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# PROGRESS REPORT NO. 1

ON

# DETONATIVE COMBUSTION

BY

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The work reported herein is essentially a continuating of experimental studies in detonation which were initiated under contract W33-038 ac-21100. Work during this quarter has centered around the experimental development of research techniques and instrumentation which can facilitate the procurement of data from the detonation-shock tube which is presently in operation.

Before going on to a description of the techniques and instrumentation that have been developed, there is presented here certain theoretical considerations. The elements of a hydro-dynamic theory of detonation are fairly well established in the literature at the present time. The number of physical parameters involved in the detonation phenomena are comparatively numerous. Consequently, it is to be expected that there has not been explored all of the various ways in which the functional information can be presented. The viewpoint which follows was arrived at by personnel now engaged in research under this contract, but it has never been made a matter of record in other progress reports. For this reason, these theoretical considerations are presented herein.

Analyses of flows involving detonation fronts have been made in the past by such men as Chapman (1899), Jouguet (1905), and Becker (1922). These analyses which employed consideration of mass continuity, momentum, and energy predicted detonation velocities in good agreement with the experimental results obtained from detonation in tubes.

Since that time, much analytical work has been carried out on heat addition to a moving gas stream in a duct of constant area. Generally, a perfect gas has been considered and the specific heat has been assumed to remain constant. In the real case, the high temperatures associated with

detonation rule out the use of such a simplifying assumption as that of constant specific heat. The equation of state, $p = \rho RT$ , is a very good approximation to the actual physical conditions as long as the molecular weight of the gas remains constant and the state of the gas is sufficiently far removed from the critical point. In the case of the gases presently under consideration, the latter is true for the relatively high temperatures and low pressures presently being dealt with. It seems then that the use of the state equation in its elementary form for the analysis of a detonation wave is adequate and advantageous in the case where an air cycle approximates the process. This applies to most cases of lean fuel-air mixtures and to a lesser extent to rich fuel-air mixtures.

Consider (Figure 1) a standing detonation wave where the conditions upstream from the wave are denoted by subscript (1) and conditions

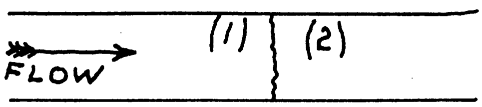



Figure 1

downstream from the wave by subscript (2). Across the detonation front, equations may be written expressing respectively considerations of conservation of mass, energy, and momentum.

$$\rho_1 V_1 = \rho_2 V_2 \qquad (1)$$

$$h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2} - Q \qquad (2)$$

$$p_1 + \rho_1 V_1^2 = p_2 + \rho_2 V_2^2 \qquad (3)$$

where:

$\rho$ = density of the gas

V = velocity of the gas

h = enthalpy of the gas

p = pressure of the gas

Q = the heat added through the detonation front

In addition to the above three equations, the equation of state may be written:

$$p = \rho RT \tag{4}$$

where:

R = gas constant for the gas

T = temperature of the gas on the absolute scale

By the use of equation (4), equation (3) may be written as

$$\rho_1 RT_1 + \rho_1 V_1^2 = \rho_2 RT_2 + \rho_2 V_2^2 \tag{5}$$

or in view of equation (1)

$$\frac{\rho_1}{\rho_2} = \frac{V_2}{V_1} = \frac{RT_2 + V_2^2}{RT_1 + V_1^2} \tag{6}$$

Solving equation (6) for $T_2$:

$$T_2 = \frac{V_2/V_1 \ (RT_1 + V_1^2) - V_2^2}{R} \tag{7}$$

Equation (7), which embodies the equations of momentum, state, and conservation of mass, gives $T_2$ as a function of $V_2$ and conditions at (1). From equation (2) it can be seen that

$$Q = \left( h_2 + \frac{V_2^2}{2} \right) - \left( h_1 + \frac{V_1^2}{2} \right) \tag{8}$$

Since the gas has been regarded as a perfect gas, h is a function of T only, and equations (7) and (8) are sufficient to obtain a plot of Q versus $V_2$. The enthalpies, $h_1$ and $h_2$, for air can be found easily from "Thermodynamic Properties of Air" by Keenan and Kaye, or from similar tables or charts. It should be pointed out that the assumptions of a perfect gas, i.e., a gas which conforms to the equation $p = \rho RT$ does not imply that the specific heats remain constant for a change in state of the gas.

A plot of equations (7) and (8) where the values for h were taken from "Thermodynamic Properties of Air" is shown in Figure 2. For these curves $T_1$ is the temperature corresponding to $V_1$ at $M = 1$. Since heat cannot be added at $M = 1$ without a readjustment of the flow, Q represents the amount of heat that would be subtracted from a stream having a velocity equal to $M = 1$ before the extraction of heat, and a velocity, $V_2$, after extraction. During the extraction of heat, the path that would be followed is shown by the dashed curve. The portions of the dashed curves to the left of the minimum ($M = 1$) points A, B, C, D, E, and F are subsonic and those portions to the right are supersonic. Isotherms are shown by solid lines. A plot of temperatures along the path line is shown in Figure 3. As in the case of constant specific heat, maximum temperatures occur at Mach numbers somewhat less than one ($M \cong 0.9$).

A shock, being an adiabatic process, is represented on these curves by a horizontal line ($Q$ = constant) from the supersonic branch of a curve to its subsonic branch. This is illustrated in Figure 4.

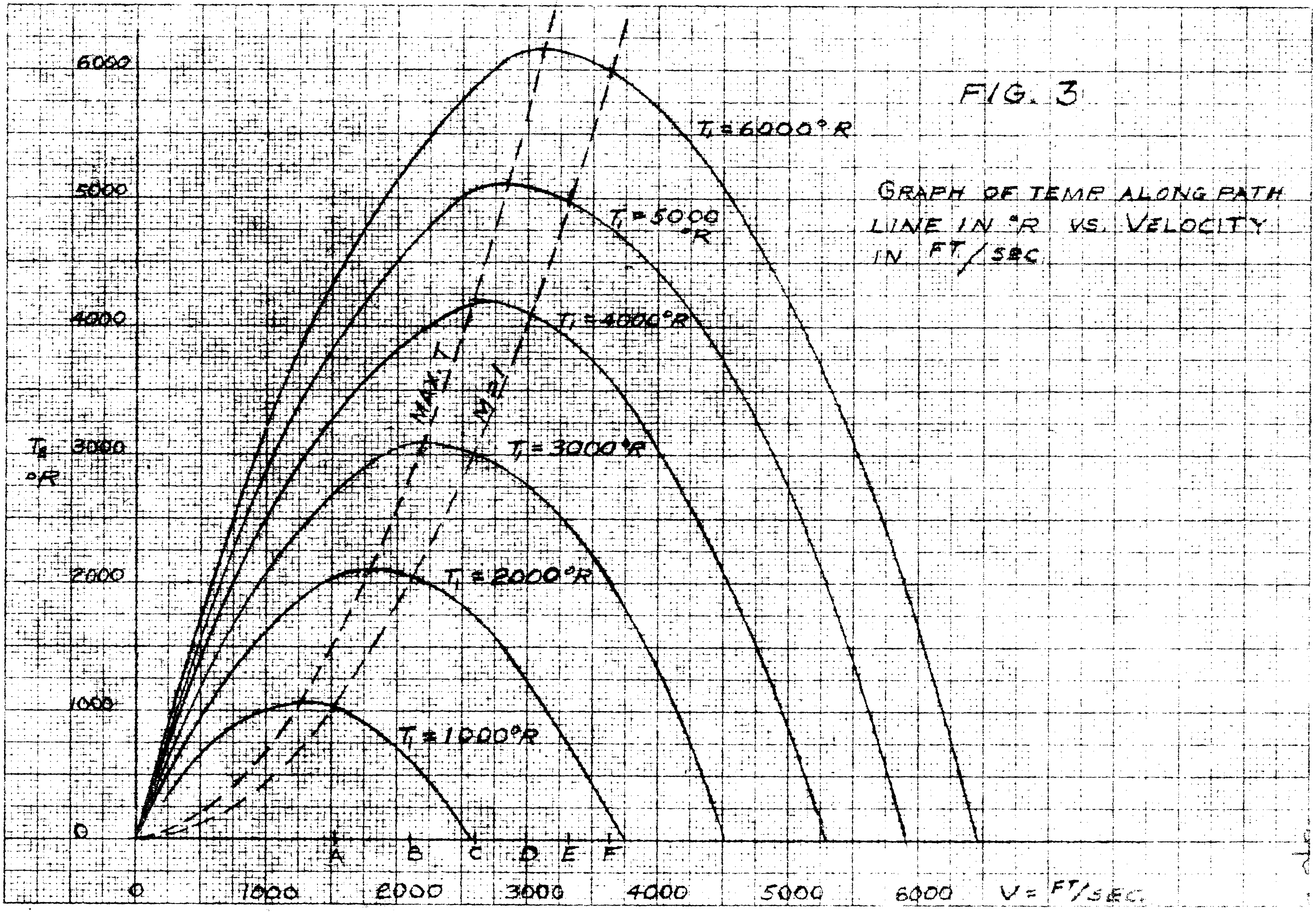


FIG. 3
GRAPH OF TEMP ALONG PATH LINE IN °R VS. VELOCITY IN FT/SEC
T₁ = 6000°R
T₁ = 5000 °R
T₁ = 4000°R
T₁ = 3000°R
T₁ = 2000°R
T₁ = 1000°R
MAX. T
M = 1
6000
5000
4000
3000
2000
1000
0
°R
0
1000
2000
3000
4000
5000
6000
A
B
C
D
E
F
V = FT/SEC.

