AD NUMBER
ADA952954
CLASSIFICATION CHANGES
TO: **UNCLASSIFIED**
FROM: **RESTRICTED**
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 05 JAN 1948. Other requests shall be referred to Office of Naval Research, Arlington, VA 22203.**
AUTHORITY
E.O. 10501 dtd 5 Nov 1953; ONR ltr dtd 13 May 1970

AD-A952 954

BULLETIN OF THE
INSTRUMENTATION
PANEL

UNANNOUNCED

RESTRICTED

PROJECT SQUID

NUMBER 1

DTIC
DEC 7 1983
H

UNITED STATES NAVY
PRINCETON UNIVERSITY

UNANNOUNCED

Project SQUID is a program of fundamental research on liquid rocket and pulse jet propulsion for the Bureau of Aeronautics and the Office of Naval Research of the Navy Department.

This Bulletin of Project SQUID is published to provide practical information regarding techniques and instrumentation in the field of jet and rocket propulsion.

Papers are contributed by scientists and engineers, working in this field at laboratories throughout the country. The Bulletin will serve as a medium of exchange for these workers in order to expedite progress in the field of propulsion.

Address all correspondence and contributions to: Editor, Engineering Research Associates, Inc., 507 - 18th Street, South, Arlington, Virginia.

BULLETIN OF THE INSTRUMENTATION PANEL

PROJECT SQUID

Number 1

5 January 1948

ATI 72???
ATI-35652
ATI-15967

Prepared for Princeton University by

Engineering Research Associates, Inc.
Washington, D.C.

under Navy Contract No. N6ori-105 Task III
under a subcontract from Princeton University

TABLE OF CONTENTS

FOREWORD

Few satisfactory solutions have been found for some of the problems of instrumentation in the field of jet propulsion. Since the subject of instrumentation in this specialized field has received little attention in the regular scientific journals, the Instrumentation Panel of Project SQUID is sponsoring this Bulletin. It will be issued as often as sufficient material is available.

It is expected that contributions will be made by research scientists and engineers who are working on experimental problems in jet propulsion at laboratories throughout the country. These papers will cover new developments in instrumentation, particularly devices and methods for measuring the physical and chemical quantities encountered. The Bulletin will also contain brief descriptions of ingenious solutions to specific problems which have helped investigators and which may be useful to other workers. To keep the information current and make it available as early as possible, the descriptions may refer to instruments in course of development but not yet completed. This should assist others in avoiding repetition of progress that may be otherwise unknown to them.

Through the Bulletin on Instrumentation it is hoped that a closer association will be effected between groups working on similar problems. The aim is also to help resolve special difficulties by the establishment of a medium through which workers may exchange ideas affecting their problems.

- - - -

We are grateful to Mr. G. Rudinger, Temporary Chairman of the Instrumentation Panel of Project SQUID for assembling part of the material for this first Bulletin. -- The Editors

ELECTRONIC CHRONOSCOPE FOR MEASUREMENT OF FLAME SPEEDS

By

Hartwell F. Calcote
Department of Chemistry
Princeton University
Princeton, N.J.

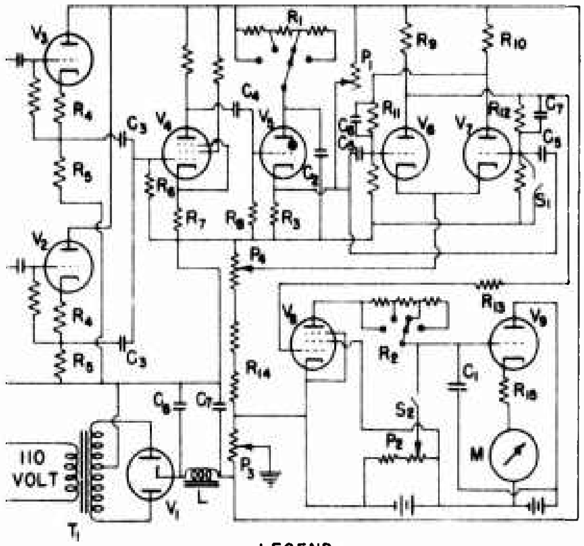
A specially designed electronic chronoscope has been used for the measurement of flame speeds. The chronoscope was calibrated by means of a one-shot multivibrator against an electric stop watch and an audio-oscillator. Flame speeds of various gas mixtures were measured by utilizing the flame conductivity.

-

An electronic chronoscope has been designed and constructed with eleven available ranges. The full scale reading varies from 4×10^{-3} seconds to 14 seconds. The instrument has been calibrated against the 60 cycle line and an audio-oscillator by means of a one-shot multivibrator, which is described later.

By utilizing the flame conductivity, flame speeds have been measured from 26 cm. per sec. to 5700 cm. per sec., corresponding to time intervals of 0.76 seconds to 3.6×10^{-3} sec. respectively.

As the flame passes a given point in the reaction tube, a condenser is started discharging through a resistance, and the discharging is stopped when the flame passes a second point. The charge on the condenser is then indicated by an electrometer voltmeter. The instrument was previously calibrated by the introduction of two pulses separated by a known interval of time. The pulses used to start and stop the discharge in an actual determination might be obtained from the flame luminosity by using photo-cells, from the flame conductivity by introducing a probe into the tube, or from the flame temperature by allowing it to melt fine wires. The flame conductivity method has been used with this instrument.



LEGEND

L_1	Choke, 10 Henries 475 Ohms; Thordarson T-13C27.
T_1	Power Transformer, 580 Volts CT 50 ma., 5 Volts At 3 Amps., 6.3 Volts At 2 Amps. CT; Thordarson T-13R11.
V_1	6X5 Vacuum Rectifier Tube.
V_2, V_3, V_6, V_7	6SN7 Double Triode.
V_4, V_8	6SJ7 Pentode Amplifier.
V_5	884 Thyratron.
V_9	6J5 Triode.
R_1	Bank Of Resistances Mounted On 10 Position Selector Switch R = 0.02 - 25 Megohms.
R_2	Bank Of Resistances Mounted On 11 Position Selector Switch R = 0.001 - 25 Megohms.
S_1, S_2	Momentary Push-Button Switch.
C_1	3 G.E. Pyranol Capacitors, 1 Microfarad Each, 500 Volts D.C.
M	D.C. Microammeter, Full Scale 200 Microamperes.

FIGURE 1 SIMPLIFIED CHRONOSCOPE CIRCUIT

A simplified circuit diagram is shown in Figure 1. V_1 is the rectifier tube connected in a conventional full wave rectifier circuit. The A.C. is supplied from the 110 volt line through the transformer T_1.

The condensers C_6 and C_7, and the choke L form the filter circuit. The low side of the output is not grounded as usual, for reasons which will be discussed later. V_2 and V_3 are the two halves of a 6SN7 double triode, connected in a conventional cathode follower circuit which has a high input impedance to match the high impedance of the flame to the circuit. Cathode bias is furnished by the voltage drop across R_4. The voltage gain of this stage is less than one. The voltage drop across R_5 is coupled by condenser C_3 to the grid of V_4, a 6SJ7 pentode, through a common grid resistance, R_6. V_4 is connected in a conventional voltage amplifier circuit. Cathode bias is furnished by the D.C. drop across R_7. The output is taken from the plate of V_4 and coupled through an RC coupling circuit R_8C_4 to the grid of V_5, an 884 thyratron.

The thyratron is biased just below the firing potential by the potentiometer P_1 and the cathode resistance R_3 so that a small positive potential on the grid will cause the tube to breakdown, discharging C_2 through the cathode resistance R_3. Since the discharge time of C_2 through V_3 is smaller than the charging time through R_1, the plate of V_5 will very quickly drop to the cut-off point, and the tube will cease to conduct. This action will give a sharp pulse across the cathode resistance R_3, which is coupled to the grids of the succeeding tubes, V_6 and V_7, through the two condensers C_5. The sensitivity of V_5 may be controlled by varying the bias with P_1. Discriminating action between pulses on the grid of V_5, which are very close together, is obtained by controlling the charging time of C_2 with the variable resistance R_1, so that the plate voltage is insufficient to permit the tube to fire when the unwanted pulse arrives at the grid of V_5.

V_6 and V_7 are connected in an Eccles Jordan trigger circuit. The bias is obtained from the potentiometer P_4, which is part of the potential divider across the power supply. The normal condition of the circuit is with V_6 "on" and V_7 "off". This condition is assured by closing the momentary push button switch S_1, which momentarily cuts V_7 "off", assuming it to have been previously "on". Since the current through R_{10} is decreased, the decrease in current through V_7 causes its plate voltage to increase. This voltage increase is coupled to the grid of V_6 by C_6 and R_{11}, so that V_6 is made to conduct giving a voltage drop across R_9. This drop is coupled to the grid of V_7 through C_7 and R_{12}, thus helping to drive the grid of V_7 beyond cut-off. When a positive pulse from R_3 is coupled to the grids of V_6 and V_7 in the normal condition, the triggering action, as above, throws V_6 "off" and V_7 "on". This switching action takes place almost instantaneously. The next pulse triggers the circuit back to its normal position with V_6 "on" and V_7 "off".

