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REPORT

GENERAL BIOPHYSICAL INVESTIGATION AND INSTRUMENTATION

FINAL REPORT

ON

TASK I: "Temperature Telemetry System for Laboratory Animals"

TASK V: "Use of Oxygen Electrodes for in Vivo Measurement of Elevated Oxygen Partial Pressures"

For

OFFICE OF NAVAL RESEARCH
Washington 25, D. C.

September 1963

Principal Investigators

Dr. Alvin Singer
Charles Reinhardt
Randal H. Thomas

Contract NOnr 2912 (00)

American
Electronic
Laboratories
COLMAR, PENNA.

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AMERICAN ELECTRONIC LABORATORIES, INC.
Richardson Road, Colmar, Pennsylvania

FINAL REPORT---TASK I

Temperature Telemetry System for Laboratory Animals

OBJECTIVES

1. To study the feasibility of supplying power to operate temperature telemeters in laboratory animals from an external magnetic field.

2. To build a model to demonstrate feasibility.

SYSTEM APPROACH

Three systems of the following characteristics were considered:

1. Audio power is supplied to the telemetering unit by means of a magnetic field generated by a coil in the cage surrounding the animal at the time that temperature information is desired.

2. A rechargeable battery included in the temperature telemeter is periodically recharged by placing the animal in a cage containing the coils which generate the necessary magnetic field.

3. A special probe containing the power transmitting coil and the receiver coil is placed in the cage near the animal during the time that temperature measurements are desired.

Further investigation led to the rejection of the system (2) due to the unavailability of a suitable battery and of system (3) due to a desire for a certain degree of automation in making the measurements.

TRANSMITTER

The transmitter (See Figure 1) consists of a radio frequency oscillator (300 KC) and a full wave rectifier consisting of the diodes D1 and D2. The voltage induced in the coil L2 by an external magnetic field is rectified and used to provide the operating voltages for the transistor Q1. The frequency of the oscillator is determined by the tank circuit consisting of the coil L1 and the capacitor C1. The capacitor C1 is temperature-sensitive in that its capacitance varies linearly in the temperature range desired as a function of temperature. This temperature-induced change in capacitance causes the resonant frequency of the tank circuit and hence also the oscillator frequency to change as a function of temperature.

After reviewing the compounds available for potting the transmitter unit, silastic rubber was chosen because of its known physiological inertness and low water absorption coefficient. The final size of the transmitter package is approximately 1/4" by 3/4" by 2-1/2". The power pickup L2 is wrapped around the transmitter assembly at its largest cross-section.

POWER TRANSMITTING ASSEMBLY

Power is supplied to the telemeter assembly by means of two large coils mounted inside the cage. These coils are constructed as shown in Figure 2. The driving frequency was chosen as 400 cycles per second since filtering in the transmitter rectifier is more efficient and can be accomplished using smaller values of capacitance and because 400 cycles per second generators are readily available. The upper limit of the power frequency was set by the necessity of having at least a 25 to 1 ratio between power frequency and transmitter frequency in order to prevent interference between the two.

The arrangement of the power coils and the power pickup coil L2 presents the difficulty that at certain orientations, no temperature information can be obtained since the transmitter stops oscillating. The probability of this occurring is 75%. The telemeter is so designed that it either oscillates at the correct frequency or it does not oscillate at all. Since the system is automatic these occasional "drop-outs" can be tolerated.