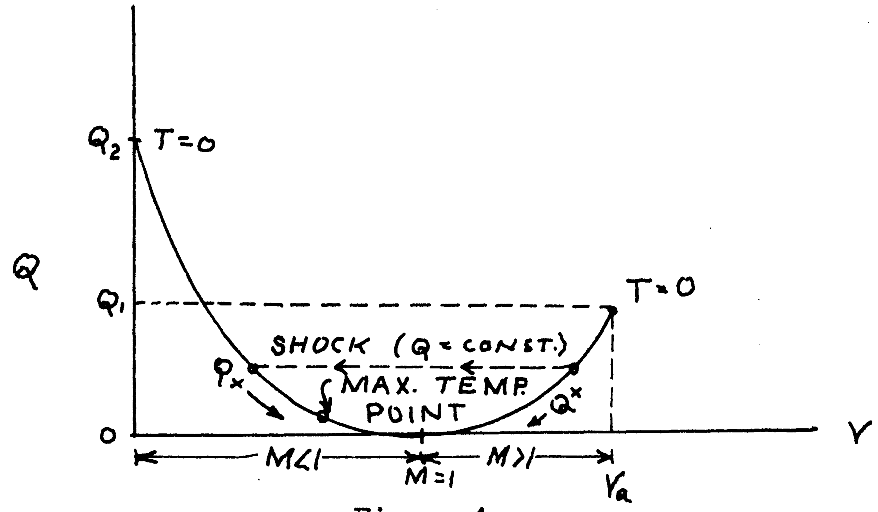



Figure 4

The value of $(Q_2 - Q_1)$, which is the difference in Q between M = 0, T = 0, and M = $\infty$, T = 0, represents the energy of ordered motion contained in a supersonic stream whose temperature is zero. It should be noted that at the point $(V_a, Q_1)$, T = 0, p = 0, and $\rho$ = 0. This follows directly from equation (1) and the fact that $V_a$ is a definite value.

The curves shown in Figure 2 can be normalized by plotting the abscissa in terms of Mach number and the ordinate in terms of a ratio of Q to some fixed value of Q. Two such normalized curves are shown in Figure 5 and Figure 6. These curves indicate that a dimensionless heating parameter should be used only in cases where the temperature change is relatively small.

An understanding of the detonation wave and the processes leading up to it can most easily be obtained from an examination of Figure 2. As an example, consider the classical apparatus for developing detonation waves (Figure 7). In this case a tube which is sealed at one end is filled with

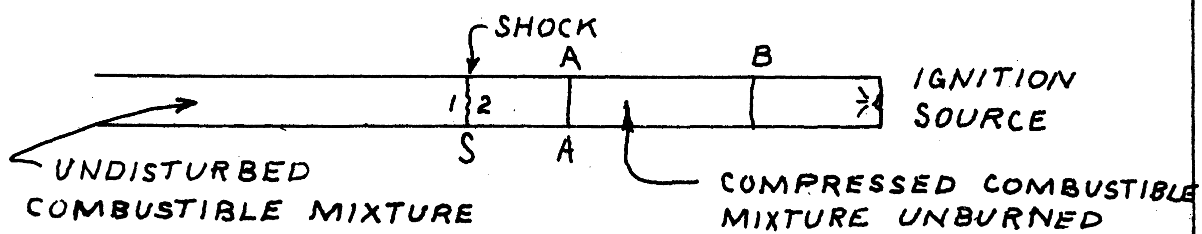



Figure 7

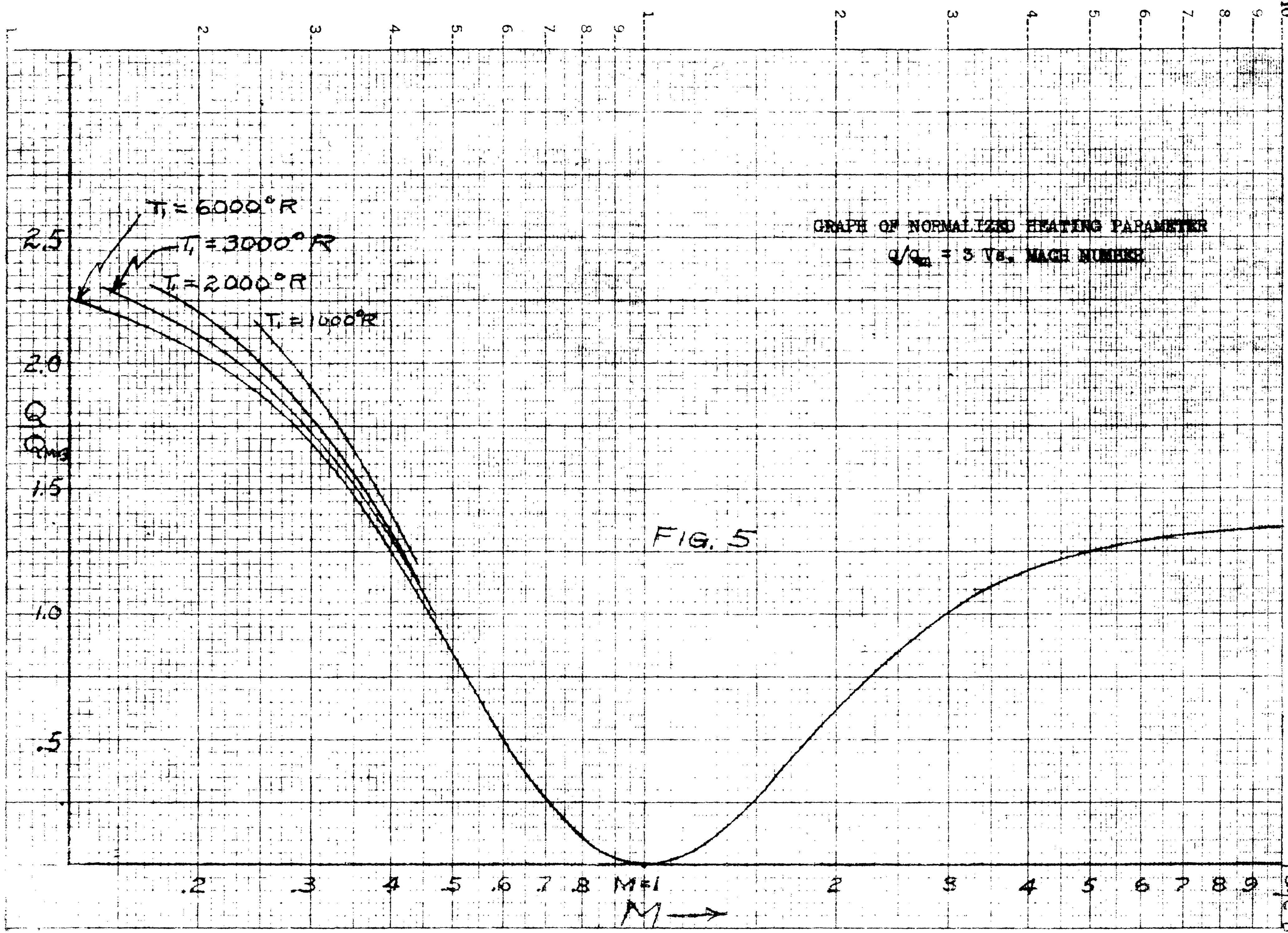

GRAPH OF NORMALIZED HEATING PARAMETER
Q/Qm = 3 Vs. MACH NUMBER
T1 = 6000°R
T1 = 3000°R
T1 = 2000°R
T1 = 1000°R
Q/QmS
2.5
2.0
1.5
1.0
.5
.2
.3
.4
.5
.6
.7
.8
M=1
2
3
4
5
6
7
8
9
M →

FIG. 5

GRAPH OF NORMALIZED HEATING PARAMETER

$Q/Q_{(M = .3)}$ vs. MACH NUMBER


Figure 6

a combustible mixture and ignited at either end. As the charge burns from point zero, it acts as a driving piston to form a shock at S. The gas behind this shock is compressed and heated to some temperature $T_2$. If this temperature is sufficiently high, the charge will be ignited by virtue of the shock (as opposed to ignition by the flame front) in some region A-A. In order to translate this in terms of Figure 2, consider a shock travelling at 3575 feet per second through a combustible fuel-air mixture which has a temperature of 500° R. These coordinates intersect on the $T_1$ = 2000° path curve. The corresponding point on the subsonic branch of this curve gives a temperature of 1300° R. and a velocity of 750 feet per second. If the temperature thus indicated is sufficient for ignition, burning will follow and heat can be added up to M = 1 or up to a velocity of 2125 feet per second. The heat necessary to produce this M = 1 is 260 BTU per pound.

