UNCLASSIFIED

LAMS-189

[redacted] SERIES B

C.3

[redacted]

CLASSIFICATION CANCELLED
For DOC
By M Bright

[redacted]

VERIFIED UNCLASSIFIED
9/21/88

UNCLASSIFIED

UNCLASSIFIED

December 29, 1944

LAMS-189 SERIES B

This document consists of
7 pages

MEMO TO: WM. HIGINBOTHAM

FROM: V. C. WILSON

RE: The possibility of initiating an implosion with a photo sensitive detonating gas.

## Summary

This is a report on a preliminary investigation to consider the possibility of initiating an implosion by surrounding the high explosive with a gas which will explode when exposed to ultra violet light, and thus will start a spherical detonation wave moving in toward the high explosive. The attractive features of this proposal are:

1. That the initiating explosive may be added in the airplane during the last minute before the "gadget" is dropped. Thus reducing the probability of premature detonation.

2. That the detonation would be spherical thus reducing the probability of jets.

The scheme has the following objections:

1. All gases discussed in the literature have a period of induction ranging from a millisecond or so to 40 seconds, or more. During this period there is negligible activity and then the gas detonates at a constant rate independent of the length of the induction period.

2. The detonation wave in the gas does not begin immediately, but requires that the explosion progress from 2.5 cm. to a meter or so depending upon the gas before the detonation wave is established.

3. The detonation wave in a gas would not be 100% certain to detonate the high explosive, but a more sensitive booster explosive would be required at the surface of the high explosive. Such a large surface of sensitive booster explosive is objectionable because it would present too large a surface which might be exposed to a stray machine gun bullet.

4. Some schools of thought believe that last minute operations to b performed in the plane should be avoided because this operation will be performed under the nervous tension of battle.

In the report there are some suggestions for avoiding objections, No. 1 and No. 2.

Some experiments could be performed to determine the seriousness of objection No. 3. Objection No. 4 is debatable.

An unsuccessful search was made for a photo-sensitive liquid to be used for this purpose.

Considering all the possible troubles with this method, it does not seem as promising as the electrical detonation method.

There is a possibility of combining a gas with the solid detonator in the electrical detonators to make them more certain to detonate.

## Introduction

Several people have considered the possibility of initiating an implosion with a gas which will detonate when exposed to ultra-violet light. Probably this method is not impossible, but there are many troubles which must be overcome before the method may be made oberative. Most of these troubles lie in the mechanism of an ordinary gas explosion. The average physicist who has not studied gas explosions may not recognize these troubles. This memo has been written so that the next person who may begin work along these lines may save some time getting acquainted in this field.

## General Discussion

Detonation in a gas: When some inflammable gas mixtures are ignited in a tube, the ends of which may be open or closed, the initial slow movement of the flame accelerates rapidly to a high speed which remains constant thereafter regardless of the length of the tube. The term detonation wave is applied to the reaction zone that travels at this high speed. Some of its properties are:

1. The speed is independent of the diameter of the tube.
2. The speed is little influenced by changes in the initial pressure and temperature of the gas mixture.
3. It is immaterial whether inflammation is started at the closed or open end of a tube and whether the source is a flame, spark detonator, light, or some other agency.
4. The speed with which a detonation wave propagates is a physical constant of the properties of the gas mixtures.

The following tables illustrate some of the properties of detonations in gases. In Table I the velocities given in the last column were measured in tubes and not in the vessels given in the preceding column.

Table III makes one wonder if a detonation wave would be set up in a sphere of reasonable size.

## TABLE I

### Detonation by Spark

| Gas Mixture | Explosion Time Millisec. | Vol. in cc. of vessel used for Col.2 meas. | Detonation vel. Meter s/sec. |
|---|---|---|---|
| Acetylene $C_2H_2 + 2\frac{1}{2}O_2$ | 1.94 | 300 | 2920 |
| Ethane $C_2H_6 + 3\frac{1}{2}O_2$ | 0.83 | 300 | 2363 |
| Methane $CH_4 + 2\ O_2$ | 1.24 | 300 | 2146 |
| Cyanogen $C_2N_2 + O_2$ | 1.06 | 300 | 2728 |
| Hydrogen $4H_2 + O_2$ | 1.67 | 300 | 3268 |
| $4H_2 + O_2$ | 4.22 | 4000 | |
| $6H_2 + O_2$ | 9.67 | 4000 | 3527 |
| Benzene 17% $C_6H_6 + O_2$ | 105.1 | | |
| 10% $C_6H_6 + O_2$ | 49.0 | | |
| Hexane 17% $C_6H_{14} + O_2$ | 91.2 | | |
| Hydrogen and Chlorine $H_2 + Cl_2$ | | | 1795 |

