration of five

of the above pressure transducers. The results of this program are described. At an initial pressure of 30 microns in the GALCIT 17-inch tube, the shock obtained at a Mach number of about 7.5 in argon is observed to have a total curvature of approximately 10 millimeters, or approximately two percent of the tube diameter. The shock thickness observed under these conditions is approximately 5 millimeters. Author

N63-18749 Aro, Inc., Arnold Air Force Station, Tenn.
VARIABLE RELUCTANCE PRESSURE TRANSDUCER DEVELOPMENT
W. E. Smotherman and W. V. Maddox Arnold Eng. Develop. Center, July 1963 43 p 1 ref
(Contract AF 40(600)-1000)
(AEDC-TDR-63-135)

Pressure transducers whose time response and pressure ranges are suitable for test-section measurements in the hypervelocity tunnels of the von Kármán Gas Dynamics Facility have been developed by the Instrumentation Branch of that facility. A description of these transducers, their theory of operation, and their performance characteristics are presented. Author

N63-18820 Royal Air Force. Inst. of Aviation Medicine, Farnborough (Gt. Brit.)
A SIMPLE TECHNIQUE FOR RECORDING SMALL EYE MOVEMENTS
G. H. Byford Air Ministry, Sept. 1961 21 p 7 refs
(FPRC/MEMO 162)

A contact lens photoelectric eye movement recording system is described. The transducer is carried on a dental bite. Sensitivities of the order of 40 sec arc per cm of trace deflection are readily obtainable with a dynamic range in excess of 50 db. Although primarily designed as a device for measuring the movements of eyes, the technique has been used for other purposes. Author

N63-19134 Stanford Research Inst., Poulter Labs., Menlo Park, Calif.
MEASUREMENT OF SHOCK PRESSURES IN SOLIDS
D. G. Doran Apr. 1963 47 p 57 refs
(Poulter Labs. TR-002-63)

This report reviews the techniques for determining the pressure exerted by shock waves in solid media. Optical, electrical, and X-ray techniques used to measure shock and free-surface velocities are described, and the deduction of shock pressure therefrom is discussed. Pressure-electric transducers are described which employ the piezoelectric and piezoresistive effects and also the shock polarization of a polar solid. The report concludes with a brief discussion of the problems encountered in the comparison of shock and static data. Author

N63-21915 National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
STATUS OF FLIGHT LEAK MEASURING TRANSDUCERS Internal Note
C. T. N. Paludan July 5, 1962 28 p
(NASA TM X-50421; M-ASTR-IN-62-14) OTS: $2.60 ph, $1.04 mf

Transducers capable of measuring small flow rates resulting from leaks in flanges in the Saturn engine systems are being developed. Principles of operation of three basic types are given in detail. The inhouse environmental tests were satisfactory; operational tests are now being made. Leakage rates up to 1000 standard cubic centimeters per minute may be measured with the present units. These units are specifically designed for liquid oxygen leaks, but are also inherently capable of operation with other cryogenic liquids, gases at less than 100° C, or even hot gases. Author

N63-21974 Princeton U., N.J.
DYNAMIC RESPONSE TESTING OF TRANSIENT PRESSURE TRANSDUCERS FOR LIQUID PROPELLANT ROCKET COMBUSTION CHAMBERS
William C. Bentley and Joseph J. Walter June 1963 164 p 45 refs
(NASA Contract NASr-36)
(NASA CR-51516; Aeronautical Eng. Rept.-595g) OTS: $12.00 ph, $5.12 mf

An investigation of the dynamic response of transient pressure transducers intended for use in liquid-propellant rocket combustion chambers was undertaken. Shock tube testing included optimization of operating techniques, especially the tailored interface, and the effects of ground shock and other mounting influences. The Kistler 601A quartz transducer was evaluated as a monitor for the Princeton Sinusoidal Pressure Generator (SPG), and a number of water-cooled transient transducers were evaluated for comparison with results from the SPG. An investigation was conducted which satisfactorily demonstrated the practical value of the SPG as a primary test device for transient pressure transducer evaluations to 10,000 cps. During evaluations, special consideration was given to developing operating techniques and improving SPG chamber design. The results from shock tube and the SPG show close agreement up to 10,000 cps, the present limit of usable SPG range. Transducers were then tested in experimental liquid-propellant rocket motors to compare laboratory measured characteristics with actual transducer performance. Author

N63-22047 Princeton U., N.J.
TRANSIENT PRESSURE MEASURING METHODS RESEARCH Summary Technical Report, 1 Mar. 1961-31 Dec. 1962
J. P. Layton, R. C. Knauer, and J. P. Thomas Sept. 1963 44 p refs
(NASA Contract NASr-36)
(NASA CR-51515; Aeron. Engr. Rept.-595f) OTS: $4.60 ph, $1.52 mf

Progress is reported on research in transient pressure measuring methods as applied to liquid-propellant rocket combustion chambers from 1 March through 31 December 1962. The discussion includes flush diagram transient pressure transducers for current liquid-propellant rocket combustion chambers, transducer heat-flux capability, a small passage technique for transient pressure measurements in large rocket motors, response of tubing connected pressure transducers, and dynamic response testing of transient pressure transducers for liquid-propellant rocket combustion chambers. C.L.W

N63-22048 Princeton U., N.J.
TRANSIENT PRESSURE MEASURING METHODS RESEARCH. AN ANALYTICAL AND EXPERIMENTAL STUDY OF THE RESPONSE OF A SMALL CHAMBER TO FORCED PRESSURE OSCILLATIONS
Clifton L. Carwile Oct. 15, 1962 71 p 5 refs
(NASA Contract NASr-36)
(NASA CR-51517; Aeronautical Eng. Rept. 595d) OTS: $7.60 ph, $2.33 mf

The various resonant modes of gas pressure oscillations in a Sinusoidal Pressure Generator, featuring a closed, flat cylindrical chamber, were theoretically determined and experimentally verified, using Freon-12 and nitrogen as test media. For chamber length-to-diameter ratios less than 1.71, the transverse modes were shown to be dominant. Since the test chamber of the Sinusoidal Pressure Generator had a length-to-diameter ratio of only 0.38, it was predicted analytically that the lowest obtainable resonant frequencies would be the first

and second tangential modes. Strong transverse, nearly sinusoidal waves corresponding to these two modes were obtained in the tests, but with frequencies somewhat less than those predicted by acoustic theory. The Sinusoidal Pressure Generator was evaluated for its designed function of determining pressure transducer frequency response. With helium as the test gas, the character of the pressure waves were shown to be essentially sinusoidal, and the amplitudes of the oscillations were adequate for transducer testing throughout a test range from 1,800 to 21,600 cps. However, a departure from uniform sinusoidal response was apparent as the frequency was increased, limiting the applicable range of the Sinusoidal Pressure Generator as currently designed to about 10,000 cps for pressure transducer evaluation. Author

N63-22395 Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.
TRANSDUCER FOR DIRECT MEASUREMENT OF SKIN FRICTION IN THE HYPERSONIC SHOCK TUNNEL
R. C. Mac Arthur Aug. 1963 33 p 4 refs
(CAL-129)

The design considerations, construction details and operating characteristics are presented for a skin-friction transducer suitable for use in a hypersonic shock tunnel. The transducer consists of a flush diaphragm connected through a flexure to a lead-zirconium-titanate piezoelectric bimorph crystal which develops a charge when placed in bending by a surface shear on the diaphragm. An inactive diaphragm-flexure-crystal arrangement is provided within the case for acceleration compensation. The transducer is relatively insensitive to normal pressure, to surface forces applied transverse to the sensitive axis, and to thermal effects. The transducer is adaptable to contoured surfaces by the attachment to the diaphragms of lightweight, foam-plastic buttons that conform to the local surface contour of the model. Author

N63-22411 Aerospace Medical Div. School of Aerospace Medicine, Brooks AFB, Tex.
PHYSICAL TRANSDUCERS FOR SENSING OXYGEN
Louis F. Johnson, Jr., J. Ryan Neville, Richard W. Bancroft, and Thomas H. Allen Aug. 1963 13 p 11 refs
(*Its* Aeromedical Review 8-63)

A continuous oxygen analyzer based on polarography or electrochemical principles is described. The device requires no applied polarizing voltage, and its operation is feasible throughout wide ranges in environmental conditions because the electrolyte is completely encapsulated along with the electrodes. Gold is used as the indicator or polarizable electrode, and the reference electrode is made of cadmium. The overall cell reaction can be written as, $2Cd + O_2 \rightarrow 2CdO$, so that the electrolyte solution is not depleted and does not limit the useful life of the device. The device used is a cylinder about 3 1/2 cm. in diameter and 2 1/2 cm. in length. The electrical output of the device depends on the area of the gold electrode exposed to the electrochemical action of oxygen, and the units normally used produce about 2.5×10^{-8} amperes per 1 mm Hg of oxygen. P.V.E.

1964
STAR ENTRIES

N64-11150 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.
HYDRAULIC POWER AMPLIFIERS [GIDRAVLICHESKIYE USILITELI MOSHCHNOSTI]
V. A. Khokhlov Transl. into ENGLISH of book Moscow, Publ. House of the Acad. Sci. USSR, 1961 11 Jun. 1963 146 p refs
(FTD-TT-62-1226/1+2; AD-413571)

The topics discussed are: (1) the components of hydraulic actuators and their characteristics, (2) classification and line diagrams of hydraulic actuators, (3) designs, basic parameters, and characteristics of hydraulic amplifiers, (4) analysis of the statics and dynamics of hydraulic amplifiers without feedback, (5) analysis of the statics and dynamics of hydraulic amplifiers with feedback, and (6) electromechanical transducers. R.T.K.