A problem which might now present itself is the case of the combustible mixture which has a heating value in excess of 260 BTU per pound. Inasmuch as heat cannot be added to a M = 1 gas stream (one dimensional system), an unsteady state exists. To offer an explanation for this case, assume for an explicit example that the heating value of the mixture is 860 BTU per pound. Once the charge is ignited, the full 860 BTU will be added to the gas. Therefore, no solution below the 860 BTU line is possible. Since the gas is undisturbed until the passage of the detonation wave, $T_1$ is always 500° R. The intersection of the 860 BTU per pound line and $T_2$ = 500° R. indicates a minimum detonation velocity of 5800 feet per second. This type of detonation is often referred to in literature as "Chapman-Jouguet" detonation.

For detonation that is developed in the tube such as shown in Figure 7, it is hard to visualize a process by which a detonation velocity less than or in excess of that found in the limiting case can be obtained. The gas

at the rear of such a wave always moves at a Mach number of one relative to the detonation front.

Suppose, however, that instead of a shock developed by a moving flame front, that a shock of sufficient strength is imposed on the fuel-air mixture that the heating value is not sufficient to produce $M = 1$ in the region behind the shock. Under such circumstances, the detonation wave will progress at a rate in excess of the "Chapman-Jouguet" condition. In this case, the rate will depend among other things upon the strength of the independently imposed shock. In the burned zone behind the front $M < 1$.

There is one other possibility, mainly that of a detonation which has supersonic speeds in advance of the front and supersonic speeds behind it. Up to this point, detonation has been regarded as a process where ignition is obtained by virtue of a shock mechanism. In a one dimensional system, it is impossible to go from supersonic speeds to supersonic speeds through a normal shock. In a two dimensional system, this is accomplished in conjunction with an oblique shock. In the case at hand, it is difficult to visualize a process wherein detonation of the supersonic-supersonic sort can occur. For normal burning, "deflagration", the flame is propagated by diffusion of active species which prepare the unburned gas for combustion. Deflagration velocities are usually in the order of a few feet per second. Therefore, it seems improbable that normal burning could occur at supersonic speeds without the aid of a shock phenomena. Once a shock does occur, all burning is confined to a region where $M \leqq 1$. It would require a decrease of entropy to go adiabatically from the subsonic region to the supersonic region.

Recapitulating, there appears to be two types of detonation waves possible for a one dimensional constant area duct. The first, a Chapman-Jouguet detonation, proceeds at a rate which is a function of the heat

release of the fuel and the initial state of the mixture. The second type proceeds at a rate in excess of the Chapman-Jouguet condition, and this rate is a function of the heat release, the initial state of the mixture, and the strength of an independently generated shock.

The method of characteristics which is so commonly applied to problems in compressible flow represents a viewpoint possessing powerful utility in coping with the problem of unsteady one dimensional flow in a detonation-shock tube. However, this approach usually requires a great deal of tedious computation to arrive at the solution of a particular problem with specific boundary conditions. For this reason, detailed computations of this sort have not, as yet, been carried out. The characteristics viewpoint is useful, however, in carrying out simple qualitative evaluations of these unsteady phenomena.

Many of these problems can be rationalized on the time versus distance plane. For example, consider the case of a shock tube wherein the combustible mixture commences at a hypothetical gas interface located some distance downstream from the diaphragm. If it is assumed that detonation ensues as a plane discontinuity at the moment that the shock wave hits the combustible mixture interface, then the problem reduces to rather simple form on the time-distance plane. This situation is illustrated in Figure 8.

In the preceding illustration, the phenomena to occur first timewise is that of diaphragm rupture in the shock tube. Associated with this occurrence is a forward shock and a rearward rarefaction. At the moment that the advancing shock strikes the combustible mixture interface, there is developed a forward detonation and a rearward shock. The magnitude of these physical occurrences can be ascertained with the use of fundamental hydrodynamical relationships. This problem is relatively simple so long as the detonation is assumed to be a plane discontinuity. In the case where the

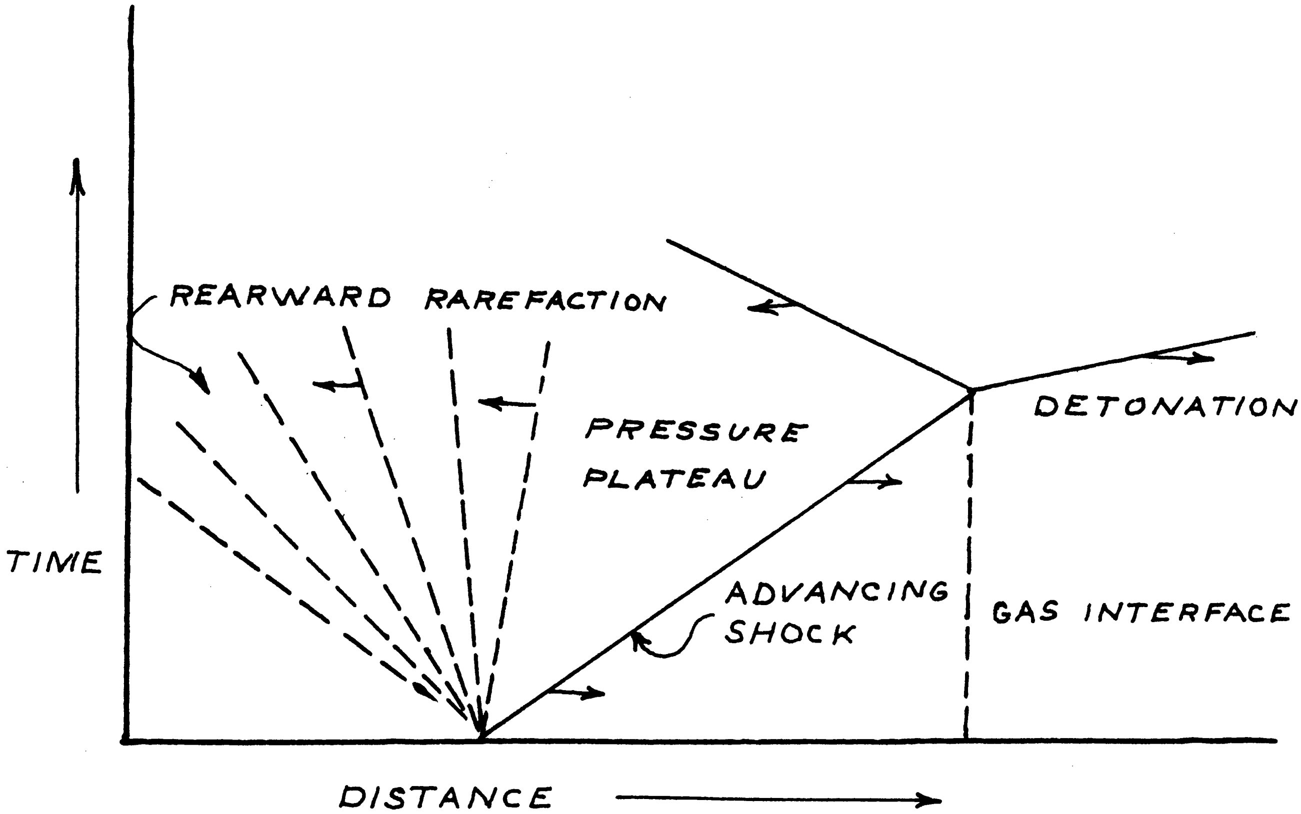

REARWARD RAREFACTION
PRESSURE PLATEAU
DETONATION
TIME
ADVANCING SHOCK
GAS INTERFACE
DISTANCE

Figure 8

chemical reaction associated with the detonation is assumed to occupy a finite region, the problem becomes somewhat more complex.

The transition from a state of normal deflagration to a state of detonation may be considered on a similar time-distance plane. Consider the case where a combustible mixture is ignited at the closed end of a detonation tube. Two distinctly different phenominalogical cases appear to be possible. These are illustrated qualitatively in Figure 9 and Figure 10.

Both cases presume a dependence of the chemical reaction rate upon pressure and temperature. For purposes of simplification here, it is again assumed that the chemical reaction takes place in its entirety at a plane of discontinuity.