The dircuit values are so chosen that the voltage drop across R_9 is sufficient in the normal "on" condition of V_6 to maintain the grid of V_8, the electronic switch, below cut-off so that it does not allow current to pass. When V_6 is "cut-off" its plate voltage rises so that V_8 is turned "on". The resistance R_{13} is necessary to limit the grid current, since the grid of V_8 would be driven positive by the plate voltage of V_6. With the next pulse turning V_6 "on" the grid of V_8 is again driven beyond cut-off and the tube ceases to conduct.

When V_8 is keyed "on" the condenser C_1 is allowed to discharge through the variable resistance R_2, the time of discharge being determined by the time V_8 is keyed "on". The amount that the condenser can discharge in this time is determined by the resistance R_2 in the circuit, which by its variability makes possible several ranges. The original charge on the condenser is determined by closing S_2 which connects the floating side of the condenser to the potential divider P_2.

V_9 in the voltmeter circuit is an ordinary triode. It is connected to operate as an electrometer tube in lieu of a regular electrometer tube. Crid current is prevented from flowing by several precautions: 1) the plate voltage is kept low, 2) the heater voltage is greatly reduced, from a normal 6.3 volts to 3.7 volts, 3) the heater is made 6 volts positive relative to the cathode, 4) the grid of the tube is always operated far below the cathode potential by means of P_2 and the large amount of negative feedback introduced by R_{15} and the resistance of the microammeter M in the cathode circuit.

In addition, to prevent the condenser C_1 from changing its charge, V_8, V_9, and the RC timing circuit are mounted on bakelite. However, bakelite has an appreciable surface conductivity so that if the circuit were grounded in the conventional manner, placing the condenser voltage more than 100 volts above the chassis voltage would discharge the condenser C_1 to the chassis, causing the meter reading to decay.

To avoid this and any other charge accumulation or loss by the condenser, the condenser leakage is balanced by making the chassis potential variable with respect to the negative side of the power supply. It is thus possible by setting P_3 once or twice a day to avoid all meter decay. In order to prevent stray electrons from striking the plate of V_8 and charging the condenser C_1, the operating voltages of V_8 are kept low and the heater operated at 5 volts insread of the normal 6.3 volts.

The instrument is allowed to warm up for approximately ten minutes. Preliminary to taking measurements the instrument is adjusted in the following way: With S_2 closed, adjust P_2 until the meter reads full scale. S_2 is then opened and P_3 is adjusted for zero meter drift. If the meter decays rapidly, S_2 should be closed and S_1 momentarily pressed. S_2 may now be opened again and the P_3 adjustment made. If the meter persists in decaying rapidly or spontaneously decays, the sensitivity should be decreased by adjusting P_1. The sensitivity may be set to a maximum by setting the range selector switch R_2 and turning P_1 slowly until the meter starts to decay in jumps. P_1 should then be turned slightly in the opposite direction until the jumping ceases. It was seldom necessary to operate at full sensitivity. To return the meter to full scale during this adjustment close S_2 and momentarily close S_1. The position of the pulse discriminator switch R_1 will vary with the triggering pulse form and the time interval to be measured as well as with the sensitivity adjustment. Therefore, it must be determined by experience. R_1 will be higher for longer time intervals and vice versa. S_2 is always left closed when not actually making a measurement.

To determine a time interval, momentarily close S_1, then open S_2 and carry out the operation to be measured. Record meter reading and obtain the time interval from a calibration chart. Promptly close S_2 again. The meter is now ready for the determination of another time interval.

As an improvement it is suggested that the circuits preceding the Eccles Jordan trigger circuit be replaced by an individual amplifier and pulse generating circuit for each pulse, i.e., the "starting pulse" and the "stopping pulse". These circuits should be of such a design that each will pass only one pulse until it is manually returned to an unstable condition.

This could be achieved by duplicating the 6SJ7 amplifier and by adding another 884 thyratron tube, using a sufficiently small plate resistance for each tube so that it will continue to fire until the plate circuit is opened.

The use of two gas tetrodes (2050 or 2051) with the elimination of the 6SJ7 amplifier, and possible elimination of the cathode followers should also be considered.

CALIBRATION OF CHRONOSCOPE

The chronoscope must be calibrated before use. Three methods have been employed, all checking to within two per cent.

The two higher range scales, 7 and 14 sec. full scale readings, were calibrated by means of an electric stop watch readable to 0.1 sec. Its time is based upon the 60 cycle line since its operation depends upon a synchronous motor. A six inch piece of bare wire was connected to one input lead of the chronoscope to act as an antenna which picked up the pulses when the stop watch was started or stopped.

By using these two calibrated scales of the chronoscope as a secondary standard, the various scales of the one-shot multivibrator shown in Figure 2 can be calibrated. The two output leads of the multivibrator are connected to the input leads of the chronoscope and the momentary push button switch Sw is pushed a known number of times. Each time the switch Sw is closed one pulse appears at each of the two outlets, the two pulses being separated by a given time interval depending upon the setting of R and C. The calibration time for the particular multivibrator scale is then determined by dividing the chronoscope time by the number of times the multivibrator push button is closed. When the multivibrator time interval is known this method is used in reverse to calibrate the chronoscope.

The multivibrator was also calibrated against a standard oscillator.

This was done by feeding pulses from the oscillator into the multivibrator and viewing its output pulses on a calibrated cathode ray oscillograph. Since the oscillator generates a sine wave, it was necessary first to pass the oscillator output through a square wave generator and then through a differentiating circuit before feeding it to the multivibrator. The sweep frequency of the cathode ray oscillograph was set to one or two times the square wave generator frequency, and then the pulse output of the multivibrator applied to the vertical plates of the oscillograph. The distance between the two pulses on the screen was then a measure of the time delay due to the multivibrator and consequently, a calibration of the multivibrator.

A third method of calibration suggested by Mr. W.R. Busing has also been employed. This utilizes pulses generated by the sweep frequency of a cathode ray oscilloscope to trigger the chronoscope. The number of pulses is controlled by a momentary push button switch and are easily counted by using a set of head phones connected in the circuit. An even number of pulses is used to trigger the circuit "on" and "off" a known number of times. The time between pulses, i.e., the sweep frequency, is determined by observing the 60 cycle power line voltage on the oscilloscope screen.

DESCRIPTION OF ONE SHOT MULTIVIBRATOR USED FOR TIMING STANDARD

A cathode coupled one-shot multivibrator or flip-flop circuit was constructed for use in calibrating the chronoscope as described above. The circuit shown in Figure 2 utilizes one double triode 6SN7 and two 6H6 double diode tubes, the power being obtained from an external power supply.

The input diode limiting circuit permits only positive pulses to reach the grid of V_1. The two output diode limiting circuits, in conjunction with the two RC differentiating circuits (100,000 ohms and .0001 μf), select the proper negative pulses for the output.