## TABLE II

### Distance to establish detonation wave in a tube

Distance in inches from spark at which detonation occurs = $P_0$ for spark at end of tube and $P_3$ for spark 3 inches from the end.

| Mixture | $P_0$ | $P_3$ |
|---|---|---|
| $2H_2 + O_2$ | 48 | 12 |
| $6H_2 + O_2$ | | 192 |
| $C_2N_2 + 2O_2$ | $8\frac{1}{2}$ | 4 |
| $C_2N_2 + 2O_2$ | 12 | 10 |
| $2C_2H_2 + 3O_2$ | $4\frac{1}{2}$ | $2\frac{1}{2}$ |
| $C_2H_2 + 2O_2$ | 9 | 5 |

## TABLE III

Influence of tube diameter on distance from firing source at which detonation occurs. Mixture = $CS_2 + 3O_2$. Spark at end of tube. D cm = cm travelled by flame before detonation.

| Tube diam. mm. | D cm |
|---|---|
| 6.5-7 | 48 |
| 10 | 50 |
| 24-25 | 58 |
| 34-35 | 84 |
| 43-44 | 103 |
| 53-54 | 131 |

Photo-ignition of a gas. A mixture of hydrogen and chlorine may be detonated by exposing it to ultra violet light of a wave length of 4785 Å, or less. The most probable reactions are:

$$Cl_2 + h\nu = Cl + Cl$$

$$Cl + H_2 = H\,Cl + H$$

$$H + Cl_2 = H\,Cl + Cl$$

The maximum absorption of $Cl_2$ is at 3400 Å. To get a rapid reaction this wave length should be used. The speed of the reaction is directly proportional to the intensity of the light. Traces of oxygen retard the reaction. This is a chain reaction and in some cases (high purity of $H_2$ & $Cl_2$) as high as $5\text{x}10^6$ chains have been initiated by one photon. Unfortunately, not every collision of a chlorine atom with a hydrogen molecule results in a chemical change. On the average, only after $10^4$ or $10^5$ collisions a reaction sets in. This means that a chlorine atom is more apt to combine with an $O_2$ molecule present or some other molecule on the wall of the vessel. Such a combination breaks a hydrogen chlorine chain and thus slows up the reaction. Even worse than this, the presence of impurities seems to be responsible for a delay in the initiation of the explosion. This delay is called the induction period. In this case the reaction does not set in until long after the mixture has been exposed to light, and then it suddenly starts at the normal rate. The explanation is that if a foreign molecule will interact with an atom of chlorine at each collision, then a small amount of this impurity will poison the reaction entirely. A long period of irradiation is needed before the whole impurity becomes chlorinated, after which the reaction proceeds at a normal rate.

Hydrogen Bromide may be ignited photo chemically. The reactions are:

$H\,Br + h\nu = H + Br$
$H + H\,Br = H_2 + Br$ (Exothermic, spontaneous in the dark)
$Br + Br = Br_2$

However, this forms only a chain of two and so does not produce a sufficiently violent reaction to start or maintain a detonation.

Hydrogen and oxygen mixtures can not be ignited by ultra violet, however, if some other gas is introduced which will some way or other produce H atoms, then the hydrogen oxygen chain can be started. Harber, Farkas, and Hartek induced a photochemical explosion of oxyhydrogen gas by introducing 0.6% of ammonia. The light induces a photochemical decomposition of ammonia giving H atoms. Below 300 mm pressure and 415°C. the formation of water alone is observed and no explosion follows. With $p > 300$ mm and $T \geq 415^\circ$ C the explosion starts some thirty or forty seconds after exposure to light. Moreover, if the illumination is cut off before the explosion has started, the reaction of the gas continues in the dark. At first the rate of reaction increases slowly but afterwards more and more rapidly, until finally explosion sets in.

A mixture of hydrogen, oxygen, and chlorine will explode under ultra violet light if there is sufficient chlorine. In this case, water is formed and practically no hydrogen chloride is formed. This indicates that the chlorine just forms atomic hydrogen to start the hydrogen oxygen chain reaction.

## Application to our Problem

Presumably in the implosion unit one would have a spherical outer suffface to the high explosive, and this would be surrounded by a gas confined in a steel spherical shell. In order that the explosion will start at the outside and move in, one would, uniformally illuminate with ultra violet light, the inner surface of the containing shell. This might be done with some sort of a lining of polystyrene slightly roughened on one surface and illuminated on an edge, or the inner surface of the shell might be coated with a fluorescent material. In this case the ultra violet light of shorter wave length than the resonances in the gas used would be propogated through the gas and the fluorescent material would convert this energy to the proper wave length to ignite the gas. For example, if a chlorine hydrogen mixture is used, the chlorine has a strong absorption at 3400 Å but practically no absorption below 2500 Å. The two strong lines from a mercury arc (1849 Å and 2537 Å) would be little absorbed by the gases. Perhaps six arcs could be used to directly illuminate all inner surfaces of the shell. The shell could then be coated with a K Cl Tl "phosphor". This is a "phosphor" which has strong absorption bands with maxima at 1960 Å, 2030 Å, and 2490 Å and fluorescent immission from 2700 Å to 4000 Å with a maximum at 3000 Å. This would convert most of the energy in the Hg lines to the proper wave length to best dissociate the $Cl_2$ molecules.