In case one, the sudden ignition of the charge results in a small but finite forward shock wave. Because of the dependence of flame speed upon pressure and temperature, the flame front moves with increasing velocity and results in the continuous generation of additional pressure pulses which are propagated forward. These pressure pulses ultimately overtake the initial shock, thus forming a forward shock of increasing intensity. It is conceivable that this shock could reach an intensity such that detonation is incipient. When this occurs, it appears that a forward detonation wave would develop. Furthermore, it is conceivable that a rearward detonation wave might also be generated simultaneously. In this case, these occurrences take place in advance of the normal deflagration front.

In some cases the experimental observations of detonation transition by others appear to verify the circumstances rationalized in case one. In other cases experimental observations appear to indicate that the normal deflagration front proceeds with increasing velocity and itself ultimately takes on the attributes of a detonation wave. A preliminary consideration of the latter situation appears to lead to the possibility of case two

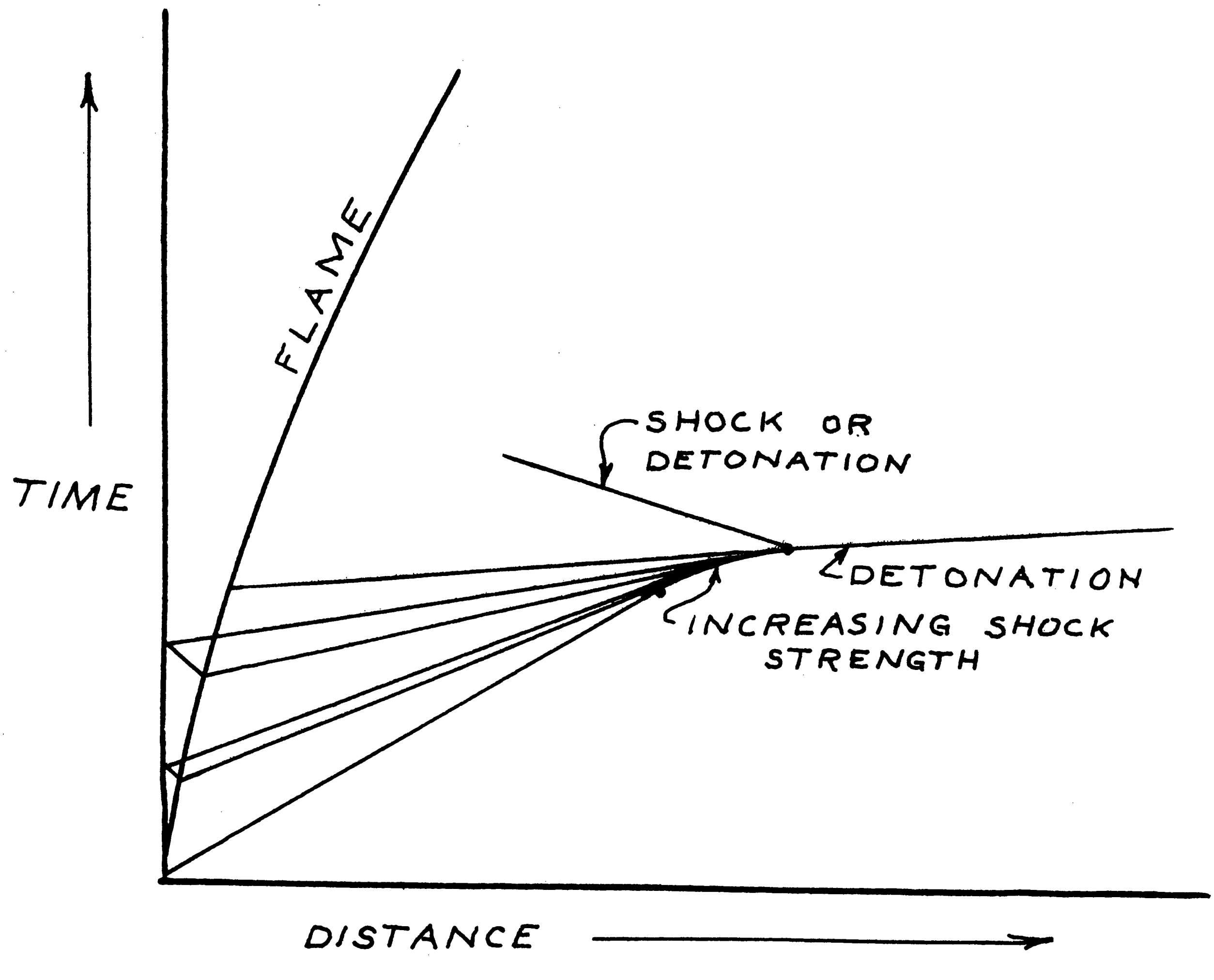
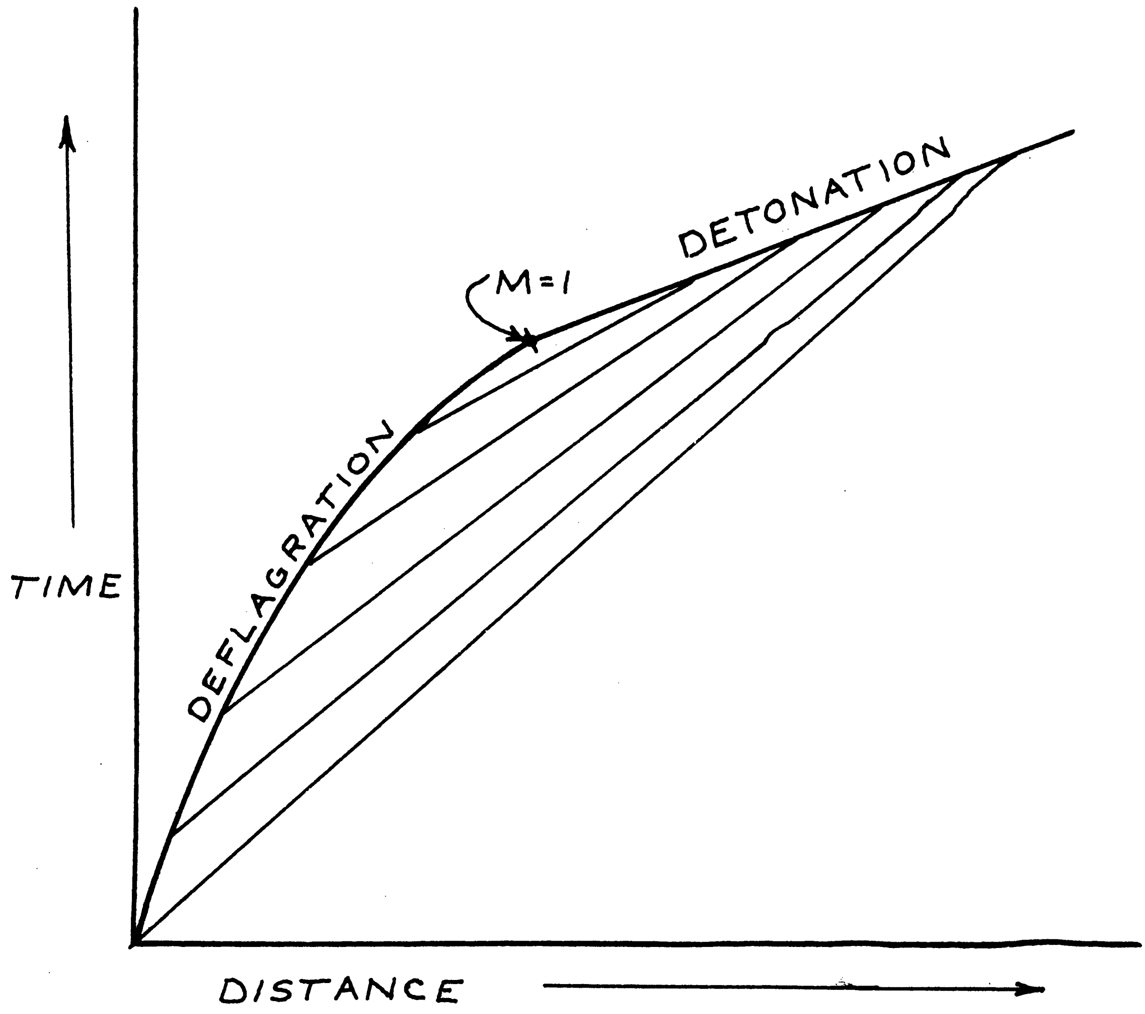

FLAME
SHOCK OR DETONATION
DETONATION
INCREASING SHOCK STRENGTH
TIME
DISTANCE

Figure 9




Fi ;ure 10

illustrated in Figure 10. In the case of Figure 9 the pressure pulses which intersect first in time and space are those pulses which are generated first by the normal deflagration front. In case two (Figure 10) it is conceivable that the pressure pulses which intersect first in time and space are those pulses which are generated last by the normal deflagration front. In this case, it would be necessary that the normal deflagration front be capable of propagation velocities up to and including a Mach number of propagation equal to one. This may be the case for some types of fuels and oxidizers under certain conditions of pressure and temperature. In such a case, then, the transition of a normal deflagration front into a detonation front could be qualitatively explained, insofar as the hydrodynamics is concerned.