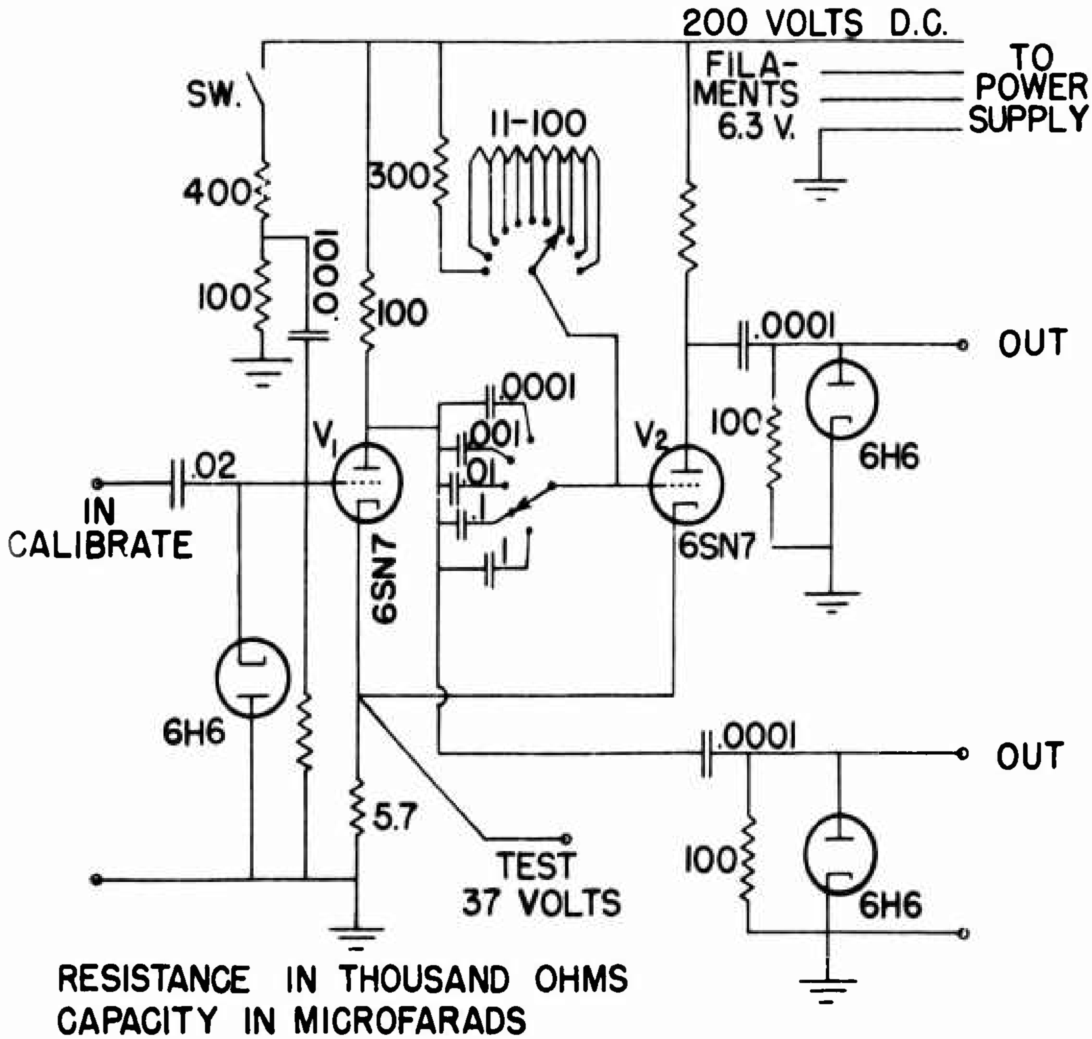


FIGURE 2 ONE SHOT MULTIVIBRATOR FOR TIMING STANDARD

The circuit values are chosen so that the plate current of V_2, when it is conducting, causes sufficient voltage drop in the V_1 - V_2 cathode resistance to keep V_1 cut-off. This is the stable condition of operation. The triggering pulse obtained either from the "input" external oscillator or by closing switch Sw is applied to the grid of V_1 turning it "on". The instantaneous drop in plate voltage of V_1 is then coupled through the variable coupling condenser C to the grid of V_2 cutting it "off". This plate drop of V_1 is also used to obtain the initial output pulse. Since V_2 is "cut-off", only the current from V_2 flows in the cathode resistance. Therefore, V_1 conducts and V_2 remains "off" until the condenser C has discharged sufficiently toward the 200 volt plate supply through the variable resistance R to allow the grid voltage of V_2 to come up to cut-off. When V_2 again starts to conduct, the operation instantly switches back to the stable condition with V_1 "cut-off" and V_2 conducting. When this action takes place the second output pulse is obtained from the decrease in plate voltage of V_2. The time between the initiating pulse and the final pulse is determined by the value of RC.

MEASUREMENT OF FLAME SPEEDS

By utilizing the flame conductivity the measurement of flame speed has been carried out at pressures from atmospheric down to 35 mm Hg. This was done for hydrocarbon-air and hydrocarbon-oxygen mixtures.

A detailed diagram of the reaction tube with the necessary circuits for hot wire ignition and triggering of the chronoscope is shown in Figure 3. Co-axial cable is used for the chronoscope leads with the outer conductor grounded. The power supply leads to the platinum plate electrodes and to the chronoscope are shielded wire; the variac leads to the 110 volt supply and to the hot wire are a shielded twisted pair. Sw is a momentarily-closed push button switch used to close the ignition wire circuit and ignite the charge.

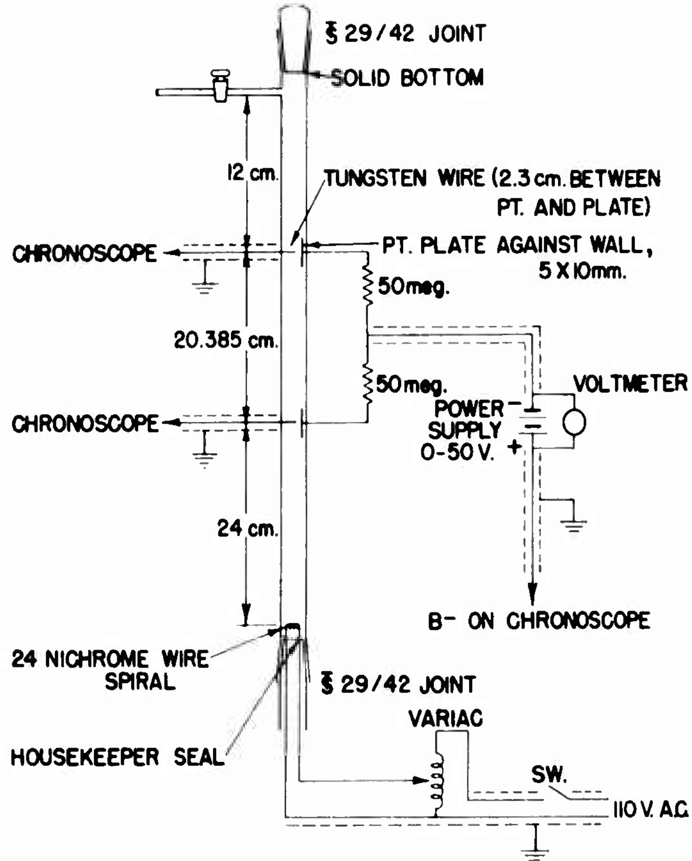


FIGURE 3 REACTION TUBE AND AUXILIARY CIRCUITS

BIBLIOGRAPHY

1. Hartwell F. Calcote, Electronic Chronoscope for Measurement of Flame Speeds. Technical Paper No. 23, Feb. 1, 1947 (Restricted). Dept. of Chemistry, Princeton University.

2. For a general discussion of the circuits involved see such books as:

   Reich, J.H. Theory and Application of Electron Tubes (2nd edition only) McGraw-Hill Book Co. (1944).

   Muller, Garman and Droz, Experimental Electronics, Prentice-Hall, Inc. (1942).

3. For a discussion of Electrometer tubes and circuit considerations, with literature references see:

   Strong, Procedures in Experimental Physics, Prentice-Hall, Inc. (1941).

THE HIGH FREQUENCY OSCILLATOR AS A FLAME DETECTOR

By

Hartwell F. Calcote
Department of Chemistry
Princeton University
Princeton, N.J.

-

A tuned plate-tuned grid oscillator can be used for detecting ionization in flames. Since this application of an oscillator depends on an increase in the dissipation of energy in the tank coil, the overall Q of the circuit must be as high as possible.

-

This paper describes a method for detecting ionization in flames by utilizing the loading characteristics of a high frequency oscillator. The oscillator tank coil is constructed around a combustion tube made of electrically insulating material. As the flame passes through the tank coil, the absorption of energy due to ion formation and increased eddy-current losses, causes an increase in the plate current of the oscillator. This increase in plate current is used to trigger an electronic chronoscope. In applying this technique to the measurement of flame speeds, two such oscillators are used to trigger a chronoscope "on" and then "off". Two distinct advantages of the method are that (1) direct measurement of flame speeds can be made without the introduction of electrodes or screen wires into the tube, and (2) the point in the tube at which the measurement is made can be varied at will by simply moving the coil from one point in the tube to another.

This application of an oscillator depends on the loading of the circuit, i.e., on an increase in the dissipation of energy in the tank coil.

Therefore, it is important that (1) the normal circuit losses be negligible and (2) that the circuit be sensitive to any change in the Q of the tank coil. Both of these requirements demand a high Q circuit. In addition the second requirement suggests that the inductance, L, in the tank circuit should be large compared to the capacity, C.

High frequencies are necessary because eddy-current losses are proportional to the square of the frequency. However, as the frequency is increased, the effective Q of the coil is decreased due to the skin effect, so that it is necessary to obtain a balance between the two effects.

The particular oscillator used was a tuned plate-tuned grid oscillator, with the plate tank coil consisting of three turns of bare No. 12 copper wire wound close-spaced around the combustion tube (28 mm. pyrex). In order to obtain the maximum L/C ratio, no additional capacity was placed in parallel with this coil. Instead the stray capacity and plate to cathode capacity of the tube was utilized. When a 6J5 triode was used, the resonant frequency was approximately 65 megacycles; with a 955 acorn tube, the resonont frequency was 100 megacycles. These frequencies were measured by the Lecher wire method.