N64-12171 Aerojet-General Corp., Sacramento, Calif.
WEAPON SYSTEM 133A: QUALIFICATION-TEST REPORT ON STATHAM DIFFERENTIAL PRESSURE TRANSDUCER Final Report
R. W. Armstrong 14 Oct. 1963 36 p
(Contract AF 33(600)-36610)
(Rept. 0162-01DR-24; AD-421712)

The Statham 3-psi-differential pressure transducer meets Minuteman requirements. Data obtained from the qualification tests of the 5-psi-absolute pressure transducer are applicable to the 3-psi-differential pressure transducer on the basis of similarity of materials, components, and manufacturing processes of the two units. Author

N64-12704 Radiation Inc., Melbourne, Fla.
TELEMETRY TRANSDUCER HANDBOOK
H. F. Fisher, Jr. Wright-Patterson AFB, Ohio, AF Flight Dynamics Lab., Sep. 1963 768 p refs
(Contract AF 33(616)-8309)
(WADD-TR-61-67, Vol 1, Rev. 1; AD-421951) OTS: $5.60

The characteristics of the transmission system and its relation to transducers and telemetry systems are discussed in detail. The fundamentals involved in various physical measurements and how these fundamentals are employed in the general design of transducers are covered. Measurements of displacement, strain, pressure, fluid flow, rotary speed, fuel quantity, ac power, acceleration, temperature, shock and vibration, and thrust are discussed. Testing and calibration techniques and facilities available are presented. Also included are a bibliography, glossary of terms, IRIG Telemetry Standards, definitions of many basic physical effects and principles related to transducer design, and detailed data on acceleration, temperature, and thrust measurement fundamentals. Author

N64-14033 Stanford Research Inst., Menlo Park, Calif. Poulter Labs.
PRESSURE TRANSDUCER FOR MEASURING SHOCK WAVE PROFILES Final Report
D. D. Keough 1 Nov. 1963 52 p refs
(Contract DA-49-146-XZ-096; Proj. Vela-Uniform)
(DASA-1414; AD-426910)

Calibration of pressure gages consisting of Manganin wire cast in epoxy or doped epoxy insulators shows that $R(P)$ is linear within experimental errors up to the highest calibration pressures obtained, ~200 kb. Hysteresis seems to be nonexistent, as does the temperature dependence of $R(P)$. These gages functioned satisfactorily in nuclear field tests where peak pressure and rate of pressure decay were obtained. Long duration

recording failed for reasons other than anticipated. A technique for obtaining Hugoniot and cross characteristic data with the pressure gage was used satisfactorily. A general technique for examining the piezoresistive behavior of conductors at high pressures has also been developed. Author

N64-14096 Aerojet-General Corp., Sacramento, Calif.
WEAPON SYSTEM 133A; QUALIFICATION TEST REPORT FOR STATHAM ABSOLUTE PRESSURE TRANSDUCER Final Report
R. W. Armstrong 27 Dec. 1963 183 p refs
(Contract AF 33(600)-36610)
(Rept. 0162-01DR-26; AD-426920)

Absolute pressure transducers, Model PA334TC-2.5, were subjected to performance, frequency response, motor static firing, and safety reliability tests. The remainder of the qualification tests, including vibration, acceleration, temperature-altitude, altitude, humidity, hermetic seal, radiofrequency, interference, and performance reliability, were performed on transducer Model PA334TC-750 and are considered applicable to Model PA334TC-2.5M based on the similarity of the two parts. Successful completion of the tests has qualified the transducer for use on second-stage Minuteman motors. Author

N64-14635 Navy Electronics Lab., San Diego, Calif.
DIRECTIVITY FACTOR COMPUTER FOR ELECTROACOUSTIC TRANSDUCERS Research and Development Report, Mar.-Oct. 1962
C. E. Green and J. R. Roshon 13 Sep. 1963 32 p refs
(NEL-1196; AD-428284)

The directivity factor computer (DFC) is described. A direct current is modified electrically in correspondence with the variations in the pressure level of the transducer; at the same time, an equal area sampling is obtained for varying orientations. The d.c. output is converted to a proportional frequency, and all cycles are counted to provide a measure of the integrated power radiated by the transducer referenced to an equivalent sphere of 2-meter diameter. Author

N64-14761 Bell Helicopter Co., Fort Worth, Tex.
DEVELOPMENT OF A SUBMINIATURE SURFACE MOUNTED PRESSURE TRANSDUCER Summary Report
F. Burpo Jan. 1963 78 p refs
(Contract Nonr-2877(00))
(Rept. 299-099-200; AD-297483)

The results of the development work and tests indicate that the subminiature pressure transducers are suitable for measuring air loads on helicopter rotors as well as in laboratory, wind tunnel, and other flight test work. These new gages measure absolute pressure, may use a.c. or d.c. excitation, are surface mounted, and require no structural modification for installation. Author

N64-16236* Dresser Electronics, Houston, Tex. Southwestern Industrial Electronics Div.
METHODS FOR THE DYNAMIC CALIBRATION OF PRESSURE TRANSDUCERS
J. L. Schweppe, L. C. Eichberger, D. F. Muster, E. L. Michaels, and G. F. Paskusz Washington, NBS 12 Dec. 1963 115 p refs (Sponsored by NASA, Army, AF, and Bureau of Naval Weapons)
(NBS Monograph 67) GPO: $0.60

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2. ANALYTIC METHODS FOR LINEAR TRANSDUCERS L. C. Eichberger p 11-29 refs (See N64-16238 08-15)
3. APPROXIMATE METHODS OF LINEAR TRANSDUCER ANALYSIS L. C. Eichberger p 31-51 refs (See N64-16239 08-15)
4. ANALYSIS OF NONLINEAR TRANSDUCERS D. Muster p 53-67 refs (See N64-16240 08-15)
5. SIMPLE APERIODIC-FUNCTION GENERATORS J. L. Schweppe p 69-75 refs (See N64-16241 08-15)
6. SHOCK TUBE METHODS J. L. Schweppe p 77-86 refs (See N64-16242 08-10)
7. PERIODIC-FUNCTION GENERATORS D. F. Muster p 87-95 refs (See N64-16243 08-15)
8. THE ELECTRONIC COMPENSATOR E. L. Michaels and G. F. Paskusz p 97-104 refs (See N64-16244 08-09)

N64-16237* Dresser Electronics, Houston, Tex. Southwestern Industrial Electronics Div.
INTRODUCTION [Methods for the Dynamic Calibration of Pressure Transducers]
L. C. Eichberger and J. L. Schweppe *In its* Methods for the Dyn. Calibration of Pressure Transducers 12 Dec. 1963 p 1-9 refs (See N64-16236 08-15) GPO: $0.60

This article covers the mathematical models for transducers; the methods of analyzing pairs of input-output functions to determine the transfer function and the frequency response curve; the methods of generating precise input functions; and the specific methods for using precise experimental measurements to determine the dynamic characteristics of a pressure transducer. Specifically, this discussion introduces the types and characteristics of pressure transducers and the concepts of calibration and analysis. C.L.W.

N64-16238* Dresser Electronics, Houston, Tex. Southwestern Industrial Electronics Div.
ANALYTIC METHODS FOR LINEAR TRANSDUCERS
L. C. Eichberger *In its* Methods for the Dyn. Calibration of Pressure Transducers, 12 Dec. 1963 p 11-29 refs (See N64-16236 08-15) GPO: $0.60

The procedural steps of analytical analysis are introduced. These steps are applied to a linear transducer, which, for simplicity, is assumed to be a single-degree-of-freedom system. The characteristic differential equation of motion for this system is given. Response functions for the system are obtained for a given input function by both the classical and operational methods of analysis. The periodic (sine, square wave, and rectangular pulse) and aperiodic (rectangular pulse and step) functions are the input functions considered. Author

N64-16239* Dresser Electronics, Houston, Tex. Southwestern Industrial Electronics Div.
APPROXIMATE METHODS OF LINEAR TRANSDUCER ANALYSIS
L. C. Eichberger *In its* Methods for the Dyn. Calibration of Pressure Transducers, 12 Dec. 1963 p 31-51 refs (See N64-16236 08-15) GPO: $0.60

Various methods are discussed by which the response function of a transducer system can be expressed analytically as a function of time or transformed directly to the frequency domain. The major part of this analysis is based on the evaluation of a

Fourier integral equation. To relieve the tedious and time consuming task of computing the integral and finding the solution in elementary situations, different approximations and/or computing aids are introduced to simplify the evaluation. Some of the approximations considered are harmonic analysis, staircase function, straight-line segment, trapezoidal, sin x/x, number series transformation, and the pseudorectangular pulse. The computing aids considered are Henderson's analyzer, Montgomery's optical Fourier analyzer, a photoelectric Fourier transformer, and an electronic analyzer with magnetic transient storage. C.L.W.

N64-16240* Dresser Electronics, Houston, Tex. Southwestern Industrial Electronics Div.
ANALYSIS OF NONLINEAR TRANSDUCERS
D. F. Muster *In its* Methods for the Dyn. Calibration of Pressure Transducers, 12 Dec. 1963 p 53-67 refs (See N64-16236 08-15) GPO: $0.60

The physical and analytical aspects of nonlinearity are discussed. The discussion focuses on the physical parameters of damping and stiffness and the manner of their representation in the analysis of transducer systems. Consideration is also given to analytical methods as they are applied to nonlinear systems. Particular attention is given to those methods and solutions of systems where the nonlinearity is confined to the restoring force term only and to those where it is confined to the damping term only. Among the methods of analysis, the describing-function method, the bilinear approximation, and the phase-plane method are discussed in detail. C.L.W.