During the past quarter, research efforts have centered largely around the development of equipment, instrumentation, and research techniques.

In order to observe detonation phenomena experimentally, two distinct methods appear useful. Detonation may be induced in a one dimensional flame tube of sufficient length either by a flame or by a shock of sufficient intensity. In this case, the detonation wave traverses the length of the tube at speeds in the order of 6000 to 10,000 feet per second. The alternative method would consist of stabilizing a detonation wave in a hypersonic tunnel through which a combustible mixture was flowing.

The advantages and disadvantages of each method are listed below:

Flame Tube or Shock Tube Method Advantages

1. Simple flame or shock tube (which may even be a length of common water pipe).
2. Static charging of tube permits the use of varied fuels and oxidants in small amounts.

3. Low and high pressure effects on detonation may easily be investigated by evacuating or pressurizing test chamber.

4. No large equipment necessary to supply fuel and oxidant.

5. The transition to detonation from a flame or shock can be investigated.

Disadvantages

1. Recording equipment of exceptionally short response time is required.

2. Equipment that requires a definite period of time to make observation is useless (Infra-red spectroscopy, etc.)

3. Direct observation of phenomenon by optical means is impossible.

Standing Wave Method

Advantages

1. Recording equipment of long response time can be used.

2. Equipment such as infra-red spectroscopes, etc. can be used to advantage.

3. Direct observation of phenomenon by optical means possible.

Disadvantages

1. More complex equipment necessary (Mach 7 or 8 nozzles, etc.).

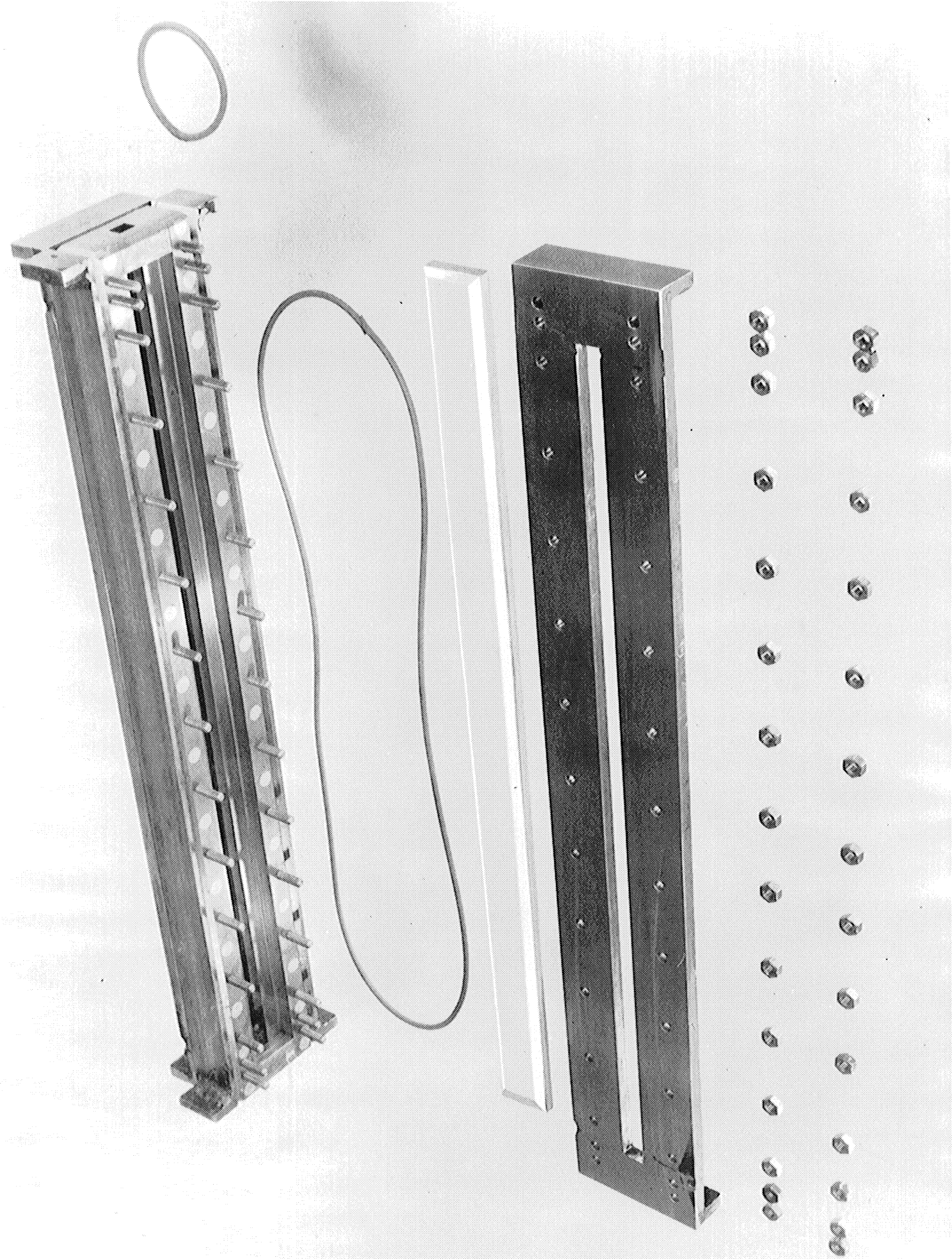
2. Large supplies of fuel-oxidant mixtures necessary.

3. Pressure effects on detonation not as easily controlled.
4. High pressure heat-exchanger necessary to establish workable total temperature.
5. Transition phenomena are not so easily investigated.
6. In order to prohibit premature burning, it would probably be necessary to mix the fuel at supersonic speeds.
7. Pressures on the order of 2 to 3 thousand psi are needed to establish high velocities at reasonable values of pressure for the supersonic stream.

In view of the circumstances outlined above, the first method (flame tube) has been followed up to the present time. As experience is gained with detonation in this equipment, it is anticipated that ultimately the standing detonation wave method will be attempted.

A shock tube with a rectangular cross section of 3/8" x 1/2" has been constructed. The test chamber consists of several interchangeable sections such as shown in Figure 11, which may be bolted together to form any desired length. The reservoir chamber, similarly in interchangeable lengths, is merely a welded up section of the same cross-sectional dimensions (3/8" x 1/2"). Separating the reservoir from the test section is a simple device for introducing a diaphragm. The diaphragm serves to keep the reservoir gases from mixing with the combustible mixture as well as to produce a shock wave upon bursting under the pressure of the reservoir gases.

A fully developed detonation wave in a stoichiometric mixture of propane and air would conceivably possess a velocity in the order of 6000 feet per second. For mixtures of propane-oxygen the velocities would be considerably higher. In order to secure photographs of such high velocity



waves, extremely short exposure times are required. A spark-shadowgraph system capable of spark durations considerably under one microsecond has been developed. The first system consisted of a dozen or so commercial plastic condensers mounted axially between two circular plates with the spark gap centrally located. (See Figure 12.)

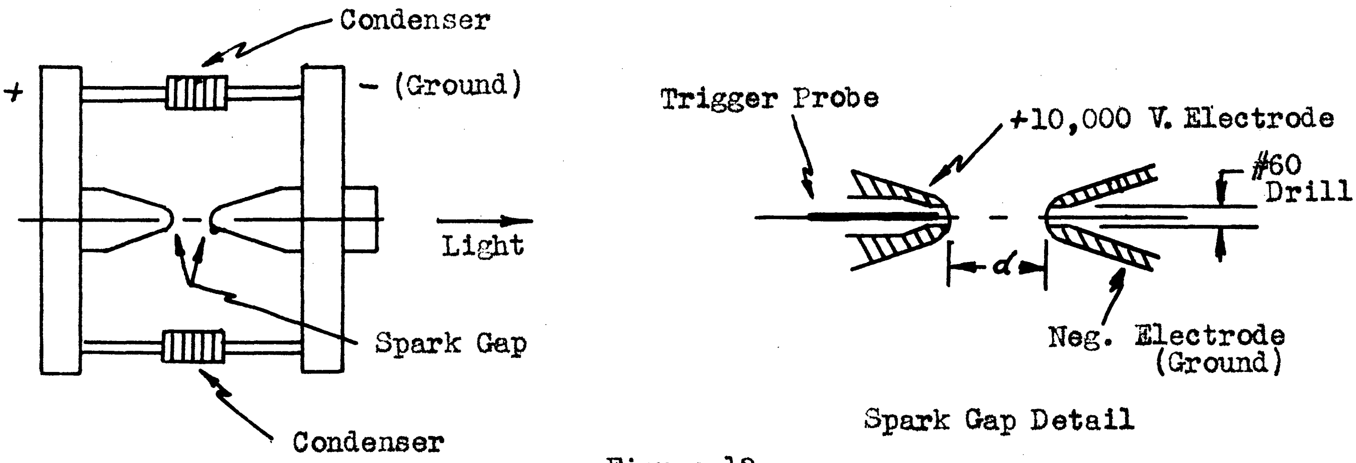



Figure 12

The condensers were charged to 10,000 volts and the negative electrode distance (d) adjusted to the point of breakdown. To spark, a pulse in the order of 5,000 volts is applied to the trigger probe which sparks to the electrode. The ionization thus produced breaks down the main gap which supplies the light energy for the spark shadowgraph. It is of utmost importance that the condensers be located symetrically as shown in order that the electromagnetic fields will cancel. If this is not done, the spark duration will be noticeably increased.