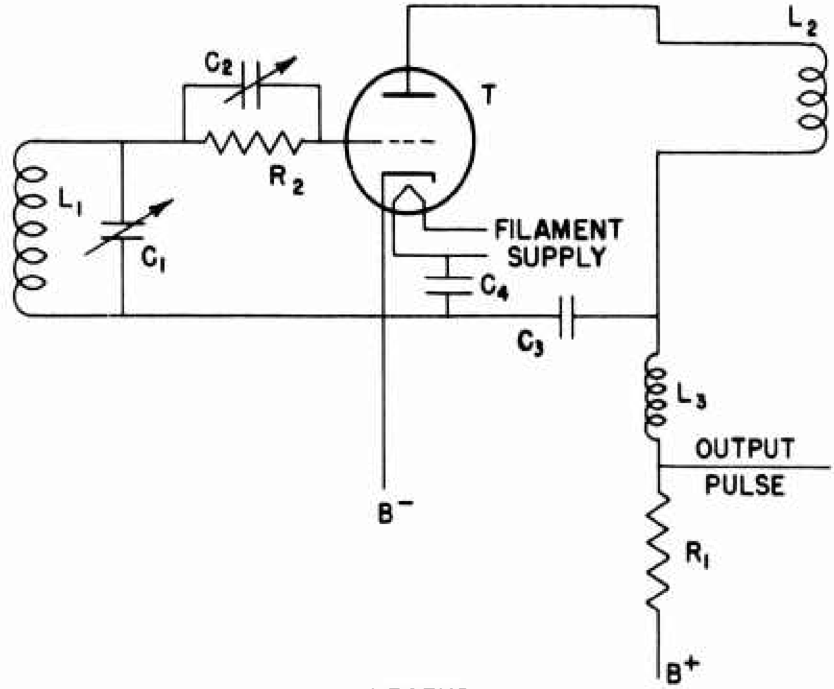
To avoid any unnecessary losses in the lead from the coil to the oscillator, the coil was mounted directly to the circuit. The circuit (Figure 1) was assembled on a piece of Lucite 8 x 11 cm. and a steel rod perpendicular to the plane of the Lucite. The rod was then mounted by means of a regular clamp holder to a long steel rod running parallel to the pyrex combustion tube. This arrangement permitted the measurement of flame speeds over any section of the combustion tube by merely moving the coil and oscillator along the tube.

Tuning of the oscillator was achieved by placing a vacuum tube volt meter across R, and tuning C, for a maximum voltage, i.e., a minimum current. C_2, which controls the feedback, was then adjusted until the circuit went out of oscillation easily by varying C_2 or by holding a hand in the vicinity of L_2.

The circuit values are not critical although maximum sensitivity will be obtained when R_1 is as large as feasible. In order to obtain a high Q for the overall circuit, C_1 should be large compared to L_1, and R_2 should be large [(2)]. The value of R_2 is usually limited by the fact that when it becomes excessively large the time constant of R_2C_2 will cause the grid bias to build up until the tube blocks, i.e., is "cut-off." The circuit then ceases to oscillate until the condenser C_2 has discharged sufficiently to permit the tube to again conduct and oscillations to take place. The cycle is then repeated giving bursts of oscillations, a phenomenon which is commonly called "motor-boating". In most oscillators this cannot be tolerated. But in this application, motor-boating at a frequency sufficiently high, so that it does not pass appreciably by the choke coil and give a trigger pulse to the chronoscope, is not objectionable. In fact it has been found to increase the sensitivity considerably.

With a B supply of 400 volts, the d.c. voltage at the point "output pulse" is 35, and a voltage pulse of approximately 6 is obtained. When motorboating is allowed, the d.c. voltage is 80 and the pulse voltage is approximately 15.

Flame speeds were measured for various fuel mixtures at different pressures, and equally satisfactory results were obtained in all cases.



LEGEND

T............955 Acorn Tube.

C_1, C_2......25 mmf. Tuning Condensers, Cardwell ZR-25-AS.

C_3, C_4.....500 mmf. Midget Mica Condensers.

L_1............Three Turns No. 12 Copper Wire, 1/2 Inch In Diameter And 3/4 Inches Long.

L_2..........Three Turns No. 12 Copper Wire Wound Close Spaced Around The Reaction Tube.

L_3..........2.5 mh. R. F. Choke.

R_1..........1 Megohm Resistance.

R_2...........0.5 Megohm Resistance.

The Filament And Plate Voltages Were Obtained From An Electronically Regulated Power Supply.

OSCILLATOR CIRCUIT

REFERENCES

(1) Hartwell F. Calcote, Dept. of Chemistry, Princeton University, The High Frequency Oscillator as a Flame Detector, Technical Paper No. 26, March 25, 1947.

(2) Radio Amateur's Handbook, American Radio Relay League, Inc., West Hartford, Connecticut. Published Yearly.

PHOTOGRAPHIC MEASUREMENT OF FLAME VELOCITY IN TUBES

By

Marjorie W. Evans, Milton Scheer and Louis Schoen
Research Division
New York University
New York, N. Y.

The apparent velocity of flames in tubes is being measured photographically. Velocities have been measured for mixtures of hydrocarbon and air in large pyrex tubes. Ignition is accomplished by means of a spark coil.

Progress of the flame is recorded by a General Radio high speed streak camera, type 651 A-E, with variable speed. The camera has been modified so that a continuous strip about a foot in length can be used in place of reels. Timing was accomplished by reflecting light from a stroboscopic tachometer on to the film during the experiment. Eastman Linegraph film was used.

Since the phenomenon occurs in a very short time it is necessary to properly synchronize timing of camera speed, ignition, and tripping of the shutter. This has been accomplished by a system of electrical relays.

In order to expedite interpretation, the photographs were enlarged, simultaneously superimposing a rectangular coordinate system.

SCHLIEREN METHODS FOR OBSERVING FLOW IN FLAME TUBES

By

Marjorie W. Evans, Milton Scheer and Louis Schoen
Research Division
New York University
New York, N. Y.

Density gradients between a hydrocarbon-air mixture and air permit Schlieren photography of flow behavior at the open end of a half-open flame tube as the flame moves toward the open end.

A coincidence system employing a 16-inch spherical mirror of 45 inches focal lingth with light source and knife edge at the center of curvature has been used in this connection. The light source was a Western Union Type C 100 Concentrated Arc Zirconium Lamp.

This system has the advantage of simplicity and sensitivity. Its chief disadvantage is the divergence of rays as they pass through the subject, and the fact that the rays on the second passage may pass through a different part of the subject than on their first passage.

Examination of flow structure in the tube during passage of the flame is being attempted. Temperature gradients within the gas may provide density gradients which can be observed by Schlieren methods. A flame tube with flat sides is used in this connection. The Schlieren method employed is a double mirror system using two 16-3/4 inch parabolic mirrors of 60-inch focal length. This system has the advantage that parallel rays pass through the subject. It is less sensitive than the single mirror coincidence system.

Two movie cameras have been used in recording the flow pattern. The first is an Eastman III high speed camera running at a speed of 1000 frames per second. The second is a Fastax 16-mm camera running at about 3500 frames per second. These exposure times are not sufficiently short to provide sharp clear pictures, but general details of flow are apparent.

AN FM CONDENSER TYPE PRESSURE GAGE

By

J.H. Hett and R. King, Jr.
Research Division
New York University
New York, N. Y.

This gage system was designed to measure oscillating gas pressures at the wall of the pulse jet. It is necessary that the system be relatively free of temperature drift, free of microphonics, and for purpose of analysis, have a high frequency response. Also the signal must be transmitted through at least 50 feet of cable.

The design of the gage head is shown in Figure 1. In use on the pulse jet, the gage is always used behind the water cooling chamber shown in Figure 2.

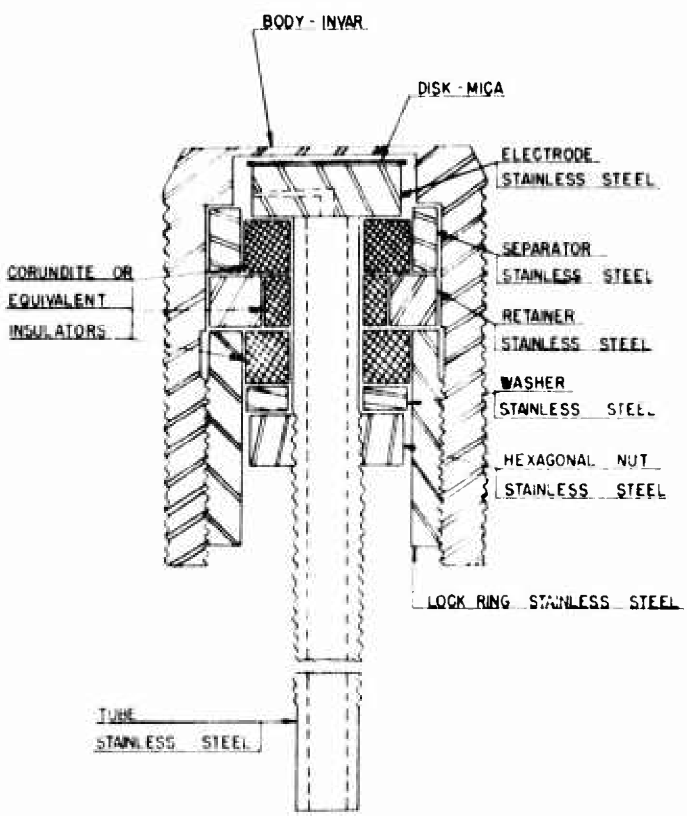


FIGURE 1

The effective diaphragm of the gage is 1/2 inch in diameter, and .020 inch thick. It is made of invar integrally with the case and is polished on both sides. The spacing is .001 inch. In the space there is a mica sheet .0003 inch thick cemented to the fixed electrode. The natural frequency of the diaphragm, which sets the upper frequency limit of the entire system, is 24.75 K.C. This frequency was determined by dropping a light steel ball on the diaphragm and recording the response on CR-Tube, using a continuous strip high speed 35 mm camera. Timing marks on the film were provided by a strobotac.