N64-16241* Dresser Electronics, Houston, Tex. Southwestern Industrial Electronics Div.
SIMPLE APERIODIC-FUNCTION GENERATORS
J. L. Schweppe *In its* Methods for the Dyn. Calibration of Pressure Transducers, 12 Dec. 1963 p 69-75 refs (See N64-16236 08-15) GPO: $0.60

All methods of transducer calibration require that a known input be applied and that the output be measured precisely. Some methods of producing the required input and of evaluating the measured response are discussed. This paper covers three types of simple aperiodic-function generations: the dropping ball, the quick-opening device, and the explosive device. Author

N64-16243* Dresser Electronics, Houston, Tex. Southwestern Industrial Electronics Div.
PERIODIC-FUNCTION GENERATORS
D. F. Muster *In its* Methods for the Dyn. Calibration of Pressure Transducers, 12 Dec. 1963 p 87-95 refs (See N64-16236 08-15) GPO: $0.60

Primary concern is given to generators capable of producing pressure changes that closely approximate one of the waveforms of specific periodic functions of primary use in the dynamic calibration of pressure transducers. These waveforms are sinusoid, square-wave, and impulse functions. The generators include acoustical shock type, rotating valve and piston in-cylinder devices, sirens, and electrical, mechanical, and electromechanical exciters. C.L.W.

N64-16244* Dresser Electronics, Houston, Tex. Southwestern Industrial Electronics Div.
THE ELECTRONIC COMPENSATOR
E. L. Michaels and G. F. Paskusz *In its* Methods for the Dyn. Calibration of Pressure Transducers, 12 Dec. 1963 p 97-104 refs (See N64-16236 08-15) GPO: $0.60

An electronic device designed to provide a transfer function, which is the inverse of the transfer function of a given transducer, is described. With the aid of this device the usable frequency range of a transducer system is extended, and the labor involved in the determination of the driving function is reduced. The discussion includes the principles upon which the device is based, a description of the circuit, and the frequency response of the device. C.L.W.

N64-17713 Joint Publications Research Service, Washington, D.C.
MEASURING THE PRESSURE OF HIGH-INTENSITY PULSE JETS BY THE TENSOMETER METHOD
V. P. Borodin et al 30 Mar. 1964 12 p refs Transl. into ENGLISH from Zh. Prikl. Mekhan. i Tekhn. Fiz. (Moscow), no. 6, 1963 p 104-107
(JPRS-23920; OTS-64-21926) OTS: $0.50

A transducer is described for measuring dynamic pressures of the order of tens of thousands of atmospheres. The transducer is made in the form of a pitot tube with a cylindrical tensometer. The transducer is simple, reliable, and practically inertia-less. A jet stream was measured for dynamic pressure utilizing the tensometric method. A description is given of the dynamic pressure measurements by utilizing the transducer. By this method, successful high dynamic pressure measurements are possible. C.L.W.

N64-17815* Stanford Research Inst., Menlo Park, Calif.
DEVELOPMENT OF A BLOOD-PRESSURE TRANSDUCER Final Report
G. L. Pressman and P. M. Newgard Nov. 1962 35 p refs
(NASA Contract NAS2-809; SRI Proj. 4025)
(NASA CR-53362) OTS: $3.60 ph, $1.25 mf

An external, arterial-blood-pressure transducer was designed, built, and tested. This improved model provided a reasonable compromise between the small size that was desired and ease of construction. Tests showed satisfactory comparison between the reading of blood pressure from the transducer and the value given by a sphygmomanometer, thus verifying the design theory. Because of the relatively large size of the present transducer, it is most valuable for use on the radial artery. Author

N64-18918 School of Aerospace Medicine, Brooks AFB, Tex. Aerospace Medical Div.
CONSTRUCTION AND USE OF A SIMPLE, SELF-GUIDING CATHETER FOR RIGHT HEART AND PULMONARY ARTERY IMPLANTATION
William P. Fife Feb. 1964 7 p refs
(SAM-TDR-64-10; AD-434425)

A catheter has been developed that can be easily and rapidly implanted in the right heart or pulmonary artery. Fabricated from Tygon tubing, the catheter contains a thin section

located 2 cm from the distal end. This results in a tip that follows the bloodstream without special manipulation. During implantation, its position is monitored by the use of a pressure transducer, thus eliminating the need for fluoroscopy. Since the catheter is self-guiding, it may be implanted with ease from such distal locations as the femoral vein. It can be used to inject substances directly into the heart or pulmonary artery, or to withdraw blood samples. It also can be used to make pressure recordings of high quality from these areas. Author

N64-19015* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MEASUREMENT OF THE HEARTBEAT OF BIRD EMBRYOS WITH A MICRO-METEORITE TRANSDUCER Technology Utilization Report
Vernon L. Rogallo Washington, NASA, Apr. 1964 16 p
(NASA-SP-5007) OTS: $0.50

A new ultrasensitive momentum transducer has been successfully adapted as a ballistocardiograph to measure the heart beat of avian embryos. Experiments have demonstrated that life can be detected as early as 4 days in the incubation period and monitored to maturity without damage to the avian embryo. Changes in heart-beat rate and intensity resulting from temperature changes, or other external stimuli, were readily detected by the instrument. The technique appears to open new avenues of investigation for application in such areas as vaccine production and drug research. Author

N64-22660 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.
MEASURING PULSATING PRESSURES WITH THE AID OF MEMBRANE TRANSDUCERS
Yu. G. Zakharov 2 Jan. 1964 21 p refs Transl. into ENGLISH from Prom. Aerodinamika (Oborongiz), no. 19, 1960 p 9–20
(FTD-TT-63-737/1+2+4; AD-433076)

When using a transducer to measure pressure changes in an airstream it is not always possible to place the transducer directly at the point of interest. Under these conditions the pressure that is being studied is brought to the transducer through a channel consisting of an input nipple, a connecting tube, and an air cavity formed by the transducer housing and the membrane. An attempt is made to determine experimentally the correction factors for the measured amplitude and phase of a pulsating pressure, by considering the transducer and the inlet tube as a single oscillating system. P.V.E.

N64-23527* Southwest Research Inst., San Antonio, Tex.
A RESISTIVE WHEATSTONE BRIDGE LIQUID WAVE HEIGHT TRANSDUCER Technical Report No. 3
Daniel D. Kana 10 May 1964 18 p refs
(Contract NAS8-11045; SwRI Proj. 02-1391)
(NASA-CR-56551) OTS: $1.60 ph

The resistive-Wheatstone bridge liquid displacement transducer used in present liquid dynamics studies is a reliable device, well suited to liquid amplitude and frequency ranges usually employed for such studies. It appears that at frequencies below 4 cps, its accuracy is within about 3% to 5% when used in ordinary tap water, most of the errors being caused by surface tension effects. If it is possible to use fixed wires without a supporting glass rod, the error due to surface tension effects would be greatly diminished. A number of parameters of the system that can be changed to adapt this transducer to different experimental requirements are listed. N.E.A.

N64-24243 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div.
MEASUREMENTS OF STRESSES IN MACHINERY COMPONENTS
V. F. Yakovlev and I. S. Inyutin 30 Jan. 1964 145 p refs Transl. into ENGLISH of the book "Izmereniya Napryazheniy Detaley Mashin" Moscow, Gos. Nauchno-Tekhn. Izd. Mashinostr. Lit., 1960 p 1–114
(FTD-TT-63-731/1+2; AD-437115)

This volume considers methods for experimental measurement of stresses within machinery components. The fundamentals of stress measurement by means of baseless wire pickups at internal points in components are set forth. Examples in which a number of problems are solved experimentally under the conditions of linear, two-dimensional, and three-dimensional stressed states with static and dynamic loads are given. Author

N64-28352* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VIBRATING MEMBRANE ELECTROMETER WITH HIGH CONVERSION GAIN
John Dimeff and James W. Lane Repr. from The Rev. of Sci. Instr., v. 35, no. 6, Jun. 1964 p 666–668 refs
(NASA-RP-289)

A vibrating membrane transducer is used as the sensing element for a high sensitivity electrometer. The method of operation provides an increased conversion gain by using a special circuit in which the electrometer current controls the displacement amplitude of a membrane forced to vibrate at its resonant frequency. The experimental transducer produces an alternating output voltage, is small and rugged, and has a conversion gain three orders of magnitude greater than electrometer transducers in current use. Author

N64-29389 National Aeronautical Lab., Bangalore (India)
PRESSURE TRANSDUCERS USING THE LINEAR DIFFERENTIAL TRANSFORMER
S. Balakrishna and S. Srinathkumar Jul. 1963 16 p refs
(TN-SE-3-63)

A pressure transducer is described that uses a linear variable differential transformer to sense the displacement at the center of a diaphragm subjected to the pressure being measured. Design details of the transducer are given, including complete specifications for the differential transformer and the electronic circuit used for indication. The diaphragm of the transducer is changed to get different full-scale pressure ranges. The accuracy of the transducer in all ranges is better than ± 1 percent. Author

N64-29393 George Washington U., Washington, D.C. Center for Measurement Science
TWO-PORT FORMULATION OF ELECTROMECHANICAL TRANSDUCERS
Louis de Pian and Robert M. Moore 10 Jul. 1964 37 p refs
(Contract Nonr-761(09))
(Rept.-1; AD-602216)