The latter system has functioned very well and a few excellent detonation shadow photographs have been taken. The light obtained from this gap, however, was marginal so the voltage was intentionally increased to overload. A picture obtained in this manner is shown in Figure 14. The condensers eventually broke down so a new condenser has been constructed which possesses none of the limitations of the former.

This condenser (Figure 13) consists of built up sections of copper

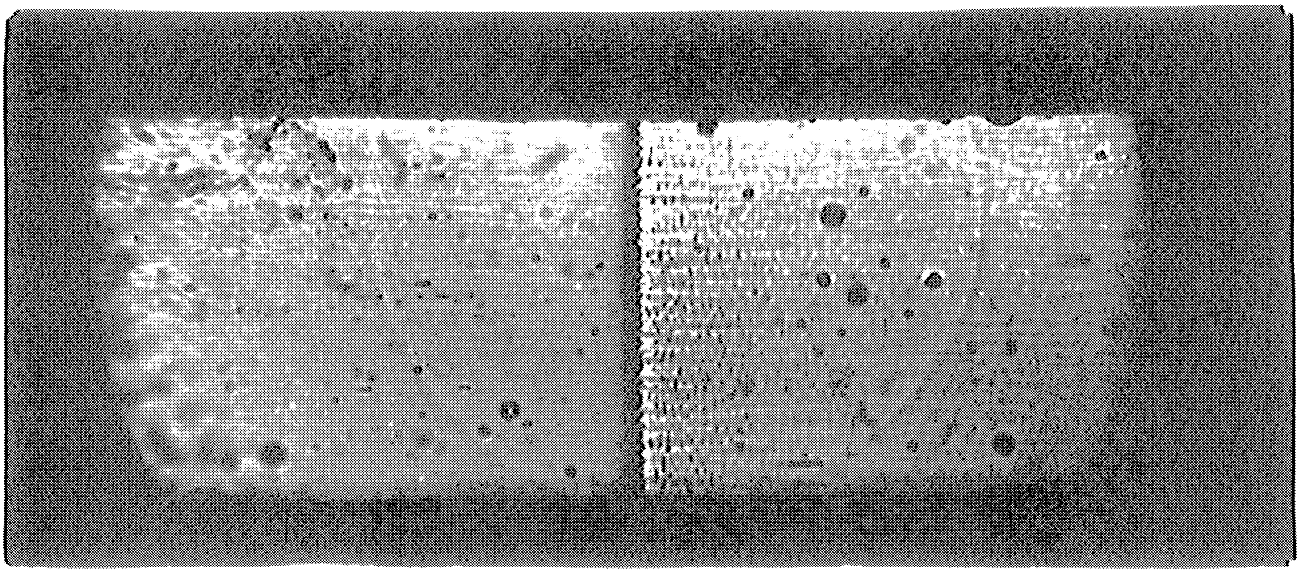


FIG. 14- SPARK SHADOWGRAPH OF AN ACETYLENE - OXYGEN DETONATION

sheet with polythene separations which serve to hold the plates apart and provide a high dielectric material. The copper plates are alternately

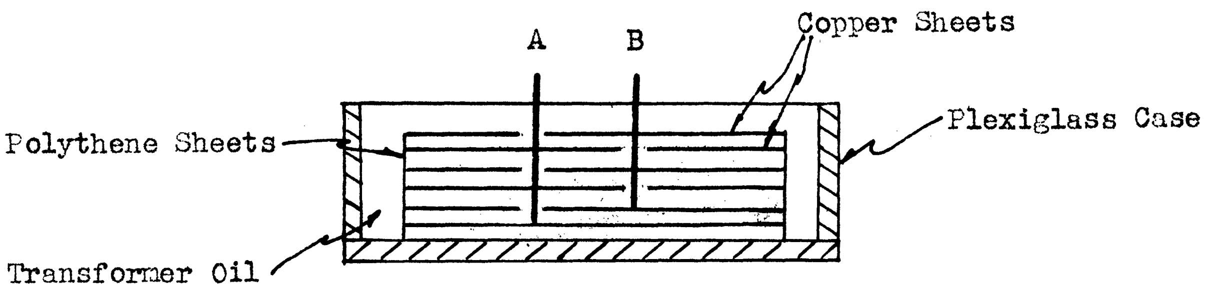



Figure 13

connected in the center by rods which serve as the electrodes. The whole assembly is placed in a plexiglass case and the case is filled with transformer oil. The same spark electrodes as those in Figure 12 are mounted on the terminals A and B. This condenser is estimated to have a capacitance of approximately 0.01 mfd. and may be charged to 50 kilovolts. Pictures taken with this system are shown in Figure 15.

The system used to supply the trigger pulse to the trigger probe consists of an ionized probe located in the shock tube, a thyratron to fire upon receiving the pulse from the ionized probe, and an induction coil to transmit the thyratron pulse into a high voltage pulse which fires the trigger probe in the main spark gap. (See Figure 16.)

This simple thyratron trigger operating with an ionized potential of approximately 250 volts on the probes performs very satisfactorily with detonation waves, but fails to perform reproducibly on shock waves. This is to be expected, for the ionization level behind a detonation wave is much higher than that behind a shock wave.

Accordingly, a small RF high voltage power supply has been constructed which produces about 2,000 volts (Figure 17). The filament transformers in