The first trouble with the $H_2$, $Cl_2$ mixture is that in an implosion gadget it will be impossible to remove the oxygen so that there will be a long period of induction. If is improbable that this period will be the same over the surface of the outer sphere. Secondly, the presence of the oxygen will slow up the reaction so that it is doubtful if a detonation wave will be set up in a reasonably sized sphere. This means the high explosive would not be detonated.

If one would try to use the hydrogen oxygen mixture with chlorine to initiate the reaction, the period of induction would be just as bad, but since the chain reaction does not depend on the chlorine, the explosion would be more violent and so would be more liable to set up a detonation wave.

It has been proved that the hydrogen oxygen explosion is dependent upon the formation of hydrogen atoms, therefore, if one could irradiate the hydrogen directly with a sufficiently short wave length ultra violet to completely dissociate the hydrogen directly then there would be no period of induction. Unfortunately, this would require a wave length of 853 Å. I know of no material which is transparent to this short wave length, therefore, it must be propogated in a vacuum. How can one confine a gas with a spherical vacuum?

The next notion is to use a molecule such as methane which might be easier to dissociate. Unfortunately, I haven't found a gas which will form a detonating mixture and can be easily dissociated. The following table is made up from data given by Sponer.

TABLE IV

| Molecule | Reaction | Potential in Volts | Corresponding Wave length in Å |
|---|---|---|---|
| $C_2H_2$ | $C_2H_2 \rightarrow C_2H_2^*$ | 11.2 | 1100 |
| | $C_2H_2 \rightarrow C_2H^+ + H$ | 17.8 | 700 |
| | $C_2H_2 \rightarrow C_2^+ + H_2$ | 23.8 | 500 |
| | $C_2H_2 \rightarrow CH^+ + CH + K.E.$ | 22.2 | 560 |
| $CH_4$ | $CH_4 \rightarrow CH_3^+ + H$ | 14.7 | 840 |
| $C_2H_4$ | $C_2H_4 \rightarrow C_2H_4^+$ | 12.2 | 1020 |
| $C_2H_6$ | $C_2H_6 \rightarrow C_2H_6^+$ | 12.8 | 970 |
| $H_2$ | $H_2 \rightarrow H + H^+$ | 18 | 690 |
| | $H_2 \rightarrow H + H^+ + K.E.$ | 26 | 480 |
| | $H_2 \rightarrow H^+ + H^+$ | 48 | 260 |
| $O_2$ | $O_2 \rightarrow O + O^+$ | 19.5 | 635 |

Some of the metal hydrides may be easily dissociated, but I doubt if enough of the hydrogen can be liberated at a surface by light to start an explosion.

Table IV leads one to abandon light as an initiator but try to accelerate electrons to dissociate the gas. I believe it has been suggested before to put a photoelectric surface on one of the concentric spheres confining the gas and place a high potential between the spheres. Then when the photoelectric surface is suddenly illuminated, the electrons emitted would be accelerated sufficiently to ignite the gas. In order to do this with $H_2$ and $O_2$ according to Table IV one would need to accelerate the electrons to 18 or 20 volts between gas collisions. For a good explosion or detonation one would want at least one atomosphere of hydrogen and oxygen, and the mean free path of an electron would be so short at this pressure that an enormous field would be required. The concentric sphere idea would have to be abandoned in favor of a grid of fine wires with several thousands of volts positive with respect to the photoelectric suface. Then the explosion would start immediately surrounding the wires. The wire grid would have to have spherical symmetry.

All this begins to look more and more like an electric detonation system; so perhaps that is the next step and one should forget about gas detonation and put extra effort on electric detonators.

At the present time electric spark detonators seem to fail completely about ten percent of the time. In all cases the spark discharge occurs but it does not always ignite the lead azide. I wonder if one could design the capsule so that it could be evacuated and filled with $H_2$ and $O_2$. The spark would ignite the gases and they, in turn, would ignite the priming explosive.

<ins>Photo sensitive liquids</ins>. A search was made for a liquid explosive which could be detonated by ultra violet light. Probably there are some, but I was unable to find any report of experiments to ignite liquids photo chemically. The hope was that a liquid might be free from an induction period, and that the detonation wave set up in the liquid might be sufficiently strong to detonate the high explosive directly without the use of a booster.