This report begins with a discussion of analogies as they pertain to electromechanical transducers. Following this discussion, the linear operating equations of the general transducer are formulated as matrix equations, and the various possible matrix parameters and equivalent networks for such devices are presented. The concept of reciprocity, nonreciprocity, and antireciprocity are then introduced, and their significance is discussed. Finally, a general development of the salient properties of linear electromechanical transducers, including natural (transient) and forced (steady state) response behavior, is developed, and the techniques are illustrated. Author

N64-30127 Bettis Atomic Power Lab., Pittsburgh, Pa.
EXPERIMENTAL AND ANALYTIC STUDIES OF ELECTRO-MECHANICAL TRANSDUCER SYSTEMS FOR TRANSIENT PRESSURE MEASUREMENTS
T. W. Hunt Aug. 1964 56 p refs
(Contract AT(11-1)-GEN-14)
(WAPD-TM-343)

Six electromechanical pressure transducer systems consisting of variable reluctance transducers, tubing, valves, and fittings with water as the pressure transmitting fluid were designed, built, and tested. The systems were used to measure transient pressure drops caused by transient flow conditions in thermal and hydraulic experiments, which simulate nuclear heating of pressurized water reactors through electrical heating of test sections. The frequency response and damping factor measurements for 21 combinations of transducer rating and system design are tabulated. The effect upon response and damping of various sizes of orifices is also tabulated. Author

N64-30204 Stanford Research Inst., Menlo Park, Calif.
DESIGN OF PRESSURE TRANSDUCERS, PROJECT COACH Final Report
D. D. Keough 20 May 1964 10 p refs
(Contract DA-49-146-XZ-273; ARPA Order-172-61)
(AD-442689)

The piezoresistance gage initially permitted recording of pressure profiles of 10- to 150-kbar peak gage pressure, and the insulator was reasonably matched to the shock impedance of desert surface. At the time of cancellation of Project Coach, work had been initiated to design, construct, and test gages matched to the shock impedance and, if possible, to the Hugoniot of salt. Matching the shock impedance proved quite feasible, and work was begun on matching the Hugoniot of salt. Matching procedures and materials are listed. D.E.W.

N64-30900 General Motors Corp., Anderson, Ind. Delco-Remy Div.
FEASIBILITY STUDIES OF THE ELECTROTHERMALLY REGENERATIVE TRANSDUCER Final Report
Robert D. Weaver 30 Mar. 1963 152 p refs
(Contract DA-33-008-ORD-2335)
(AD-403290)

A new method of converting thermal energy to electricity has been investigated and the results are presented. The method employs electrochemical principles, and the device has been named the Electrothermally Regenerative Transducer. The study has shown a limiting efficiency of 35% conversion of heat. A transducer system capable of providing 500 A continuously at 28 V, with a maximum current of 5000 A at 18 V, has been designed. The average efficiency calculated for the design is 24% and the weight is 811 lb. Laboratory data obtained on single electrodes show current densities of more than 25 $A/in.^2$ to be possible. Author

1963
IAA ENTRIES

A63-10758
DRAG-BODY FLOWMETER.
Mead Stapler (Ramapo Instrument Co., Inc., Bloomingdale, N.J.)
Instruments and Control Systems, vol. 35, Nov. 1962, p. 97-99.

Description of a drag-type flowmeter for measuring the impact force of a moving stream in terms of flow rate in gallons per minute (0.1 to 10,000 gpm). In the design of a drag-body flowmeter the following basic features are considered: sensitivity, stability, infinite resolution, negligible hysteresis, insensitivity to variations in line pressure and temperature, resistance to corrosion, and capability of withstanding hydraulic shock. The meter should have an electrical transducing system which is isolated from the fluid, and is compatible with existing strain gages. It should not have any wearing or rotating parts. Suggested areas of application include measurement of transient-flow response in servovalve testing and flow recording of high-temperature, cryogenic, or corrosive fluids.

A63-11187
PERFORMANCE CHARACTERISTICS OF TURBINE FLOWMETERS.
Montgomery R. Shafer (National Bureau of Standards, Washington, D.C.)
(American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 26-Dec. 1, 1961, Paper 61 - WA-25.)
American Society of Mechanical Engineers, Transactions, Series D - Journal of Basic Engineering, vol. 84, Dec. 1962, p. 471-479; Discussion, p. 479-485; Author's Closure, p. 485.

Discussion of the general performance of turbine-type or propeller flowmeters operating on liquid hydrocarbons in the range 0.5 to 250 gpm. Particular characteristics investigated include the effects of flow rate, viscosity, pressure level, entrance flow pattern, and orientation on the performance of these meters. It is shown that metering precision better than 0.2% can be attained for selected ranges of flow rate and viscosity when entrance conditions and meter orientation are suitably controlled. Other factors briefly reviewed include dynamic response, totalization considerations, and the readout instrumentation.

A63-11204
SURVEY OF PRESSURE TRANSDUCERS.
K. S. Lion (Massachusetts Institute of Technology, Cambridge, Mass.)
Electro-Technology, vol. 71, Jan. 1963, p. 50-52.

Brief review of transducer-system principles and design parameters, applicable to measurements of static and dynamic pressures in fluid-flow fields. Types of pressure transducers discussed and illustrated include resistive (Bridgman), capacitive, piezoelectric, and electrokinetic. The development of some new types of capacitative transducers, with elastic deformation of the dielectric layer, is noted.

A63-12250
MESURE DES PRESSIONS RAPIDEMENT VARIABLES ET EN PARTICULIER DANS DES ECOULEMENTS A HAUTE TEMPERATURE [MEASUREMENT OF QUICKLY VARIABLE PRESSURES WITH SPECIAL APPLICATION TO HIGH TEMPERATURE FLOWS].
Jean Girvès (ONERA, Chatillon-sous-Bagneux, Seine, France).
La Recherche Aéronautique, Nov.-Dec. 1962, p. 44-52. In French.

Description of progress achieved by ONERA in the design of pressure pickups which have a broad bandwidth or which will be brought into direct contact with media heated to 3,700°K. Various types of pickups and the electronic detecting systems are considered in detail. It is pointed out that, in addition to the specifically aeronautical applications, these pickups are adaptable to a wide range of problems, due to their capability to give simultaneously the mean pressure and the rapid variations of the instantaneous pressure. The transistorized versions of these pickups are of particular interest. The electronic detector which operates in conjunction with these pickups allows telemetering over long distances.

A63-12412
INSTRUMENTATION FOR SHOCK TESTING.
J. E. Rhodes (Endevco Corp., Pasadena, Calif.)
Society of Automotive Engineers, National Aerospace Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 8-12, 1962, Paper 585A. 11 p. 10 refs.

Discussion of methods for measuring transient shock motion, emphasizing acceleration determinations. The distortion of rectangular pulses by low- and high-frequency, first- and second-order transfer functions is described. Frequency response requirements are considered in relation to accelerometers and galvanometer recorders and filters. It is seen that, in addition to high resonant frequency, an accelerometer should follow the characteristic response for an undamped single-degree-of-freedom mechanical system without spurious minor resonances. The galvanometer resonance frequency should be high so that minimum distortion of the basic transient is introduced. A review of shock transducers includes the following: (1) variable-potentiometer transducers, (2) seismic differential-transformer and variable-reluctance transducers, (3) strain-gage accelerometers, and (4) piezoelectric accelerometers. The calibration of transducers and the effects of mounting techniques in transducer resonance frequency are briefly discussed.

A63-12478
INSTRUMENTATION FOR SHOCK AND VIBRATION MEASUREMENTS.
R. R. Bouche (Endevco Corp., Pasadena, Calif.)
(American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 27, 1962.)
IN: Experimental Techniques in Shock and Vibration. New York; American Society of Mechanical Engineers, 1962, p. 71-80. 31 refs.

Description of the performance characteristics of the instruments and the techniques used in shock and vibration measurements including mechanical impedance. Shock and vibration measurements are made on structures, equipment, and high-performance vehicles. It is indicated that shock and vibration instrumentation is suitable for making accurate measurements over wide ranges of frequency, temperature, and vibration. Shock motion testing requires that the entire measurement system possess wide frequency response and linear phase-shift characteristics. It is also pointed out that the use of these instruments should lead to a better understanding of the dynamic behavior of structures, and permit more realistic testing of equipment.

A63-13024
THE TOROIDAL DISPLACEMENT TRANSDUCER.
Rolf K. Brodersen (Martin-Marietta Corp., Orlando Div., Orlando, Fla.)
Electro-Technology, vol. 71, Mar. 1963, p. 115-119.

Survey of the principles, characteristics, and relative merits of electrodynamic displacement transducers of both the variable-reluctance and constant-reluctance types, with particular reference to a novel toroidal displacement transducer of the latter type. This transducer has the salient features of operating with constant air-gap reluctance, independent of rotor angular position, so that no tangential forces due to rotor angular displacement are developed. Both the primary and the secondary coils are stationary, and since

they are wound on the same stator ring, no flexleads are required. The combination of the following two features is novel: (1) the primary coils can be tuned to provide magnetic support of the rotor, and (2) if magnetic suspension is not desired, the primary coils can be tuned so that the rotor is completely force-free in the radial direction. A schematic diagram of a circuit for four-pole toroidal pickoff, with tuned primary coils, is presented.

A63-13194

RESOLUTION OF PRESSURE IN TURBULENCE.

G. M. Corcos (University of California, College of Engineering, Dept. of Aeronautical Sciences, Berkeley, Calif.)

Acoustical Society of America, Journal, vol. 35, Feb. 1963, p. 192-199. 11 refs.