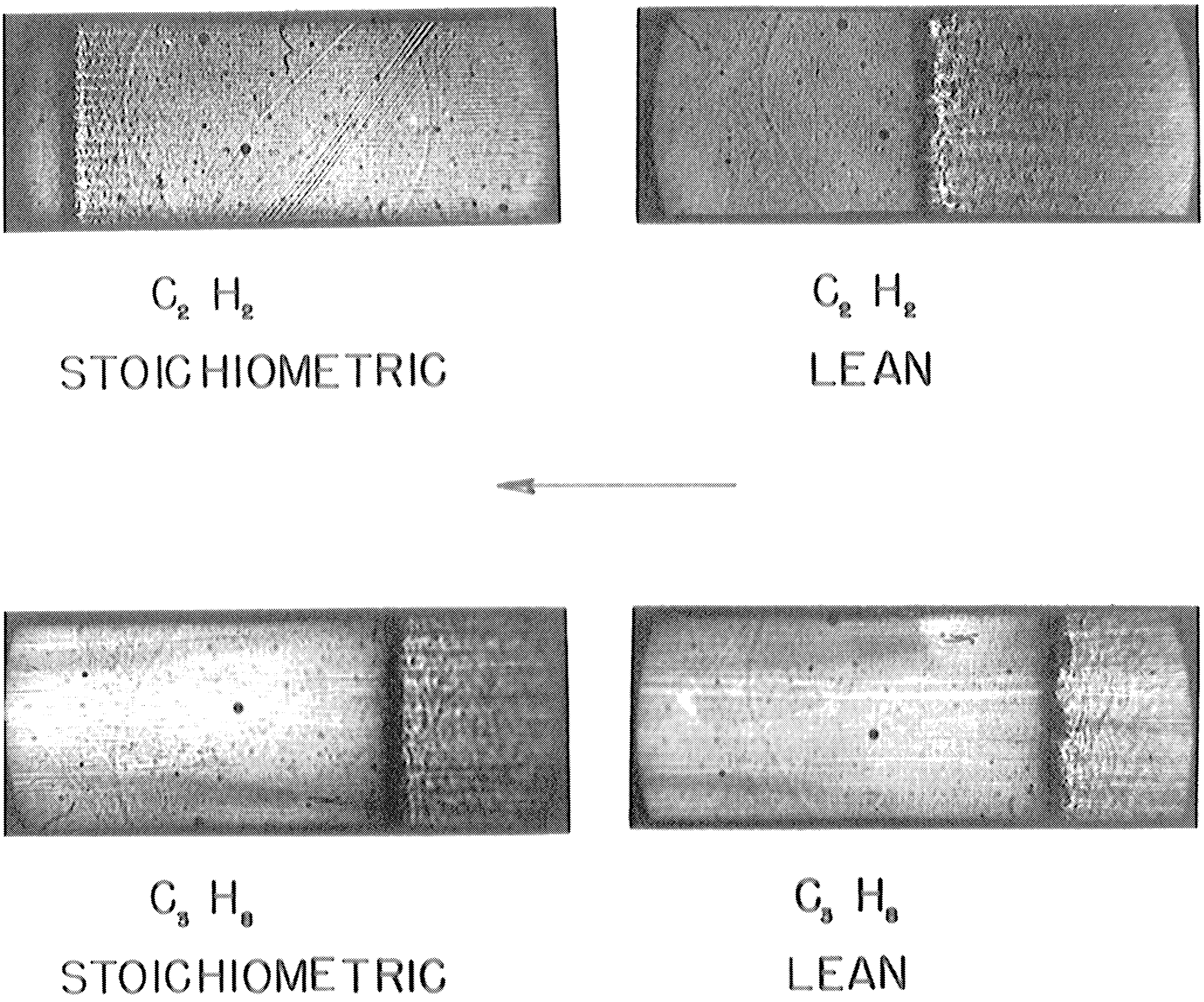
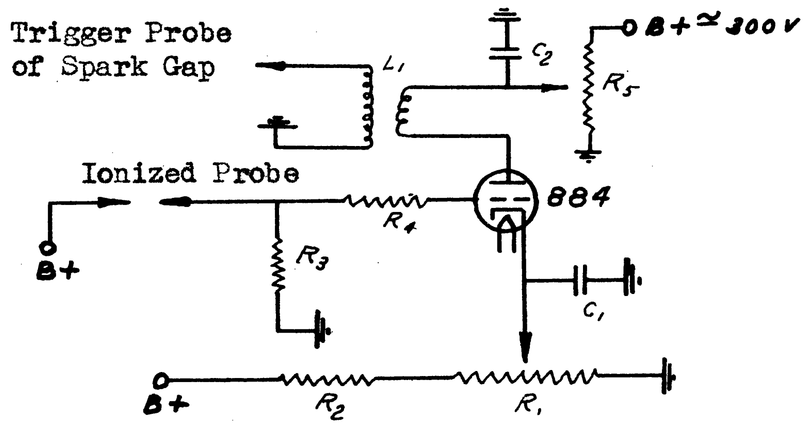
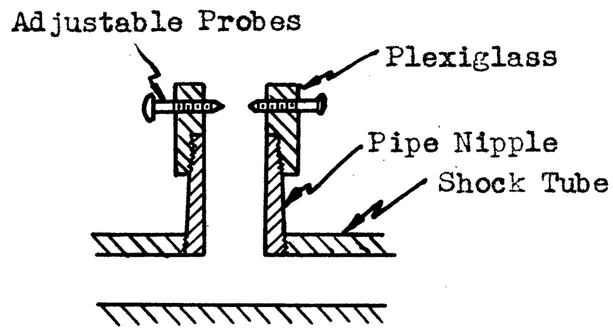



FIGURE 15

DETONATION OF A FUEL OXYGEN MIXTURE
IN A SHOCK TUBE



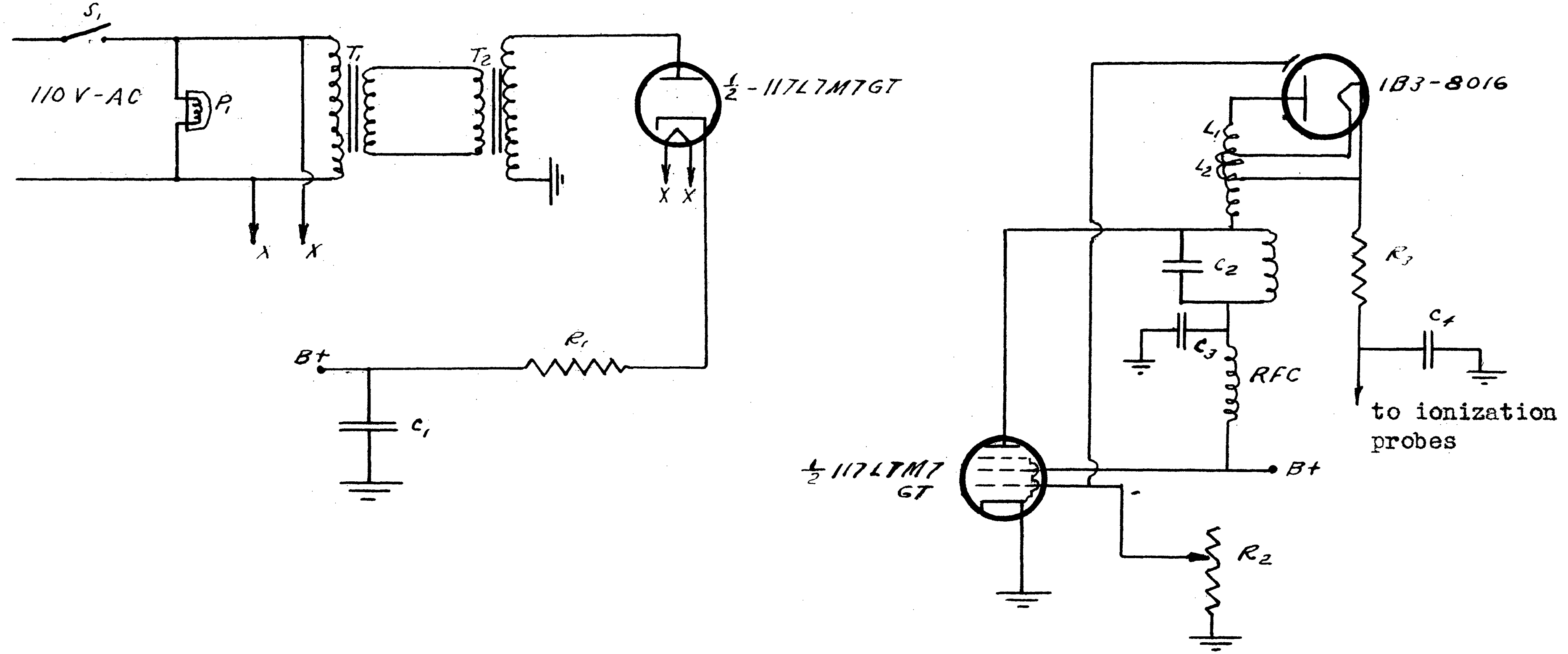

(a) Triggering Circuit




(b) Ionizing Probe Detail

| | | |
|---|---|---|
| $R_1$ and $R_5$ | - | Potentiometer |
| $R_2$ | - | 20,000 |
| $R_3$ | - | 330,000 |
| $R_4$ | - | 220.000 |
| $C_1$ | - | 50 mfd. |
| $C_2$ | - | .02 mfd. |
| $L_1$ | - | Plymouth coil |

Figure 16




$S_1$ - SPST switch
$P_1$ - 110V pilot light
$T_1$ and $T_2$ - 110V - 6.3V at 3 amp. filament trans.
RFC - 2.5 mhy at 50 ma.
$L_1$ - high volt. R-F trans.
$L_2$ - 10 turns #18 wire around low side of high volt. primary

$R_1$ - 5000 $\Omega$ 10 watt
$R_2$ - .050 megohms
$R_3$ - 50 megohms
$C_1$ - 40 $\mu$fd 150V
$C_2$ - 1000 $\mu\mu$fd mica
$C_3$ - .001 $\mu$fd paper
$C_4$ - 250 $\mu\mu$fd mica

Figure 17

this circuit serve only to isolate the 110 volt ac line from the chassis. The feedback to this oscillator circuit is supplied by the small condenser made up of a 1/2" wide piece of shim stock clamped around the 8016 high voltage rectifier tube. The voltage output is regulated by $R_2$ in the grid circuit.

The higher voltage on the ionization probes results in the triggering system functioning much more smoothly, and a shock triggers the system very reproducibly. There is, however, still approximately 100 microseconds of unexplained time lag in the system. It appears to be a reproducible lag but such a lag is too much to tolerate if the initial stages of detonation are to be studied. A different type of triggering device is now being experimented with which will employ a charged coaxial cable delivering the voltage pulse directly through the ionized gap to the trigger probe of the spark gap, without interposing a thyratron circuit. It is felt that in this way all time lag except for that taken in the ionizing of the gaps will essentially be eliminated. It is also anticipated that controlled delays can be introduced by means of a time delay network of condensers and inductors.