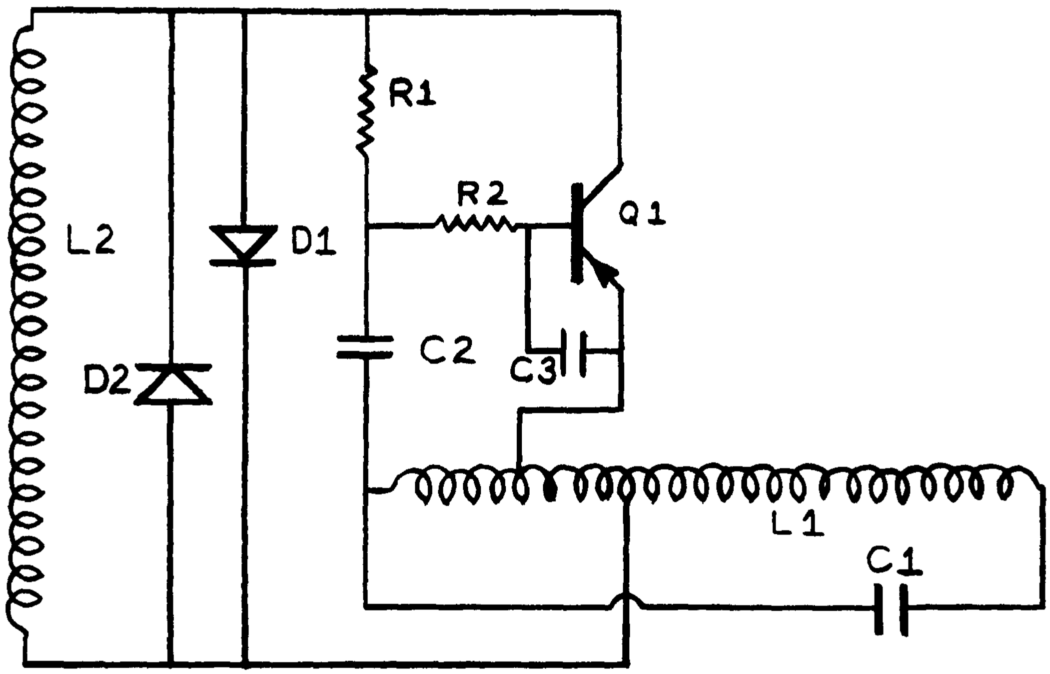
SUMMARY

A small semi-flexible implantable telemeter has been developed which transmits a radio frequency proportional to the temperature of the surrounding tissue. The unit contains no batteries, but derives its power from an external magnetic field emanating from coils mounted inside the animal cage.

The telemeter itself measures 1/4" by 3/4" by 2-1/2", including the power pickup coil which surrounds its largest cross-section. The complete unit is encapsulated in a non-toxic silicone rubber developed for tissue implantation.

Temperature-frequency calibration of the prototype telemeter is repeatable within ±0.25%F. The frequency shift at 300-kilocycles amounts to about 2.5-kilocycles per degree F.

Because the system lends itself to automatic recording of animal temperature as often as desired, it seemed reasonable to consider satisfactory a 75% probability of temperature indication at any time. This permits the use of a simple, undirectional field-coil system inside the cage, since one can afford to miss temperature readings occasionally. This will occur when the plane of the telemeter is parallel with the power field. Although the operating power induced in the telemeter will decrease with angle as this orientation is approached, it was possible to design the oscillator in the telemeter so that it will either oscillate at the proper frequency, or not at all. This achievement makes the system feasible.



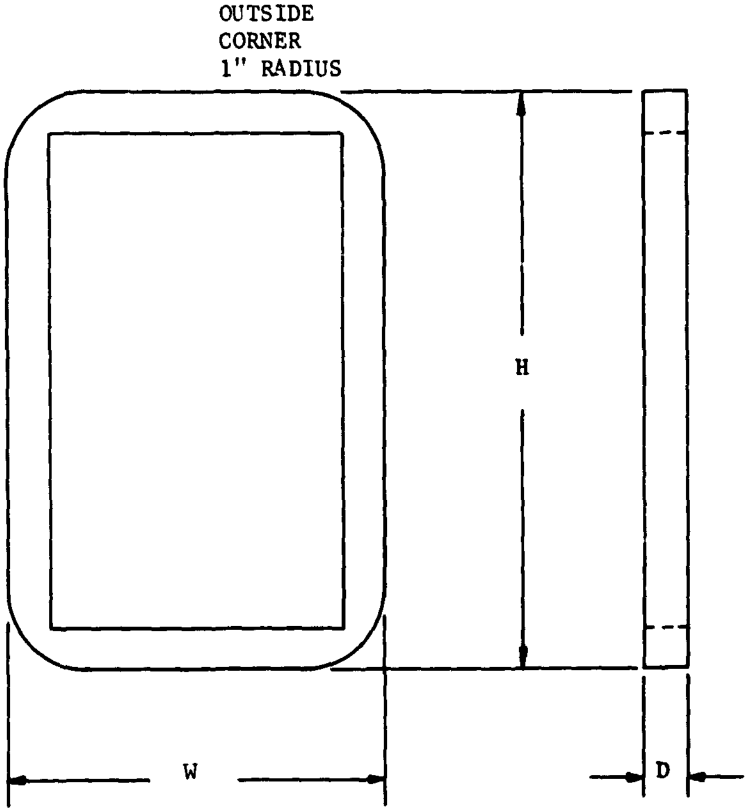
C1 .0005 μfd. (TRANSDUCER)
C2 .005 μfd.
C3 .0001 μfd.
R1, R2 10K Ω
Q1 2N240 PHILCO
D1, D2 T1G TRANSITRON
L1 100 TURNS ON FERRITE CORE
L2 POWER PICKUP, 1000 TURNS