Contract No. NSF G-18815.

Discussion of the ability of a transducer to resolve the spatial details of a turbulent pressure field, with particular reference to two applications. The first is an evaluation of the adequacy of contemporary measurements of the properties of turbulent pressure fields in shear flows, and the second is an assessment of the possible discrimination by a sonar receiver between sound and local turbulent pressure fluctuations which act as background noise. To this effect, an example of the mapping of a random function of several variables by a linear operator is examined. Making use of a formalism and of recent experimental information on the spatial structure of turbulent pressure fields in boundary layers, the mapping or distortion of statistical quantities associated with the second-order moments of the pressure fields is demonstrated. The attenuation of the frequency-spectral density and of the cross-spectral density is presented in a table, in asymptotic form. The numerical results indicate that the attenuation caused by the finite size of transducers is generally more severe than is suggested by previous computations, mainly because the lateral correlation of pressure is highly frequency-dependent. Referred to the applications under consideration, these findings indicate the type of spatial relations required for the evaluation of transducer resolution.

A63-13649

ERROR BAND CONCEPT DEFINES TRANSDUCER PERFORMANCE.

Harry N. Norton (General Dynamics Corp., Astronautics Div., San Diego, Calif.)

Ground Support Equipment, vol. 4, Dec. 1962-Jan. 1963, p. 20-23.

Brief discussion of the error-band concept which simplifies specifications and performance verification of transducers. The inadequacy of the instrument-oriented specifications in terms of individual errors is briefly considered. The factors included in an error-band specification, which is the band of maximum deviations of output values from a specified reference line or curve, are presented. The reference line is found to remain unchanged for all error bands of a transducer regardless of environmental or test conditions applicable for them.

A63-15141

SURVEY OF PRESSURE TRANSDUCERS.

G. Tegerdine.

Engineering Materials and Design, vol. 6, Apr. 1963, p. 260-268.

Brief summary of the design, principles of operation, and applications of small-displacement-force pressure transducers. Considered are the potentiometer-, the variable inductance-, and the variable capacitance-types of transducers, as well as the vibrating-cylinder and strain-gage pressure transducers. Specifications are presented for the commercially available transducers of these types which are manufactured by 10 British instrument firms.

A63-15342

A FAMILY OF DIGITAL TRANSDUCERS.

Myron L. Feistman and Paul Erskine Brown (Radio Corporation of America, Camden, N. J.)

IEEE Transactions on Aerospace, vol. AS-1, Feb. 1963, p. 7-14. 17 refs.

Discussion of the function of digital transducers, the applications for which they are especially required, and the variables which they are best adapted to measure. A brief survey of methods of digitizing is given in which the principles used in this system are presented. The practical problems involved in the design of a usable transducer are considered, and several transducers are described. It is concluded that with a 90-yr half-life material such as Pu^{238}, and a count rate of 1×10^4 cps, the accuracy is expected to be better than ± 1%. The solid-state amplifier and counter weighs less than 0.5 lb and occupies less than 15 in.^{3}; transducer volume is less than 4 in.^{3}, and power requirements are less than 1 watt.

A63-15855

A STRAIN GAGE PRESSURE TRANSDUCER WITH ALL-ROUND PERFORMANCES.

Yao T. Li (Massachusetts Institute of Technology, Dept. of Aeronautics and Astronautics, Cambridge, Mass.)

IN: Air, Space, and Instruments - Draper Anniversary Volume. New York, McGraw-Hill Book Co., Inc., 1963, p. 376-384.

Description of a pressure transducer, the pressure-sensing element of which consists of a pair of concentric cylinders. Pressure is admitted to the space between the two cylinders to expand the outside one while compressing the inside one. A strain gage of wire foil, or solid-state material, is bonded to the outside of the outside cylinder and the inside of the inside cylinder to form the standard Wheatstone bridge. This configuration allows good temperature compensation and provides for four active arms. The reciprocal dimensional change of the inner and outer cylinders provides linearity compensation. The device has high accuracy, high overload characteristics, and high response speed with good damping properties.

A63-15940

TWISTED BEAM TRANSDUCER: FREQUENCY SHIFTS IN VIBRATING MODES OF BEAMS UNDER TWIST.

Alexander M. Voutsas (International Telephone and Telegraph Corp., Federal Electric Corp., Paramus, N. J.)

(American Rocket Society, Missile and Space Vehicle Testing Conference, Los Angeles, Calif., Mar. 13-16, 1961.)
AIAA Journal, vol. 1, Apr. 1963, p. 911-913.

Description of a miniature electromechanical device which measures input angles, within a fraction of a second arc, through conversion from a mechanical angular displacement to a difference in frequency. The input angle is shown to be linearly dependent on the difference in transverse natural frequencies of two equally pretwisted flat tapes when their common-end junction is further twisted from its equilibrium pretwisted position by the desired input angle. A change in twist angle changes the natural frequency of the tape, and therefore, the measurement of the difference in frequency between the two tapes is a direct measurement of the input angle. Formulas presented for the natural frequency of a tape at zero twist, and for the natural frequency of a twisted tape, lead to a relation which provides the calibration formula. The sensing elements and the vibrating tapes are diagramed and described. Experiments conducted from 0^o to 360^o of total twist angle confirm the theoretical relationships presented. The twisting beam transducer is a laboratory device that lends itself to a wide use in instrumentation, in space guidance components, and in telecommunications.

A63-16327

HALL-EFFECT TRANSDUCERS.

Joseph Star (Instrument Systems Corp., Halltest Div., Westbury, N. Y.)

Instruments and Control Systems, vol. 36, Apr. 1963, p. 113-116.

Study of the application of Hall-effect devices and of the characteristics associated with them. The principal fields of application are in the measurement and control of magnetic fields and currents, and in the multiplication of currents. These applications are described, and the requirements which must be satisfied for semiconductors in the Hall generator are discussed.

A63-16703
MODE THEORY OF MULTITERMINAL TRANSDUCER CHAINS.
Israel Bar-David (Ministry of Defense, Scientific Dept., Hakirya, Tel Aviv, Israel).
IEEE Transactions on Circuit Theory, vol. CT-10, Mar. 1963, p. 72-81. 13 refs.

Application of the mode concept to the analysis of linear multiterminal transducers operating at a discrete frequency. The transducer matrix is examined, with restrictions on reciprocity, symmetry, and losslessness introduced as special cases. The proper modes of signal transmission are classified into reactive, pseudo-active, and power-handling modes. Single and multiple mode operation is studied, and a mode-sorter termination is developed for the multiple mode. An analysis of special multiterminal transducers shows that qualitative restrictions, such as losslessness and reciprocity, impose orthogonality relations upon the modes, whereas configurative restrictions, such as symmetry and reciprocity, reduce the complexity of the problem by constraining the modes into pairs with reciprocal properties. The feasibility of achieving pseudo-active, growing modes in lossless nonreciprocal transducers is demonstrated by an example. Mode sorters are shown to be realizable as transformer banks in symmetrical chains. Appendices include the calculation of mode constants.

A63-16881
A DEVICE FOR MEASURING HEAT TRANSFER RATES IN HYPERVELOCITY WIND TUNNELS.
R. L. Ledford (ARO, Inc., von Kármán Gas Dynamics Facility, Tullahoma, Tenn.)
(University of Denver, Denver Research Institute, Symposium on Hypervelocity Techniques, 2nd, Proceedings, Denver, Colo., Mar. 20, 21, 1962.)
IN: Advances in Hypervelocity Techniques. New York, Plenum Press, Inc., 1962, p. 673-691.
Contract No. AF 40(600)-800.

Description of a heat-transfer-rate transducer which may be employed to measure transient heat-transfer rates ranging upward to approximately 1,000 Btu/ft^2 sec in intermittent, electric-arc-driven wind tunnels. The transducer utilizes a copper disk as a calorimetric mass and a thermocouple as a temperature sensor. A detailed description of its associated instrumentation is also given along with results of an evaluation test conducted on the entire system.

A63-17170
A METHOD FOR DEFECT DISCRIMINATION IN AUTOMATIC, MULTIPLE TRANSDUCER INSPECTION SYSTEMS.
Walter A. Gunkel (Southwest Research Institute, San Antonio, Tex.)
(Society for Nondestructive Testing, Inc., South Texas Sect., and Southwest Research Institute, San Antonio, Tex., Feb. 27-Mar. 1, 1962.)
IN: Annual Symposium on Nondestructive Testing of Aircraft and Missile Components, 3rd, Proceedings. San Antonio, Society for Nondestructive Testing, Inc., South Texas Sect., 1962, p. 129-140.

Description of a multiple-transducer system designed and tested for automatic defect discrimination. Covered are primary discrimination, multiple-transducer inspection systems, and combinational discrimination. The latter is obtained by an analysis of the combinations of signals existing on the nine output channels.

A63-18304
CRYOGENIC ACCELERATION AND TEMPERATURE TRANSDUCTION.
Earl I. Feder and Eric J. Straus (Gulton Industries, Inc., Instrumentation Div., Metuchen, N. J.).
IN: Institute of Environmental Sciences, 1963 Annual Technical Meeting, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1963, p. 353-362.

Description of the design and calibration techniques for accelerometers and temperature probes at cryogenic temperatures. Several simple environmental test methods are shown covering a calibration temperature range from -150° to -450°F. Data are presented on the characteristics and performance of piezoelectric accelerometers at low temperatures. Also discussed is a temperature probe based upon the utilization of a carbon element, and capable of providing measurement and control of temperatures near absolute zero.