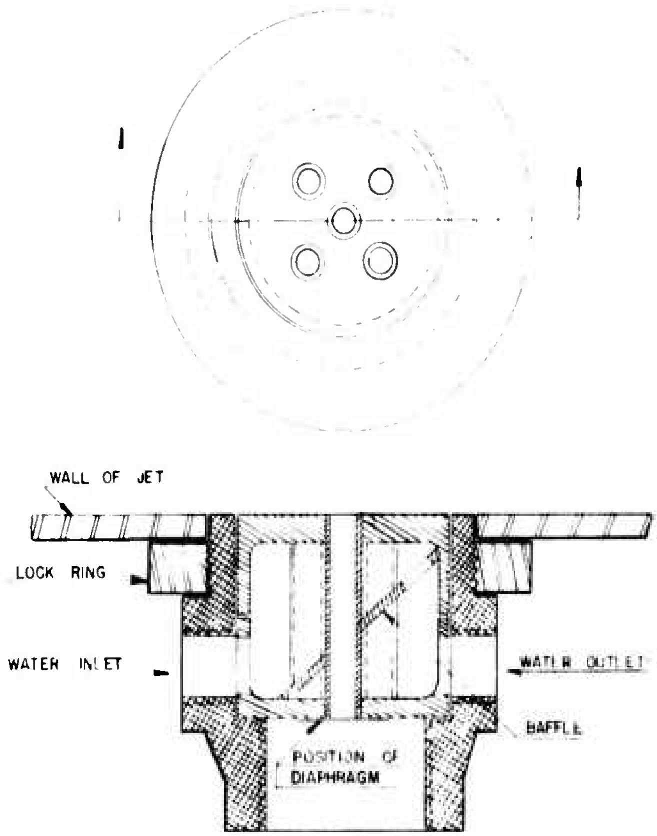


FIGURE 2

The cooling chamber has five open tubes one inch long by .123 inch internal diameter. The water pressure used is 85 psi at temperature 60°F.

The gage diaphragm is mounted within .005 inch of the back of the cooling chamber. Experiments on a Dynajet show that all five holes will pass at least 7 K.C.; three holes about 3 K.C.; and one hole 2 K.C. Experiments are being conducted with the nine-hole chamber. The present cooling chamber stabilizes the temperature at the back surface of the operating diaphragm at 100°F. after six seconds of Dynajet operation. The receiver circuit is actually tuned with this operating temperature.

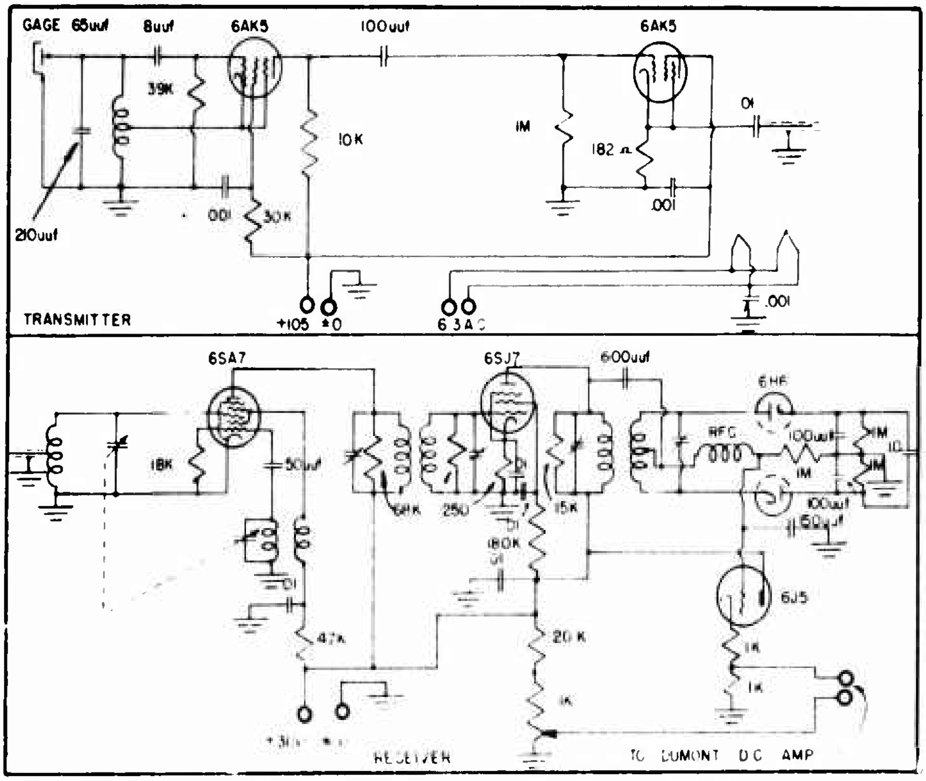


FIGURE 3

The circuit diagram is given in Figure 3; block diagram in Figure 3A. Mounted directly back of the gage is a transmitter which consists of a Hartley oscillator electron coupled to a cathode follower output tube. Both tubes are 6 AK 5 miniatures. The output impedance is about 50 ohms. The carrier frequency is 2 m.c. The output is fed through a coax cable to the receiver, which consists of a 6SA7 pentagrid converter tube, producing intermediate frequency of 450 K.C. A 6SJ7 amplifier is coupled to the converter and feeds the discriminator transformer. The input transformer is double tuned and broad banded by shunting with a resistor. The discriminator transformer drives the ratio detector used here, because it is relatively insensitive to amplitude variations. It also supplies a DC voltage proportional to the IF signal which might be used as an automatic level control.

The DC output of the ratio detector feeds the cathode follower and then through the connecting cable to a modified DuMont 208 oscilloscope having DC response. No gain control has been provided, and thus far has proved unnecessary. The gain has been adjusted so that the full linear output from the discriminator, about 3 volts covers 4 inches on CR Tube screen.

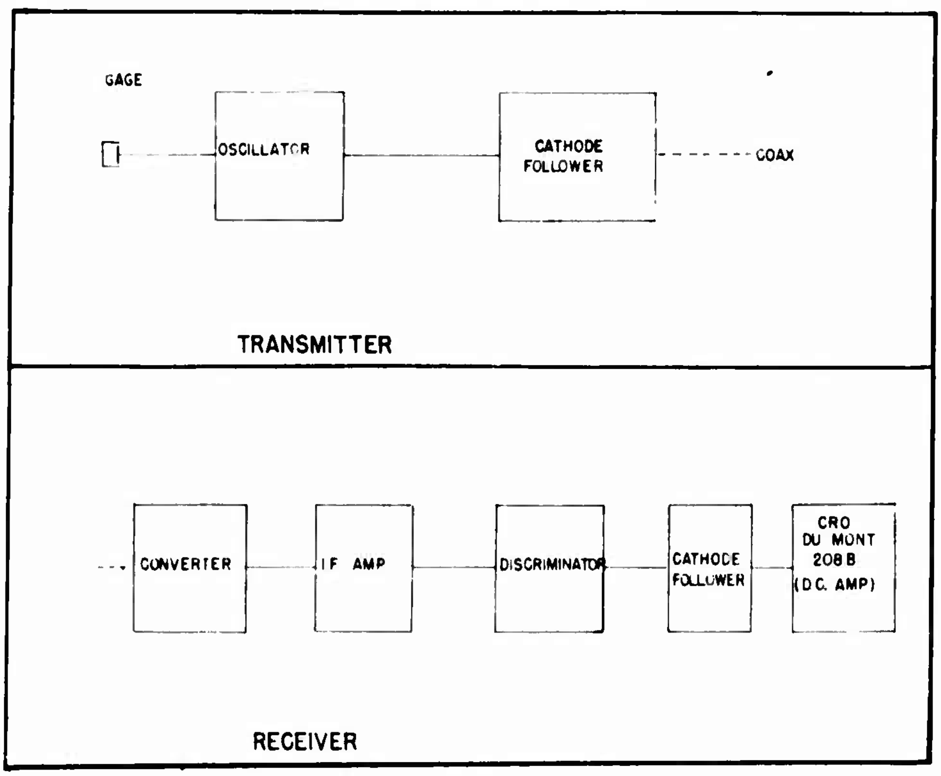


Figure 3A

To measure the pressures in a Dynajet which range from 20 to 25 pounds peak to peak, it was necessary to reduce sensitivity of the gage with a shunted capacity in addition to the stray capacity of the gage head which is about 65 mmf. The diaphragm itself provides a capacity change of 1 mmf for 10 psi applied pressure. The transmitter is practically non-microphonic, although no potting wax or plastic was used.