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS IN INCHES.
TOLERANCES ON:–
FRACTIONS – ± 1/64
DECIMAL – ± .005
ANGLES – ± 1/2°
COMMERCIAL TOLERANCES APPLY TO ALL STOCK SIZES & SURFACES.
DO NOT SCALE DRAWING.

TITLE: FIELD POWERED TEMP. TELEMETER
NEXT ASSEMBLY

AMERICAN ELECTRONIC LABORATORIES, INC.
PHILADELPHIA, PA.

DRAWN JCE DATE 4/27/62
CHECKED RJT DATE 4/27/62
APPROVED DATE 4/27/62
MATERIAL
SCALE
SIZE B
DWG. NO.
REV.



TYPE	H	W	D
1	20"	15 1/2"	1 5/8"
2	23"	20"	1 5/8"
3	19"	12 1/2"	1"
4	15	10"	1"

Material - Knot-Free Framing Lumber

Figure 2

FINAL REPORT - TASK V

Use of Oxygen Electrodes for in Vivo Measurement of Elevated Oxygen Partial Pressures

INTRODUCTION

The platinum electrode has been used for many years in electrochemistry for the determination of oxygen partial pressure and hydrogen concentration. By covering the platinum electrode with a semi-permeable membrane, it is possible to measure oxygen concentration in protein-containing fluids such as blood and tissue serum. The semi-permeable membrane, which may be teflon or polyethylene, prevents the platinum from becoming contaminated by the protein. It is our purpose in this research task to explore the use of the membrane-covered electrode (first introduced by Dr. Leland Clark) in the vascular system of experimental animals exposed to hyperbaric environments.

PRESSURE CHAMBER

In order to obtain the required hyperbaric environments, a pressure chamber has been designed and constructed. This pressure chamber (see Figure 1) is in the form of a cylinder approximately 3 feet in diameter and 7 feet long. It is capable of maintaining pressures up to 10 atmospheres and allows for the use of up to four gases in combination. Provisions have been made for measuring temperature and pressure directly. In order to remove any excess heat, outlets for a cooling coil are available.

Electrical connection to the chamber is by means of an umbilical cord having 26 leads, hence it is possible to monitor the electrocardiogram, electroencephalogram, blood pressure (using the intracardiac blood pressure catheter developed in another phase of this contract), body temperature, respiration rate, pulse rate, blood oxygen partial pressure, and chamber oxygen partial pressure.

Visual observation is made through a Lucite covered pressure-tight port in the top of the chamber. The chamber itself is illuminated by means of an internal flood lamp. A picture of the chamber appears as Figure 2.

OXYGEN ELECTRODE

The oxygen electrode consists of a platinum polarographic electrode maintained as a cathode working against a silver-silver chloride reference electrode. With respect to this reference electrode the platinum is held at a potential of -0.6 volts. The polargraphic waveform for oxygen consists of two waves given by the following equation.