The optical system for the spark shadowgraphs consists of a collimating lens, a short focal length camera lens, a pin hole, and a light proof film pack holder (Figure 18). The second lens and the pin hole are not necessary for normal shadowgraph pictures of shocks, but with detonation the fogging from the burning is quite severe. The pin hole is not so small that it produces any noticeable pin hole Schlieren effect.

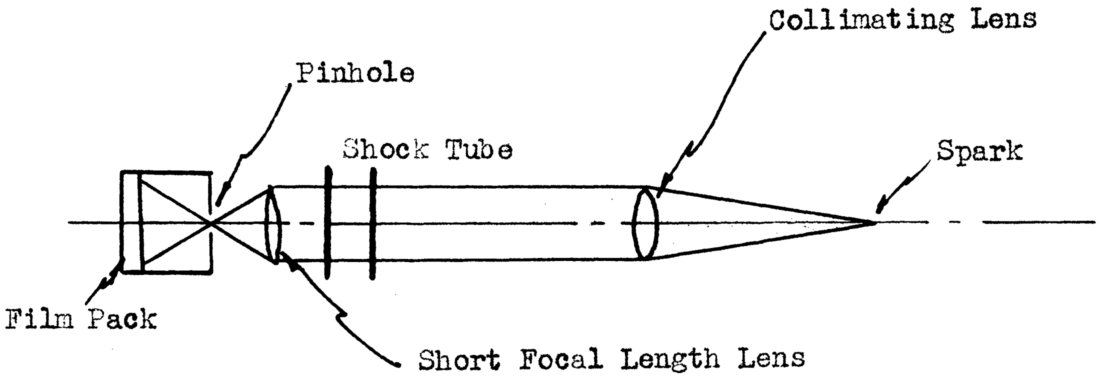
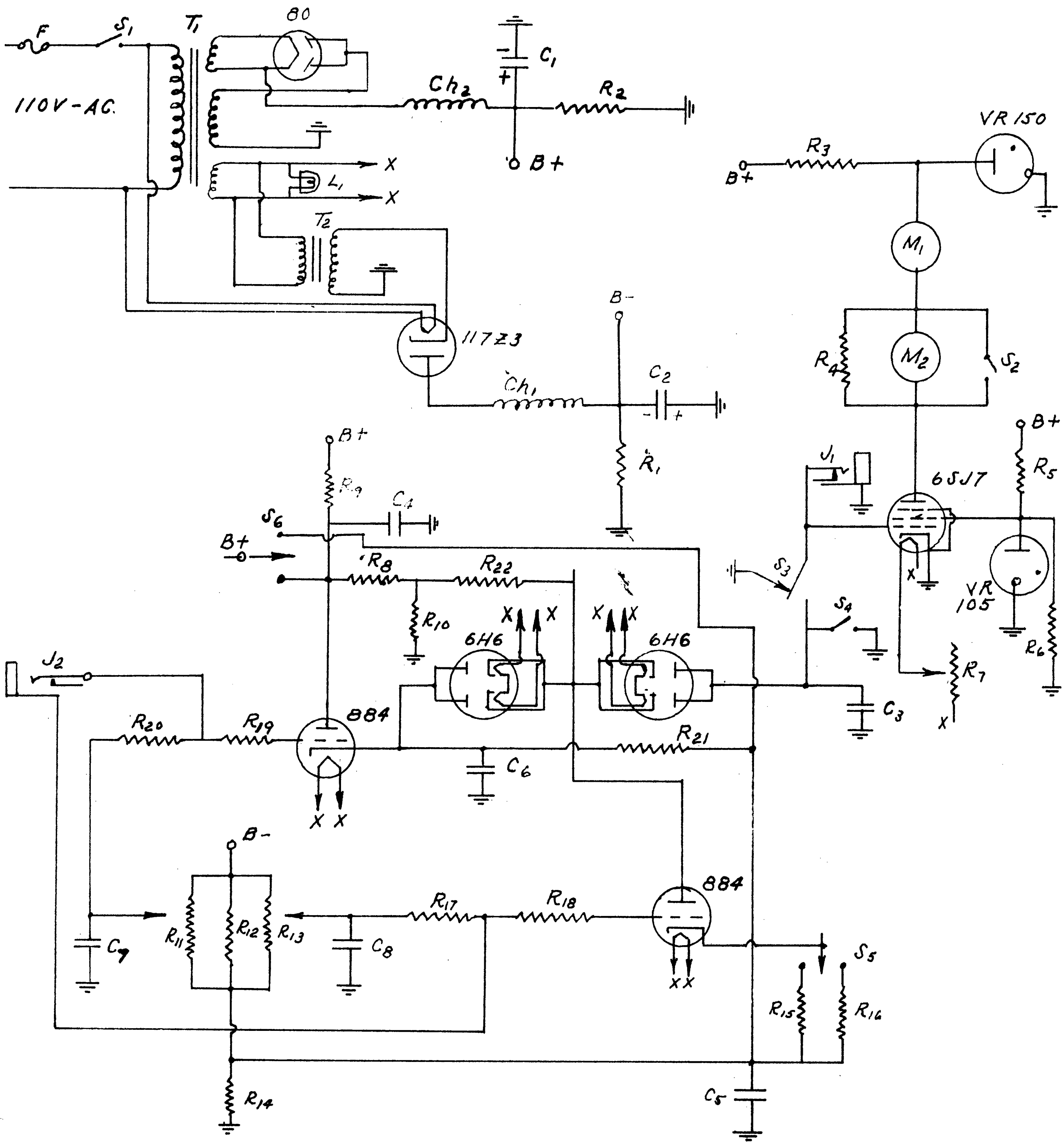



Figure 18

A timing circuit to time steady-state detonation waves has been fabricated and checked for operation in the shock tube. In a qualitative way it appears to work satisfactorily. The timing element is based upon the familiar RC type timing circuit. A pulse from an ionization probe located in the shock tube triggers a thyratron which starts to charge a condenser. A second pulse from another ionization probe located further downstream triggers a second thyratron which stops the condenser charging process. The voltage on this condenser, which is a measure of a time interval, is then read by a floating grid type of vacuum tube voltmeter. (See Figure 19 for this circuit.)

Another piece of equipment is now being constructed which will be used to calibrate the timing circuit. The above timing circuit will be useful mainly for the timing of waves that have attained a steady velocity, so it is to be anticipated that some form of strip photography technique may have to be resorted to in order that studies may be made of the transient conditions during the transition from deflagration to detonation.




XX - heater circuit

$T_1$ - 110V pri. - 400V - ct.
5.3V at 2 amps.
6.3V at 3 amps.

$T_2$ - fil. trans. 110 - 6.3V

$Ch_1$ - 8 hry. 50 ma

$Ch_2$ - 8 50 ma

(continued on next page)

Figure 19

$M_1$ - 15 ma meter
$M_2$ - 1 ma meter
$L_1$ - pilot light
$S_1$ - SPST switch
$S_2$ - SPST switch
$S_3$ - DPST - spring loaded
$S_4$ - SPST - switch
$S_5$ - Band switch
$S_6$ - DPDT switch
$J_1$ - open circuit jack
$J_2$ - jack
$R_1$ - 56,000 Ω 2 watt
$R_2$ - 23,000 " 5 watt
$R_3$ - 17,000 " 2 watt
$R_4$ - 47 " 1/2 watt
$R_5$ - 60,000 "
$R_6$ - 220,000 "
$R_7$ - variable
$R_8$ - 50,000 Ω
$R_9$ - 25,000 "
$R_{10}$ - 560 "
$R_{11}$ - pot. "
$R_{12}$ - 67,000 " 1 watt
$R_{13}$ - pot. "
$R_{14}$ - 67,000 "
$R_{15}$ - 180 "
$R_{16}$ - 500 "
$R_{17}$ - 750,000 "
$R_{18}$ - 150,000 "
$R_{19}$ - 150,000 Ω
$R_{20}$ - 750,000 "
$R_{21}$ - 12,000 "
$R_{22}$ - 12,000 "
$C_1$ - 20 μfd 450V
$C_2$ - 8 μfd 450V
$C_3$ - 8 μfd pyranol
$C_4$ - 40 μfd 450V - electrolytic
$C_5$ - 40 μfd 450V - electrolytic
$C_6$ - 50 μμfd 450V
$C_7$ - .02 μfd 600V
$C_8$ - .02 μfd 600V

During the next quarter, efforts will be continued along similar lines in order to improve the reliability of the instrumentation and the experimental techniques. Up to this point, the data that is being secured consists of spark shadowgraphs and propogation velocity measurements. It is foreseen that the next physical parameter to be given serious consideration is pressure. In the ultimate, it would be desirable to possess information concerning the complete time-space history of pressure within the shock tube. Consideration will be given to ways and means of securing such pressure information.

During the next quarter, efforts associated with the completion of the eight inch interferometer will be carried on under this contract. Progress on this work will be reported in the next quarterly report.