A63-19640
THE DEVELOPMENT OF AN IMPLANTABLE, NONOCCLUSIVE, NON-INVASIVE BLOOD PRESSURE MEASURING SYSTEM.
H. A. Gorman, R. Grau, J. Craig, and F. LaRue (Martin Marietta Corp., Martin Co., Denver, Colo.).
American Institute of Aeronautics and Astronautics, Summer Meeting, Los Angeles, Calif., June 17-20, 1963, Paper 63-167. 8 p. Members, $0.50; nonmembers, $1.00.

Review of hemodynamic investigations to develop an accurate, implantable blood-pressure transducer-transmitter system for sensing both the systolic and the diastolic pressures within intact arteries of subjects in orbiting vehicles, and for delivering the data from the subject to receiving-recording equipment. The feasibility of a nonoccluding, noninvading system is established. The transducer developed is a silicone-rubber split cuff on which strain gages are bonded to give a circumferential deflection reading during the entire pulse wave. The signal is fed to the transmitter by a braided cable enclosed in the silicone rubber which isolates the strain gages and wiring from the humeral fluids of the body. The surgical implantation and calibration of the system are described.

A63-19670
A HALL EFFECT ACCELEROMETER.
Maciej Nalecz and Henryk Ziomeckl (Polish Academy of Sciences, Institute of Automatic Control, Electrotechnical Dept., Warsaw, Poland).
Franklin Institute, Journal, July 1963, p. 14-25.

Description of a new measurement technique for accelerometers, using the Hall effect in semiconductors. The mechanical system of the accelerometer consists of a mass suspended from the frame by a flat spring. The accelerations to be measured are proportional to the deflection of the other end of the spring. The mechanical displacements are measured by the Hall voltage, with the Hall generator mounted at the end of the spring and moving in a nonuniform magnetic field. When the gradient of the magnetic field is linear the Hall voltage is proportional to the measured acceleration. Two magnetic systems with permanent magnets are discussed. Using the Hall generator with the gradient equal to about 10,000 gauss/mm, Earth accelerations from 1 g to 10^{-4}g can be measured on the linear scale.

A63-20741
WHERE ULTRASONIC TRANSDUCERS ARE TODAY.
Erhard Sittig (Dura-Bond Bearing Co., Durasonics Division, Palo Alto, Calif.).
Electronic Industries, vol. 22, June 1963, p. E2-E5.

Description of the properties and applications of various classes of ultrasonic transducers. The classes discussed are piezoelectric single crystals, ferroelectric electrostrictive ceramics, and magnetostrictive metals. Various characteristics of these types of transducers are tabulated, among them density and piezoelectric constant. The application of ultrasonic transducers for electrical circuit components, passive vibration and sound signal pickups, sound and vibration generators, and modulators of electromagnetic radiation are discussed, as are the power output and operating frequency limitations of these devices.

A63-20914
ALIGNMENT AND MEASUREMENT WITH ELECTRONIC LEVELS.
John M. Miller (Grumman Aircraft Engineering Corp., Bethpage, N. Y.).
Tool and Manufacturing Engineer, vol. 51, July 1963, p. 75-78. Abridged.

Description of the electronic level, which incorporates the significant advance of a transducer to convert mechanical displacement of the pendulum or bubble into a proportional electrical signal

that is recorded on a meter in seconds of arc. The application of an electronic level in checking bearing race alignment is illustrated in detail. Also described is the application for checking surface tables The checking method is called isoleveling because lines of equal level are applied to the electronic level directly on the surface of the table with easily-removed grease pencil. It is noted that electronic levels cost less than autocollimation equipment and can be used by less-skilled personnel.

A63-24318
EQUIVALENT CIRCUIT OF A VIBRATING SYSTEM MAGNETOSTRICTIVE TRANSDUCER-CONCENTRATOR-SAMPLE.
Lin Dzon-mou (Polish Academy of Sciences, Institute of Basic Technical Problems, Dept. of Vibrations, Warsaw, Poland).
Proceedings of Vibration Problems, vol. 4, no. 2, 1963, p. 175-184.

Analysis of the equivalent circuit of a magnetostrictive transducer with lumped constants, operating near mechanical resonance, and loaded by a transformer. The electric-equivalent circuit of a transformer of longitudinal and torsional vibrations is also examined. The investigation is part of a study of fatigue phenomena and physical nonlinearities in solids.

1964
IAA ENTRIES

A64-10619
DIFFUSION LAYER ULTRASONIC TRANSDUCER.
N. F. Foster (Bell Telephone Laboratories, Inc., Whippany, N.J.)
Journal of Applied Physics, vol. 34, Apr. 1963 (Part I), p. 990, 991.

Techniques which, by diffusing copper into the surface of conductive cadmium sulfide single-crystal samples enables the formation of thin piezo-electrically active layers. Such diffusion layers can act as ultrasonic transducers with operating frequencies well above 100 Mc. Short delay lines with less than 30 dB of insertion loss at 175 Mc have been made using such diffusion layer transducers.

A64-12483
SPECIFICATION CHARACTERISTICS OF PRESSURE TRANSDUCERS.
Harry N. Norton (General Dynamics Corp., General Dynamics/Astronautics, San Diego, Calif.).
Instruments and Control Systems, vol. 36, Dec. 1963, p. 91-95.

Consideration of procedures for listing the specific characteristics of pressure transducers. These instruments are discussed in the context of the following outline, which can be used for specification purposes: (1) design characteristics, including mechanical and electrical properties; and (2) performance characteristics, including static, dynamic, and environmental performance, and performance reliability.

A64-13598
SELECTION OF AN AIRBORNE TRANSISTORIZED TRANSDUCER FOR USE IN AIRCRAFT SYSTEMS [WYBÓR UKŁADU PRZETWORNICY TRANZYSTOROWEJ PRZEZNACZONEJ DO PRACY W POKŁADOWYCH URZĄDZENIACH LOTNICZYCH].
Waldemar Makulski.
Instytut Lotnictwa, Prace, no. 18, 1963, p. 40-48. In Polish.

Discussion of the basic relations of a transistorized transducer, with particular reference to the relations which define the suitability of a transducer for aircraft applications. It is shown that a transducer coupled to two transformers exhibits the most suitable characteristics in aircraft environments. The technical and design data of this type of transducer are presented.

A64-13885
THE LIFT AND DRAG FORCES ON A CIRCULAR CYLINDER OSCILLATING IN A FLOWING FLUID.
R. E. D. Bishop and A. Y. Hassan (London, University, University College, Dept. of Mechanical Engineering, London, England).
Royal Society (London), Proceedings, Series A, vol. 277, Jan. 7, 1964, p. 51-75.

Description of a transducer used to measure the fluctuating lift and drag forces, and the steady drag force, acting on a circular cylinder placed transversely to a fluid flow. The theory of the transducer is reviewed, and the method used to determine the lift forces at different amplitudes and frequencies is discussed. Response diagrams, obtained by keeping the flow rate constant and varying the amplitude of the oscillations, are presented.

A64-16625
LOW-PRESSURE MARVELS - SOLID-STATE TRANSDUCERS.
J. C. Sanchez (Micro Systems, Inc., Pasadena, Calif.).
Astronautics and Aeronautics, vol. 2, Apr. 1964, p. 50-53.

Review of small-diaphragm transducers developed to improve the reliability, precision, sensitivity, and size of instrumentation for low-pressure measurements. Possible applications are: re-entry measurements on ablation heat shields of advanced space vehicles, transfer standard for condensible-vapor calibrations of gas-sensitive gages, measurement of model and tunnel pressures in hypersonic helium blowdown tunnels, replacement of nonlinear gas-composition-sensitive thermal conductivity gages, replacement of radioactive ionization gages, and similar uses. Some promising approaches to the design and manufacture of such instruments are discussed, with particular reference to the bonded semiconductor (piezo-resistive) strain gage, and capsule (or diaphragm-type) transducers.

A64-17216
EXPERIMENTAL MECHANICS IN THE DEVELOPMENT OF A NEW MINIATURE PRESSURE TRANSDUCER.
Charles W. Bert and Nelson A. Crites (Battelle Memorial Institute, Solid and Structural Mechanics, Columbus, Ohio).
IN: EXPERIMENTAL MECHANICS, PROCEEDINGS OF THE FIRST INTERNATIONAL CONGRESS ON EXPERIMENTAL MECHANICS, NEW YORK, NOVEMBER 1-3, 1961.
Edited by B. E. Rossi.
New York, Macmillan Co.; Oxford, Pergamon Press, Ltd., 1963, p. 307-322. 16 refs.
Contract No. NOnr-2877(00).

Development of a miniature pressure transducer of the diaphragm type, with strain elements based on a new concept, to measure in flight the air pressure acting on a helicopter rotor blade. With a number of these transducers installed along the blade chord, the pressure distribution can be measured under various flight conditions. This information is of importance in connection with a study of the aerodynamics of the blade and possible improvement in the blade design. With an overall volume of less than 0.001 in.^{3}, the instrument is believed to be the smallest pressure transducer that can measure static pressures as well as relatively high-frequency pressure fluctuations. It is also believed to offer promise for investigations of strain distributions in such small parts as gears, bearings, housings, and switches.

A64-17295
WHAT'S AHEAD IN BIOMEDICAL MEASUREMENTS?
L. E. Slater (Case Institute of Technology, Cleveland, Ohio).
ISA Journal, vol. 11, Feb. 1964, p. 55-60. 23 refs.