In Acid Media

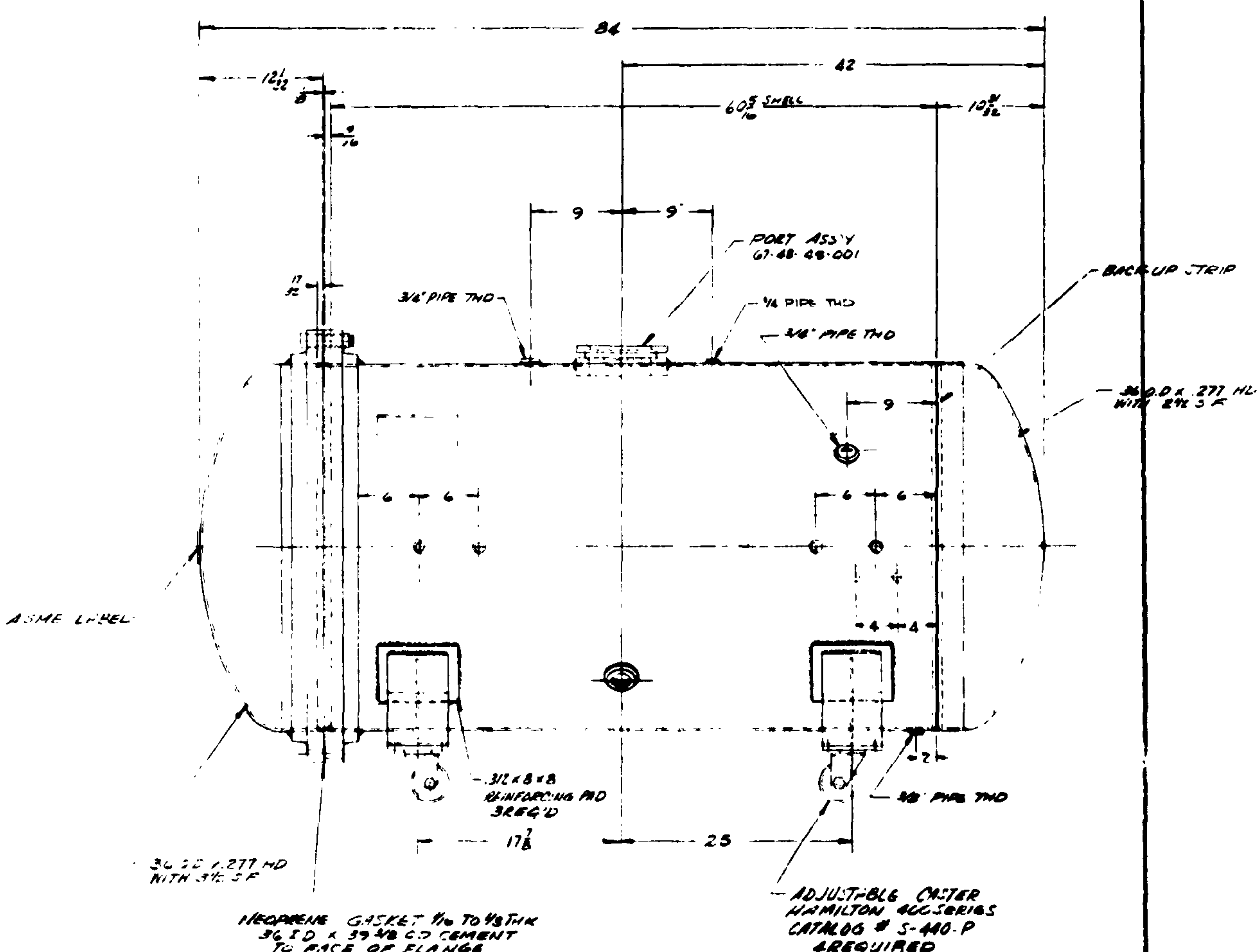
(1) $O_2 + 2H^+ + 2e \longrightarrow H_2O_2$ then $H_2O_2 + 2H^+ + 2e \longrightarrow 2H_2O$

In Alkaline Media

(2) $O_2 + 2H_2O + 2e \longrightarrow H_2O_2 + 2OH^-$ then $H_2O_2 + 2e \longrightarrow 2OH^-$

Several large versions (1cm. overall diameter) have been constructed and evaluated. A transistorized bridge current measuring instrument has been constructed which is similar to that described by Katz and Gagnon.[1]

1. Katz, L., and E. D. Gagnon, "Some Techniques in Polarography", IRE Transactions in Bio Medical Electronics, BME 8, 2 April 1961, (117-121).