The pressure cycle of the Dynajet is given in Figure 4. The gage response on the oscilloscope was calibrated by mounting the gage head in an air chamber and bursting a diaphragm at known pressures. Peak to peak pressures were about 20 pounds. High frequency components are over 6 KC.

Possible errors in wave shape of the cycle due to temperature fluctuations have been investigated by chopping a blow torch flame with a toothed wheel placed between the diaphragm and the flame. The flame is adjusted so that the rate of heating in the condenser diaphragm was the same as in the operating jet. No change was observable on the oscilloscope. The frequency response of the entire pressure system is limited by the diaphragm. For use in the JB-2, a heavier diaphragm will be installed, giving a natural frequency of approximately 35 K.C. The linearity of the present system has been checked and within the deflection range is better than 3 per cent.

The gage has also been used to measure pressures at the end of the flame tubes which are about 6 pounds peak to peak. For this purpose the gain has been increased by reducing the shunting capacity. The deflection used was 1 inch on the scope for 5 pounds psi.

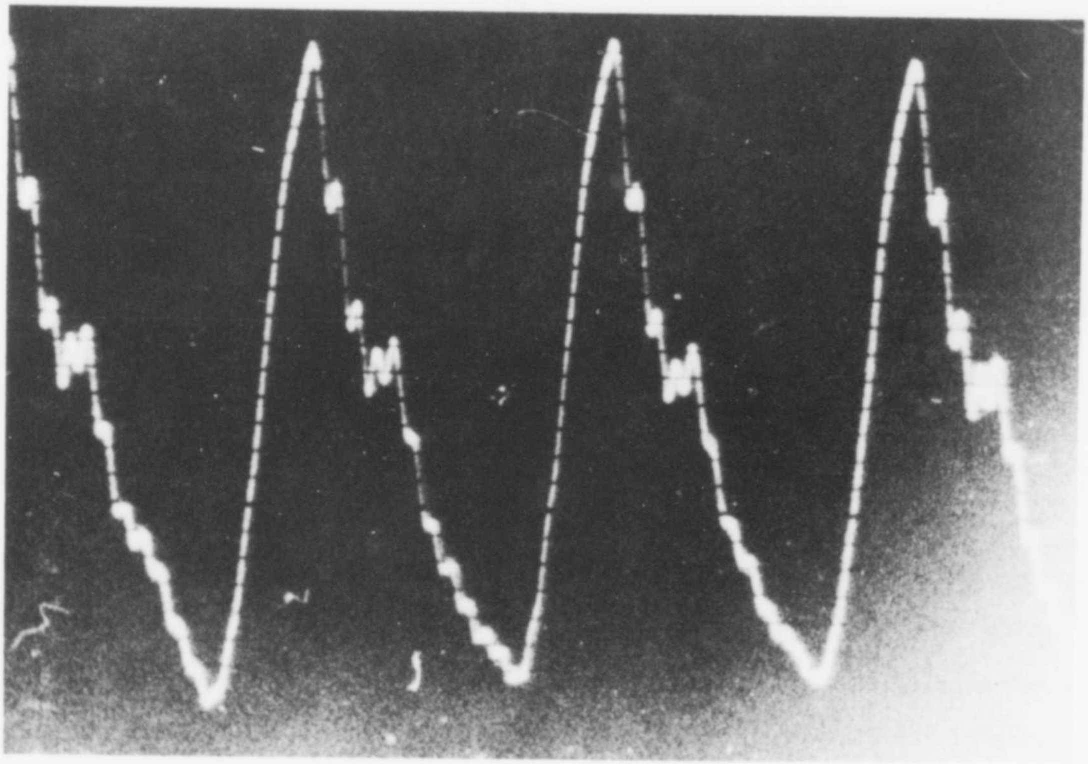


FIGURE 4

PRESSURE VS. TIME OF THE DYNAJET

Peak to peak pressure approximately 20 pounds
Period approximately 1/200 second
Taken through a five tube cooling chamber

HIGH-SPEED PHOTOGRAPHY OF FLAME PROPAGATION

By

M. Polanyi and G. Rudinger
Aerodynamics Department
Cornell Aeronautical Laboratory
Buffalo, New York

-

The combustion process of an air-gas mixture can be photographed at high speed when the luminosity of the flame is increased by coloring with sodium.

-

The combustion process in a cylindrical pyrex chamber, open at one end, was photographed with a high speed motion picture camera. A stoichiometric city air-gas mixture was used in the experiment. The light intensity of the flame was far too low to be photographed without intensification, and coloring with sodium was used in the following way:

Both ends of the combustion chamber are closed. Air is blown into it through a hole in the side, and escapes through another small hole. Before reaching the chamber, the air goes through a small box containing a fine powder of sodium carbonate. In a few seconds, an amount of powder sufficient to produce a luminous flame is blown into the chamber where the fine particles remain suspended in the air for at least one half hour. (This is ample time to finish setting up the experiment and make the exposure.) The chamber is connected to a vacuum pump, and pressure is reduced by the partial pressure of the fuel gas at the intended air/fuel ratio. The pressure in the chamber is then brought back to atmospheric by introducing city gas. Then a few minutes should be allowed for proper mixing of the gas. At least one end of the chamber must be open during combustion. Firing is accomplished by means of a spark.

A Western Electric Fastex 16 mm. camera was used. The exposures were taken on Super-XX panchromatic film with a lens aperture of f/2. 2900 frames per second was the highest speed at which pictures were taken. This corresponds to an exposure time of about 1/9000 second for each frame. In this arrangement, the luminosity of the flame was sufficient to have permitted a much further increase of film speed.

HIGH-SPEED MOTION PHOTOGRAPHY OF SCHLIEREN PATTERNS

By

G. Rudinger
Aerodynamics Department
Cornell Aeronautical Laboratory
Buffalo, New York

-

A simple optical system employing two parabolic mirrors and a carbon arc as a light source was used to photograph Schlieren patterns. The size of the image was reduced by mounting an achromatic lens in front of the camera.

-

The general experimental setup is shown in Figure 1. M_1 and M_2 are two parabolic mirrors of 12 inches diameter and 6 feet focal length. They form an image of the light source L at the position of the knife edge at K. The image of the test section S is formed at I. If a screen is placed at I, the image could then be photographed, but it would be preferable to place the film directly at I and thus utulize the whole amount of light reaching I. Increasing the distance d between S and M_2 will decrease the size of I, but even at the extreme distance possible in the room, I was still too large to be directly recorded on the film of a 16-mm high-speed motion camera. The required further reduction in size was achieved by mounting a simple achromatic lens of 6 inches focal length in front of the camera (Western Electric Fastex) after removing the camera objective of 2 inches focal length. Since only a small refraction of light rays is necessary to reduce the image to its required size, no disturbing aberrations are produced by this simple optical system.

A carbon arc operated by direct current was used as light source, and the exposures were taken on Super XX panchromatic film. This arrangement gave a satisfactory film at a rate of 3000 frames per second.

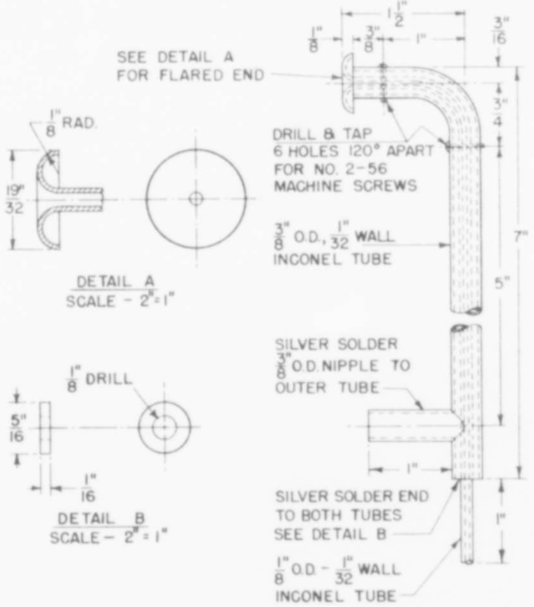
WATER COOLED TOTAL PRESSURE TUBE

by

Frank Suozzi
Aerodynamics Department
Cornell Aeronautical Laboratory
Buffalo, New York

This instrument was built to measure the total pressure of a hot gas stream of which Figure 1 shows a detailed drawing. Water is introduced through an inconel tube of 3/8 inch outside diameter and is ejected downstream by a smooth flared end at the exit. This flared end, welded to the inconel pressure tube of 1/8 inch outside diameter, is designed to read correctly at large yaw angles. Figure 2 is a photograph showing the water flowing smoothly downstream.

This instrument was tested in a gas stream of about 3000^{o}F and gave good results with a gravity water feed system. Upon removal of the tube from the hot gases, the tube was always found to be cool.