Presentation of the design concept of biomedical measuring devices that may ultimately approach microbic size. Removable probes having been used for measurements within living tissue; it is suggested that the transducer itself could be implanted as a semi-permanent device, transmitting information by radio. Semiconductor device technology is considered a promising source for micro-sized transducers. Speculation is made concerning the possibility of uniting the concept of biomagnetism with quantum mechanics. A second speculation suggests that microminiature sensing systems may permit extension of man's homeostatic (self-regulating) capabilities to permit adaptation to unusual environmental stresses.

A64-17660
INSTRUMENT TRANSDUCERS.
Hermann K. P. Neubert (Ministry of Aviation, Royal Aircraft Establishment, Farnborough, Hants., England).
Oxford, Oxford University Press, 1963. 400 p.
$13.45.

The book introduces the reader to the performance and design of a variety of instrument transducers, defined as devices which, for the purpose of measurement, convert physical input quantities into electric output signals. The discussion is limited to transducer types for which the technology is sufficiently advanced to satisfy the stringent conditions of high-class measuring instruments with predictable performance. Chapter 2 gives an overall view of instrument transducers with respect to their input and output quantities, linked by the particular transducing principle employed. It also discusses problems concerning classification of instrument transducers, and seeks to clarify the principle of electro-mechanical analogies, in which electro-mechanical devices are represented by all-electric circuits. A brief introduction to feedback-type transducers is included. Chapter 3 discusses the performance of instrument transducers with mechanical input elements, constituting first- and second-order vibratory systems, which may be excited by static, sinusoidal, or transient input quantities. The three essential elements of these systems are discussed with respect to their concept and realization. Pressure-sensitive elements and their characteristics are examined. Chapter 4 deals with the output characteristics of variable-resistance, variable-inductance, and variable-capacitance electromagnetic generators, and of piezoelectric and magnetostrictive transducers. Following an introduction to the basic physical principles involved, the discussion goes into details of design and materials peculiar to individual types of transducers, and concludes with a review of problems of transducer construction. Chapter 5 gives an account of force-balance transducers with a feedback path between transducer output and input. The application of the force-balance principle in dynamics is demonstrated by the example of a linear acceleration transducer. The book is intended for the instrumentation expert, the experimental physicist, and the electrical engineer. A bibliography is provided for each section of the book.

A64-20505
SHEAR STRAIN MEASUREMENT IN SOLID PROPELLANT ROCKET MOTORS.
G. M. Dicken and J. H. Thacher (Hercules Powder Co., Allegany Ballistics Laboratory, Cumberland, Md.).
American Institute of Aeronautics and Astronautics, Annual Meeting, 1st, Washington, D.C., June 29-July 2, 1964, Paper 64-506. 9 p.
Members, $0.50; nonmembers, $1.00.

Discussion of a semiconductor transducer which is capable of measuring shear strains in low-modulus propellant-like materials. A survey of existing and/or proposed stress/strain measuring devices is included. The new low-modulus dc semiconductor transducer and the evaluation test procedure are then described. The test procedures used to characterize the inert propellant used in this work are given. The grain structural analysis is presented and utilized to evaluate experimental results. Finally, the proposed use of the transducer in live propellant rocket motors is outlined.

A64-21755
A TACHOMETER AND SYNCHROSCOPE FOR RECIPROCATING ENGINE AIRCRAFT.
M. J. Delaney (Bendix Corp., Scintilla Div., Sidney, N.Y.).
IEEE International Convention Record, vol. 12, pt. 8, 1964, p. 179-185.

Description of an electronic tachometer and synchroscope developed for light reciprocating engine aircraft. The dual tachometer, for use on multiple-engine aircraft, consists of an indicator unit and two magnetic transducers. The transducers, when installed on the aircraft's magnetos, provide electrical pulses related to the crankshaft revolutions which operate the indicator unit. The indicator unit consists of a dual electronic circuit and a pair of panel meter mechanisms installed in a standard aircraft instrument case. The synchroscope drive signals are obtained from the tachometer transducers.

A64-22505
A MAGNETODYNAMIC MOTION TRANSDUCER.
M. N. Kaplan (North American Aviation, Inc., Space and Information Systems Div., Downey, Calif.).
IN: NATIONAL CONVENTION ON MILITARY ELECTRONICS, 7TH, WASHINGTON, D. C., SEPT. 9-11, 1963, PROCEEDINGS.
Conference sponsored by the Professional Technical Group on Military Electronics, Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
New York, Institute of Electrical and Electronics Engineers, 1963, p. 140-143.

Recommendation of a means for measuring a physical characteristic of space known to exist, but never before measured by direct means. An MDM transducer is described which employs moving solid dielectric media to physically convey charge; it is stated that liquid or gaseous dielectrics could be employed, where quantitative correction could be made for the effects of ion mobility. It is concluded that, when the motion vector is finite, it should be measurable by means of a shielded MDM transducer in the presence of a superposed potential gradient. The MDM-transducer should find numerous uses, including passive airborne ground speed sensing, as well as motion sensing deep in magnetized space. It might also find use as a surface means for sensing geographic north.

A64-22766
A NEW METHOD FOR MEASURING THE PRESSURE DISTRIBUTION ON HARMONICALLY OSCILLATING WINGS OF ARBITRARY PLANFORM.
H. Bergh (National Aeronautical and Astronautical Research Institute, Amsterdam, Netherlands).
International Council of the Aeronautical Sciences, Congress, 4th, Paris, France, Aug. 24-28, 1964, Paper 64-576. 8 p. 6 refs.
Members, $0.50; nonmembers, $1.00.

Description of a method of measuring the pressure distribution by means of a pressure transducer mounted inside a scanning valve. The scanning valve, located outside the test section, is connected to the model orifices by equal pressure leads. The correction procedure is specially simplified so as to eliminate the influence of the pressure leads. The equipment, developed to measure a large number of pressures automatically, is described. Examples are presented which are considered to demonstrate the usefulness of the technique.

A64-23179
TRANSDUCERS FOR DYNAMIC MEASUREMENTS.
R. R. Bouche (Endevco Corp., Pasadena, Calif.).
IN: INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL TECHNICAL MEETING, PHILADELPHIA, PA., APRIL 13-15, 1964, PROCEEDINGS.
Mt. Prospect, Ill., Institute of Environmental Sciences, 1964, p. 97-110. 17 refs.

Discussion of the applications, principles, and performance of various types of transducers. Although some of the transducers described measure constant mechanical stimulus - i.e., zero frequency, the discussion is directed toward their use for dynamic measurements. The transducer types covered are: seismic transducers, variable resistance transducers, variable inductive transducers, piezoelectric transducers, and piezoresistive transducers. A variety of calibration methods is also presented.

A64-24231
TRANSDUCERS FOR MEASUREMENT. I - INTRODUCTION AND THEORY OF PRESSURE MEASUREMENT.
L. E. Bollinger (Ohio State University, Dept. of Aeronautical and Astronautical Engineering, Columbus, Ohio).
(Symposium on Environmental Measurements, Cincinnati, Ohio, Sept. 4-6, 1963.)
ISA Journal, vol. 11, Aug. 1964, p. 45-48.

Discussion of pressure-sensing devices that can be actuated by waves from one or more transmission systems or media and that can supply related waves to one or more other transmission systems or media. In a brief introduction to transducers in general, the author

indicates that, ideally, transducers should respond instantaneously with respect to time. That is, for a step-function input, the output signal should follow the input signal without distortion in amplitude, frequency, or phase. Over a limited range, many actual transducers are said to approach this ideal. The type of transducer selected to obtain measurements of pressure in fluids is indicated to depend on a number of aspects of the particular application, including: range, accuracy, frequency response, location of detector and indicator, reliability, simplicity, availability, fluid temperature, fluid velocity, fluid corrosiveness, adaptability to automatic control, and cost. Discussions are also presented on Newtonian and non-Newtonian fluids, the influence of Reynolds number on flow, laminar and turbulent types of flow, fluid dynamics, and Bernoulli's equation.

A64-24737

A PIEZOELECTRIC ACCELEROMETER.

Jack Willis and Bruce Darrel Jimerson (California, University, Dept. of Engineering, Los Angeles, Calif.).

IEEE, Proceedings, vol. 52, July 1964, p. 871, 872. 5 refs.

Presentation of a design for an accelerometer thought to have a potential sensitivity of 1.5 g for a 1-lb inertial mass. The propose accelerometer is assumed to have: (1) a proof mass of 1 lb; (2) a frequency shift that is linear over the range of interest; (3) a constant operating temperature; (4) oscillator stability of about one part in 10^9 (achieved by controlling temperature); (5) a maximum range of 20 g; (6) a pair of crystals; and (7) ideal coupling between the proof mass and the transducer. The change in frequency expected when acceleration changes from 0 to 20 g is said to be of the order of 4 Kc for a crystal with an oscillator frequency of 300 Kc. Methods of improving both sensitivity and linearity are discussed, including the application of a dc bias voltage to the crystal.

A64-24919

MEASUREMENTS OF INTERNAL STRESS IN ELECTRONIC ENCAPSULATING RESINS WITH A SMALL SOLID STATE TRANSDUCER.

G. Dallimore, F. Stucki, and D. Kasper (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Research Laboratories, Palo Alto, Calif.).

SPE Journal, vol. 20, June 1964, p. 544-546.

Description of a small solid-state ferrimagnetic pressure transducer which can be embedded in an electronic package. Internal pressure data during thermal cycling and thermal shock, measured by the transducer on three types of resins, are provided. The effect of a silicone rubber coat on the transducer is also discussed. It is concluded that the transducer described offers the resin chemist, electronic packaging engineer, and design engineer a new tool for determining the effects of various catalysts, fillers, flexibilizers, diluents, and other modifying agents on the cure shrinkage and internal stresses generated during thermal cycling and thermal shock. In addition, it is anticipated that this device can be used to measure the effects of vacuum and radiation environments on electronic embedment materials.