84
42
SHELL
9
9
PORT ASS'Y
3/4" PIPE THD
1/4 PIPE THD
3/4" PIPE THD
BACK UP STRIP
9
6
6
6
6
4
4
2
ASME LABEL
REINFORCING PAD
3 REQ'D
25
PIPE THD
NEOPRENE GASKET
TO FACE OF FLANGE
ADJUSTABLE CASTER
HAMILTON 400 SERIES
CATALOG # S-440-P
4 REQUIRED
SUPPLIED BY A.E.C.

FIGURE 1

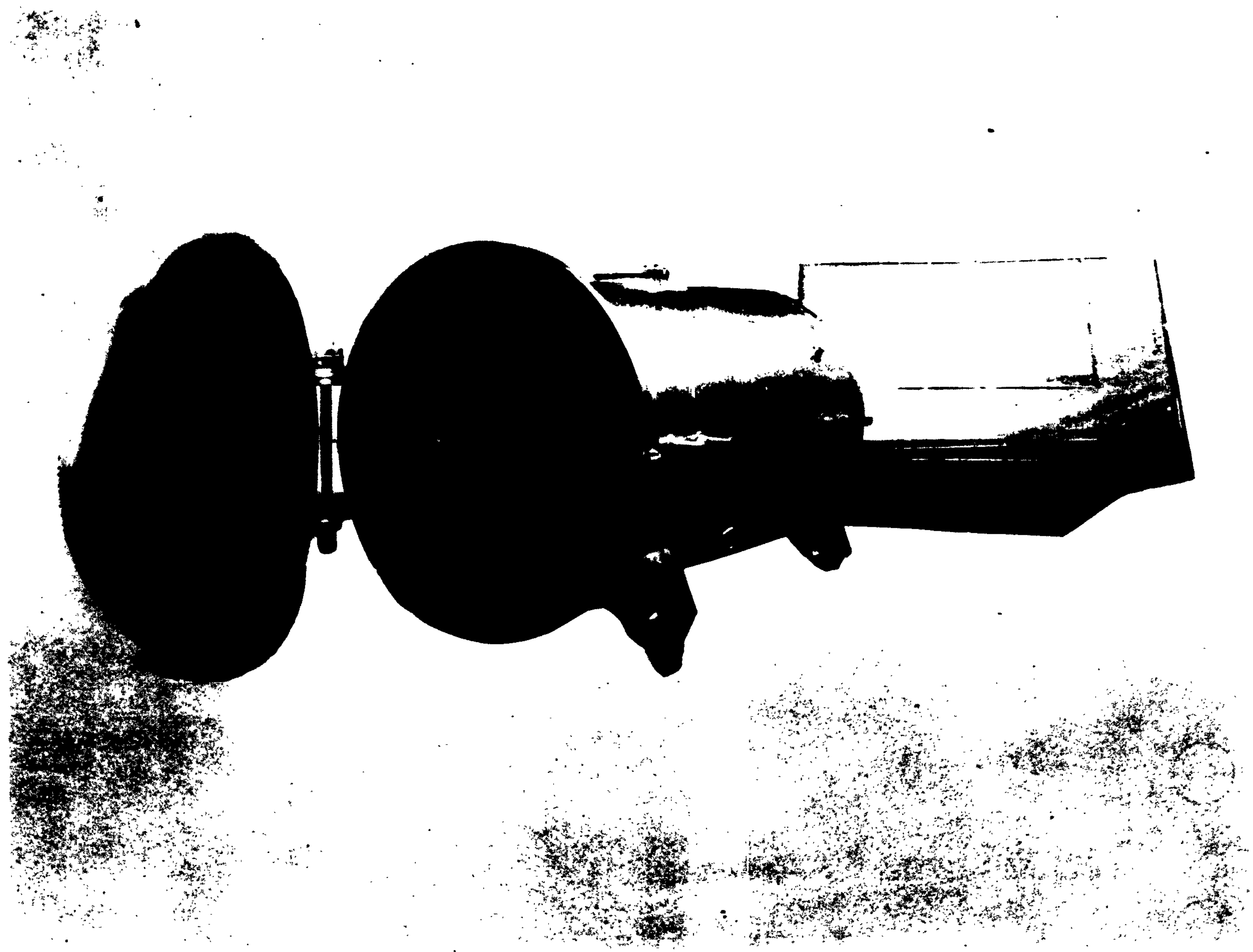


Figure 2.