SEE DETAIL A
FOR FLARED END
1 1/2"
1/8"
3/8"
1"
3/16"
3/4"
1/8" RAD.
19/32"
DRILL & TAP
6 HOLES 120° APART
FOR NO. 2-56
MACHINE SCREWS
3/8" O.D., 1/32" WALL
INCONEL TUBE
7"
5"
DETAIL A
SCALE - 2"=1"
SILVER SOLDER
3/8" O.D. NIPPLE TO
OUTER TUBE
1/8" DRILL
5/16"
1/16"
1"
DETAIL B
SCALE - 2"=1"
SILVER SOLDER END
TO BOTH TUBES
SEE DETAIL B
1/8" O.D. - 1/32" WALL
INCONEL TUBE

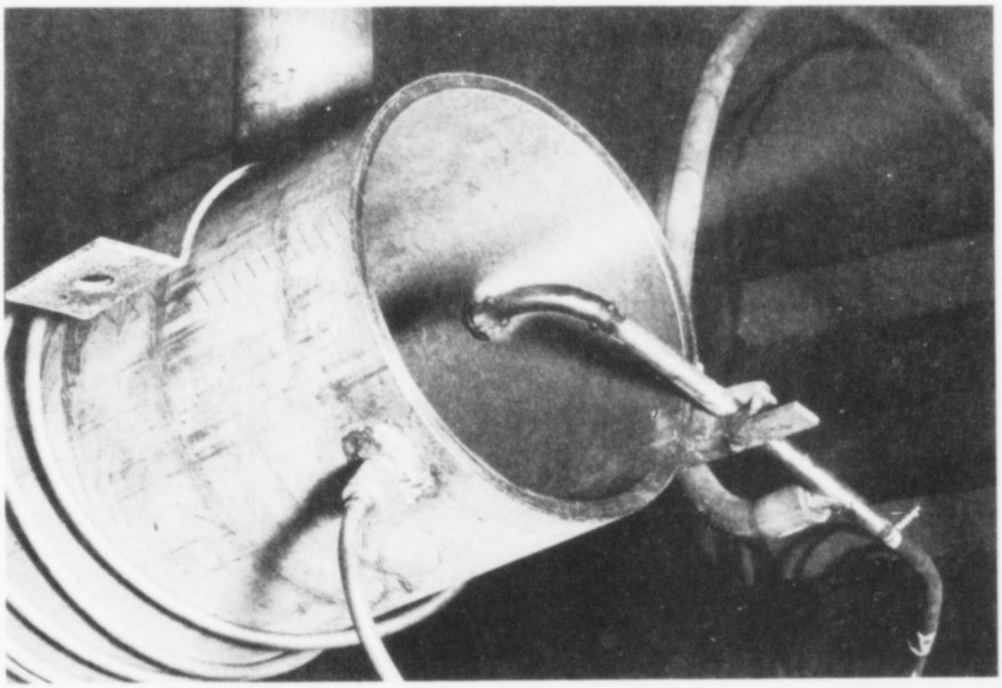


FIGURE 2

VARIABLE-REACTANCE TRANSDUCER FOR MEASUREMENT OF DISPLACEMENT

By

N. Vorie
Physics Department
Cornell Aeronautical Laboratory
Buffalo, New York

-

A variable-reactance transducer with a sensitivity to 5mV bridge unvalance for 4 V bridge input and 0.1" total core movement, has been designed for measuring displacement. The instrument is a cylindrical shape, 1-3/4" x 2-1/2". No change in sensitivity was observed after temperature and shock tests.

-

This instrument is of the variable reluctance type where the inductive reactance of coils in two arms of a bridge is varied by movable iron cores. The circuit is shown in Figure 1. Two arms of the bridge R_1 and R_2 are shunted by inductances L_1 and L_2 and joined together at the center point by means of a resistor R_5. L_1 and L_2 are of the confined magnetic field type with outside shells made of molded powdered iron. In assembling this transducer, two coils are put back to back and housed in a metal container to keep them in alignment. A powdered iron core, of length equal to the center-to-center distance of the coils, is situated within the coils and is coaxial with them. For "zero" balance, the core is centrally located and the coil inductances should be equal. Slight inequalities of the two coils are balanced out by a short adjustable core of the same diameter as the main one which is supported near the end of one coil. Inductance of the coils is nominally 24 milli henries with core out. This value was chosen to produce the desired sensitivity when the high-permeability powdered-iron core was added.

In designing this transducer, it was found necessary to arrange the circuit in such a way that, whatever the unbalance of the bridge, the total impedance of the circuit remained constant. Otherwise the frequency of the carrier oscillator would shift. This was accomplished by locating a single iron core in two coils. Therefore, as the core is moved. an increase in inductance of one coil is compensated by a decrease of inductance in the other.

Sensitivity of the transducer has been adjusted to 5 mV bridge unbalance for 4V bridge input and 0.1 inch total core movement. The response is linear over a whole scale. The instrument was subjected to a temperature-sensitivity test over a temperature range of 80°F. No zero shift or change in sensitivity could be observed during or after the tests. The same stability was found to prevail during vibration or shake tests. Physical dimensions of the transducer are 1-3/4" x 2-1/2" in a cylindrical form; these dimensions could be reduced if necessary.

The sensitivity of a transducer, built in the manner described, can be made much larger by decreasing the coil inductance and increasing the permeability of the iron core. Experimental models were built having a sensitivity of 0.005 inches for full scale unbalance of 5 mV.

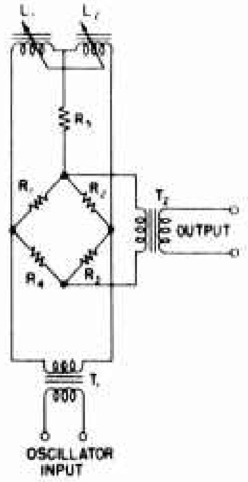


FIGURE 1

BIBLIOGRAPHY AND ABSTRACTS

FLAME TEMPERATURES

A Theoretical Study of a New Technique for the Measurement of High Flame Temperature

by

Donald H. Jacobs and Seymour Scholnick

Theoretical computations have been made to determine whether a sufficient concentration of emitting atoms of alkaline metal could be obtained in the exhaust gas through the addition of small quantities of an appropriate salt to the fuel to make the exhaust flame a black body radiator at a single wave length. Indications are that a concentration of 10^{-7} grams of sodium per cubic centimeter of flame gas are sufficient to accomplish this purpose. If this is accomplished as indicated it would be possible to determine the temperature of the exhaust gas from a measurement of its emissive power at that wave length.

North American Aviation, Inc.
Municipal Airport
Los Angeles 45, California
Report No. AL 160
Restricted
March 31, 1947

A method of coloring flames with salt is found in the following article:

Method of Coloring Flames with Salts
by A.C. Collard
Review of Scientific Instruments
Volume 18, No. 6, June 1947
Page 451

FLUID FLOW

Empirical Method for Frequency Compensation of a Hot-Wire Anemometer

By

Raymond A. Runyon and Robert J. Jeffries

This paper describes improvements in the design of equipment associated with the hot-wire anemometer for the measurement of fluctuating air-flow quantities. A frequency compensation circuit is provided; the frequency response characteristic of which may be continuously varied to match the wind tunnel operation conditions through the design frequency range of the instrument (10 to 1000 seconds per second). Use of the electronic circuit permits rapid empirical determination of the frequency response characteristic of a hot-wire anemometer. Actual wind tunnel operating conditions and experimental verifications of the theory involved are included. Methods developed are not limited to the specific frequencies and the mass flow measurements considered, but are applicable to all dynamic measurements with a hot-wire in which the flow variations are small with respect to the mean flow.

Langley Memorial Aeronautical Laboratory
Langley Field, Virginia
NACA Technical Note No. 1331
June 1947 Washington, D.C.

High Temperature Furnace for Electron Diffraction Studies

By

Earl A. Gulbransen

A furnace is described for use with the electron diffraction camera for the study of chemical and physical reactions occurring on surfaces up to 1000°C. The specimens are mounted in the body of a 25 Cr-12 Ni alloy block which is surrounded by a series of radiation shields. The metal block is heated internally by a tungsten-wire heating element mounted on a BeO core and operates in a hydrogen atmosphere. The several motions necessary for manipulation of the specimens are accomplished through a Wilson seal. Temperatures of 1000°C are achieved with a heat input of the order of 450 to 500 watts in forty minutes. The use of the furnace is illustrated.

Westinghouse Research Laboratories
East Pittsburgh, Pennsylvania
The Review of Scientific Instruments
August, 1947

Extended Applications of the Hot-Wire Anemometer

By

Stanley Corrsin

The use of the hot-wire anemometer has been extended to include the measurement of temperature fluctuation level as well as temperature-velocity correlation, in a turbulent flow with heat transfer.

Secondly, the hot wire can be used for the determination of mean relative concentration in the mixing of two gases of different known thermal characteristics.

Finally, the instantaneous response of a hot wire in a turbulent flow with mixing of two gases of different thermal characteristics has been computed. This permits measurement of the concentration fluctuation level as well as the concentration-velocity correlation.