A64-25349

ACCURATE PRESSURE TRANSDUCERS FOR EXTREME ENVIRONMENTS.

P. J. Colburn (Ultra Electronics, Ltd., London, England).

Industrial Electronics, vol. 2, Sept. 1964, p. 407-409.

Description of a recently developed, self-contained, force-balance pressure transducer. The instrument, complete with electronics, is said to operate over a temperature range of -40 to +150°C, to have errors limited to 1/3% of full scale, and to measure absolute pressures up to 15 psia. It can reportedly withstand very high vibration levels without giving erroneous readings and can be mounted in an aircraft without antivibration mounts. Its response time is indicated to be of the order of 20 msec and its output is 1 vdc/psi from 1 k ohms. The choice of the force-balance element and of the pressure-sensing element is described, and characteristics of the null detector and the amplification and stabilization techniques are discussed.

A64-25773

TRANSDUCERS FOR MEASUREMENT. II - DEVICES FOR MEASURING PRESSURE.

L. E. Bollinger (Ohio State University, Columbus, Ohio).

ISA Journal, vol. 11, Sept. 1964, p. 65-70.

Discussion of pressure-measuring devices. The following transducers are considered: (1) Manometers. The meniscus problem and the height of a column of liquid are mentioned; (2) Pitot and pitot-static tubes. A relationship is derived which yields the kinetic energy correction factor, knowledge of which allows a more accurate determination of the fluid velocity from the measurement of dynamic pressures in multidimensional flow fields; (3) Bourdon tubes. A schematic diagram is given along with the specifications for making a good tube; (4) Resistance and capacitance gages; and (5) Piezoelectric gages. The last two change their physical values with a change in pressure.

A64-26403

TRANSDUCERS FOR MEASUREMENT. III - TEMPERATURE FROM ONE EXTREME TO THE OTHER.

L. E. Bollinger (Ohio State University, Columbus, Ohio).

ISA Journal, vol. 11, Oct. 1964, p. 73-80.

Review of the history, theory, and applications of modern temperature-measuring equipment. Beginning with the conventional mercury-in-glass thermometer, the following specific types of temperature transducers are discussed: liquid-in-glass thermometers, bimetallic thermometers, radiation pyrometers, resistance thermometers, thermistors, and thermocouples. The typical optical pyrometer, thermistor circuits, the basic thermocouple circuit, the Seebeck, Peltier, and Thomson effects, and voltage outputs of various thermocouple metals vs platinum as a function of temperature are diagrammed. Basic laws governing a thermoelectric circuit are defined: the law of homogeneous circuits, the law of intermediate metals, and the law of intermediate temperature.

A64-26453

NATIONAL TELEMETERING CONFERENCE, LOS ANGELES, CALIF., JUNE 2-4, 1964, PROCEEDINGS.

Conference sponsored by the American Institute of Aeronautics and Astronautics, Institute of Electrical and Electronics Engineers, and Instrument Society of America.

North Hollywood, Calif., Western Periodicals Co., 1964. 472 p. $10.00.

CONTENTS:

WILDLIFE TELEMETRY. Lowell Adams (California, University; George Williams Hooper Foundation, San Francisco, Calif.) and W. Conlev Smith (U.S. Navv, Monterev, Calif.). 7 p.

SOME PRACTICAL ASPECTS - RADIO TELEMETRY IN CLINICAL MEDICINE. William E. Thornton and David A. Davis (North Carolina, University; North Carolina Memorial Hospital, Chapel Hill, N. C.). 3 p.

RADIATION RESISTANCE OF A LOOP ANTENNA IN A CONDUCTING MEDIUM, WITH REFERENCE TO BIOMEDICAL RADIOTELEMETRY. Victor W. Bolie (North American Aviation, Inc., Anaheim, Calif.). 4 p. 8 refs. [See A64-26459 22-09]

SESSION III - MULTIPLEXING AND SYNCHRONIZING.

DEVELOPMENT OF OPTIMUM FRAME SYNCHRONIZATION CODES FOR GODDARD SPACE FLIGHT CENTER PCM TELEMETRY STANDARDS. Jesse L. Maury, Jr. and Frederick J. Styles (NASA, Goddard Space Flight Center, Md.). 10 p. 6 refs. [See A64-26460 22-08]

A SIMPLIFIED APPROACH TO OPTIMAL PCM FRAME SYNCHRONIZATION FORMATS. Robert C. Masching (Lockheed Aircraft Corp., Sunnyvale, Calif.). 17 p. [See A64-26461 22-08]

THE EFFECT OF BIT AND GROUP SYNCHRONIZATION ON THE RECEPTION OF PCM/FM TELEMETRY SIGNALS. F. A. Perkins (Radiation, Inc., Melbourne, Fla.). 18 p. 20 refs. [See A64-26462 22-08]

THE DIGICOM - A HIGH SPEED ELECTROMECHANICAL STEPPING COMMUTATOR. John F. Brinster (General Devices, Inc., Princeton, N.J.). 4 p.

THE METAL-OXIDE-SEMICONDUCTOR TRANSISTOR IN PCM TELEMETRY SYSTEMS. I. Berner (Radio Corporation of America, Camden, N.J.). 16 p. 8 refs. [See A64-26463 22-09]

SESSION IV - TELEMETRY'S NEW FRONTIER - OCEANOGRAPHY.

A METEOR BURST COMMUNICATION SYSTEM FOR SHORT-RANGE MASTER-SLAVE APPLICATIONS. J. E. Sparks and Q. C. Wilson (Ball Brothers Research Corp., Boulder, Colo.). 9 p. 13 refs. [See A64-26464 22-08]

ACQUISITION OF OCEANOGRAPHIC DATA VIA METEOR TRAIL FORWARD SCATTER. R. E. Johnson (Boeing Co., Seattle, Wash.). 7 p.

AN EXPERIMENT WITH A SHORT PATH LENGTH UNATTENDED TROPOSCATTER TELEMETRY LINK IN THE ARCTIC OCEAN. Beaumont M. Buck and Walter P. Brown (General Motors Corp., Santa Barbara, Calif.). 8 p. 7 refs. [See A64-26465 22-08]

RADIO REFRACTION BY THE MARINE LAYER AND ITS EFFECT ON MICROWAVE PROPAGATION. Earl E. Gossard (U.S. Navy, San Diego, Calif.). 7 p. 7 refs. [See A64-26466 22-08]

SATELLITE TELEMETRY OF OCEANOGRAPHIC OBSERVATIONS. George E. O'Rourke (Sylvania Electric Products, Inc., Waltham, Mass.). 8 p. 8 refs. [See A64-26467 22-08]

TELEMETRY OF OCEAN CURRENT DATA FROM DEEP MOORED BUOYS. Robert G. Walden and Robert M. Snyder (Woods Hole Oceanographic Institution, Woods Hole, Mass.). 5 p.

HIGH FREQUENCY TELEMETRY AND COMMUNICATIONS FOR OCEANOGRAPHY. James M. Snodgrass (California, University, La Jolla, Calif.). 7 p. 5 refs. [See A64-26468 22-08]

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HIGH ACCURACY ANALOG-TO-DIGITAL CONVERSION UNDER SEVERE ENVIRONMENTS. Philip A. Toney (Dynatronics, Inc., Orlando, Fla.). 9 p. [See A64-26479 22-09]

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APOLLO PCM TELEMETRY EQUIPMENT WITH AUTOMATIC FAULT ISOLATION. Vernon A. Dorrell (North American Aviation, Inc., Downey, Calif.) and Donald R. Sorchych (Radiation, Inc., Melbourne, Fla.). 12 p. [See A64-26495 22-08]

APOLLO SPACECRAFT DATA STORAGE SYSTEM. Richard C. Collum, Jr. (Collins Radio Co., Cedar Rapids, Iowa) and P. M. Bryant (Leach Corp., Azusa, Calif.). 9 p. [See A64-26496 22-09]

THIRD ANNUAL REPORT OF THE TELEMETERING STANDARDS COORDINATION COMMITTEE TO THE NATIONAL TELEMETERING CONFERENCE. Joseph F. Koukol (California Institute of Technology, Pasadena, Calif.). 9 p.

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A64-26454 •

AN ADVANCED AEROSPACE TELEMETRY TRANSDUCER.

R. H. Russell (Micro Systems, Inc., Pasadena, Calif.).

IN: NATIONAL TELEMETERING CONFERENCE, LOS ANGELES, CALIF., JUNE 2-4, 1964, PROCEEDINGS.

Conference sponsored by the American Institute of Aeronautics and Astronautics, Institute of Electrical and Electronics Engineers, and Instrument Society of America.

North Hollywood, Calif., Western Periodicals Co., 1964. 8 p.

Description of a design approach to a second-generation aerospace telemetry transducer. The transducer described is for measurement of pressure, but the discussion is said to apply equally to temperature-sensing versions. The transducer uses a solid-state signal conditioner and solid-state sensors within the mechanical pickup. The signal conditioning module utilizes a dc-dc converter to provide dc isolation, and the associated problems of ac isolation and common mode output noise are discussed. The problems of a design compatible with specified operation under thermal shock conditions are considered, and a solution is indicated and applied to the system design. A very low mean time between failures was set as a design goal; through the use of ultralow power circuitry and careful parts choice, a significant improvement was found possible. The same approach permitted an excitation power requirement reduction of almost one order of magnitude.

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