Guggenheim Aeronautical Laboratory
California Institute of Technology
Pasadena, California
The Review of Scientific Instruments
July 1947

PHOTOGRAPHY

Auto-Iris -- A Device for Automatically Controlling the Lattitude of Film Exposure with Widely Varied Light Sources

By

I.B. Irving and H.A. Gray, Jr.

The auto-iris was designed to surmount the difficulties of making motion picture tracking films of small, high-velocity test vehicles against backgrounds of widely varying light intensities. It consists of a light sampler in the telescopic lens adapter housing, which supplies a signal proportional to the light received by the film to a Servo Amplifier and motor. The motor adjusts the iris to a pre-selected stop setting. This device makes it possible to automatically maintain an exposure to an accuracy of ± .25f stop under ordinary Cine-Theodolite tracking conditions.

This technique with minor variations could be extremely useful in flame propagation studies.

Johns Hopkins University
Applied Physics Laboratory
Silver Spring, Maryland
Report No. CM-381
March 20, 1947

THRUST

Description of a Thrust Measuring Device for Jet Propulsion Units

By

K.W. Anderson, H.L. Kressin and B. Kass

A practical self-compensating, direct thrust-measuring device of the displacement type has been designed and developed for use in flight testing of jet propulsion units. The measuring device is a linear variable differential transformer, consisting of three coils arranged co-axially with the core, and connected so that the position of the magnetic core within the coils is indicated by the voltage on the output leads. The voltage across the output leads is the voltage unbalance of the two end coils due to the difference in inductance set up in each coil by the location of the magnetic core. This voltage is generated by impressing a constant alternating voltage on the primary core which is located in the center. The change in output voltage is directly proportional to the change in core position.

Naval Air Materiel Center
Aeronautical Engine Laboratory
U.S. Naval Base Station
Philadelphia, Pennsylvania
Report No. ARL-977
Restricted
April 1, 1947

A High Temperature X-Ray Diffraction Apparatus

By

L.S. Birks and H. Friedman

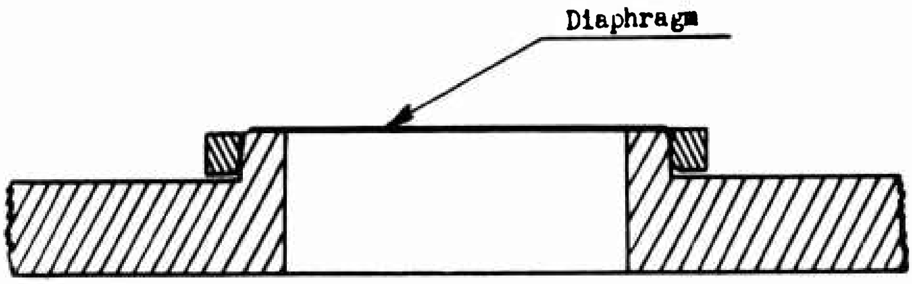
An apparatus is described for heating an x-ray specimen to 1200°C in vacuum while its diffraction pattern is being recorded continuously on a Geiger counter spectrometer. The heater consists of a length of 0.030-inch tungsten wire embedded in beryllium oxide, the whole enclosed in a polished tantalum case. Either a flat metal sheet, or powder packed in platinum gauze mounted on sheet metal is suitable as a specimen. An area about one centimeter square in the center of the specimen is irradiated by the x-ray beam in the focusing type of spectrometer. The temperature is uniform over this area to ± 5 degrees centigrade. Two concentric radiation shields reduce heat loss. The outer shield also acts as the vacuum-tight body of the oven and has beryllium windows to pass the x-rays. Results indicate that rapid structure changes may be observed as they occur with this apparatus.

U.S. Naval Research Laboratory
Washington, D.C.
The Review of Scientific Instruments
August, 1947

NOTES AND ANTIDOTES

Thin Metal Diaphragm

A method has been developed for mounting thin metal diaphragms to achieve a uniform plane surface and a fluid tight seal. The technique employs the drum head principle in which the diaphragm is pressed between two annular rings as shown in the sketch below.



Assembly of Thin Metal Diaphragm

Diaphragms of .005 inch to .00025 inch in thickness, and up to 10 inches in diameter have been used successfully. One of the critical points of this thickness is the amount of clearance between the outside diameter of the inner ring and the inside diameter of the outer ring. This clearance should be enough to allow the outer ring to be pressed on without shearing the diaphragm, but should be small enough to insure a good seal between the diaphragm and the rings. For example, the clearance allotted on a 2-inch diameter diaphragm with a floor thickness of .001 inch would be between .0002 inch and .0004 inch. Some of the better materials for the diaphragm are nickel, silver, and copper. The material for the diaphragm and the rings should have approximately the same coefficient of thermal expansion, if the instrument is to operate over a wide temperature range.

This type of diaphragm is very useful as the elastic element in a condenser-type pressure gage in which a high frequency response is desired. The range of pressure would necessarily be limited to the elastic constants of the diaphragm. This method of mounting a diaphragm is also useful as a holder when the diaphragm metal is to be soldered or welded to some other location.

Problems in Telemetering

To interesting problems in telemetering have been brought to the attention of the editors. The first is a problem of measuring and telemetering the thrust of a pulse jet powered target aircraft. The second is one of telemetering the fuel flow to the pulse jet power plant in this aircraft. We are passing these problems to the readers of the Bulletin with the hope that someone has come across one or both of them and achieved a satisfactory solution.

Your comments will be welcome.

TSDIN FORM 69 A (13 MAR 47)

RESTRICTED

Engin. Reeearch Associates, Inc. AUTHOR(S)	DIVISION: Guided Missiles (1) SECTION: Propulsion (3) CROSS REFERENCES: Flame propagation - Testing (37314.6)	ATI- 18747 ORIG. AGENCY NUMBER R-1 REVISION

AMER. TITLE: Bulletin of the inetrumentation panel Project Squid

FORG'N. TITLE:

ORIGINATING AGENCY: Princeton University, N. J.

TRANSLATION:

COUNTRY	LANGUAGE	FORG'N.CLASS	U. S.CLASS.	DATE	PAGES	ILLUS.	FEATURES
U.S.	Eng.		Restr.	Jan'48	50	13	photos, diagrs, drwgs

ABSTRACT

Instrumentation relating to liquid rocket and pulse jet propulsion research, known as "Project Squid", is reported. Articles discues an electronic chronoscope for measurement of flame speeds, the high frequency oscillator as a flame detector, photographic measurement of flame velocity in tubee, an FM condenser type pressure gage, high speed photography of flame propagation, water cooled total pressure tube, and variable-reactance transducer for measurement of displacement. High speed motion photography of Schlieren patterns, which are methode for observing flow in flame tubes, was also described.

RESTRICTED

TITLE: Bulletin of the Instrumentation Panel-Project Squid

AUTHOR(S): Colcote, R. F.; Evans, M. V.; Scheer, M.; and others (University, N. J.
ORIGINATING AGENCY: Engineering Research Associates, Inc., for Princeton
PUBLISHED BY: Engineering Research Associates, Inc., Washington, D. C.

ATI- 35652

REVISION (None)

ORIG. AGENCY NO. Bul. No. 1

PUBLISHING AGENCY NO. (Same)

DATE	DOC. CLASS.	COUNTRY	LANGUAGE	PAGES	ILLUSTRATIONS
Jan'48	Restr.	U.S.	Eng.	46	photos, diagrs

ABSTRACT:

The Bulletin of Project Squid provides practical information regarding techniques and instrumentation in the field of jet and rocket propulsion. Various papers contributed by research scientists and engineers who are working on experimental problems in jet propulsion are discussed. The topics covered are electronic chronoscope for measurement of flame speeds; high frequency oscillator as a flame detector; photographic measurement of flame velocity in tubes; Schlieren methods for observing flow in flame tubes; an FM condensor type pressure gage; high-speed photography of flame propagation and Schlieren patterns; water-cooled pressure tubes; and variable-reactance transducer for measurement of displacement. Other papers concerning flame temperature, fluid flow, high temperature, extended applications of hot-wire anemometer, and a high temperature X-ray diffraction apparatus are briefly described.

DISTRIBUTION: Copies of this report obtainable from Air Documents Division; Attn: MCIDXD

DIVISION: Power Plants, Jet and Turbine (5)
SECTION: Testing (17)

SUBJECT HEADINGS: Project Squid (75406); Engines, Jet - Development (32990); Engines, Rocket - Development (34108.7)

ATI SHEET NO.: R-5-17-9

CADO CONTROL NO.:	US CLASSIFICATION:	ATI NO.: 72630	OA NO.:

TITLE:

Same as ATI-35652 and 18777
4-5-50 6-6-50

AUTHOR(S):

55-0
50.3

ORIGINATING AGENCY:

FOREIGN TITLES:

PUBLISHED BY:	PUBLISHING NO.:
TRANSLATED BY:	TRANSLATION NO.:

PREVIOUSLY CATALOGED AS:

AIR FORCE-WPAFB-L-12 MAY 50 100M

CADO FORM NO. 5C — LIBRARY CARD