ADA158 936

MINUTES OF THE RAPID ACTION FIRE PROTECTION SYSTEM SEMINAR

AMCCOM SAFETY OFFICE

23-24 OCTOBER 1984

PREFACE

This seminar was held as a medium by which there could be a free exchange of information on rapid action fire protection systems used in munition production operations. The objectives of the seminar were:

- Discuss system operating principles & system components.
- Exchange latest technical data, developments, and improvements.
- Discuss lessons learned during installation, operation, & maintenance of deluge systems.
- Exchange views on deluge system specifications.
- Exchange views on response times.
- Provide sources of information and points of contact.

With this idea in mind, these minutes are being provided for your information. The presentations made at this seminar do not imply indorsement of the ideas, accuracy of facts presented, or any product by either the AMCCOM Safety Office or the Department of Army. Mr. Robert Loyd was the seminar coordinator. Questions concerning the seminar should be directed to him at AV 793-2975, FTS 367-2975, or commercially at (309) 782-2975.*

LAWRENCE E. SMITH
Chief, Safety Office

Approved for public release, distribution unlimited.

* Note new commercial number.

AMCCOM SAFETY OFFICE RAPID ACTION FIRE PROTECTION SEMINAR

SCHEDULE-23 OCT 84

0800-0820....Administrative details (badging, non-availability statements ect.)

0820-0830...Introduction-Lawrence E. Smith & Robert A. Loyd AMCCOM Safety Office

0830-0840...Welcome-Brigadier General Guy P. Bowen, Deputy Commanding General for Procurement and Readiness, AMCCOM

0840-0900...History of deluge systems-Robert A. Loyd, AMCCOM Safety Office

0900-0915...Break

0915-1015...Ultra-violet & infra-red detector-Bernhard Stinger & Bill Rovick, Detector Electronics

1015-1020...Break

1020-1050...Combination ultra-violet & infra-red detectors-Rodger Wendt, ARMTEC

1050-1115...Deluge systems for Ammunition Peculiar Equipment-Jerry Miller, Tooele Army Depot

1115-1200...Lunch

1200-1300...Solenoid operated deluge systems-W. Alan Cozby & Gary Fadorsen, Automatic Sprinkler

1300-1315...High speed video recording systems-Bob Wilson, Video Logic

1315-1330...Break

1330-1430...Squib operated deluge systems-Joseph H. Priest, Charles Pappas, & H.A. Thompson, Grinnell Fire Protection Systems

1430-1500...Discussion & summary

AMCCOM SAFETY OFFICE RAPID ACTION FIRE PROTECTION SEMINAR

SCHEDULE-24 OCT 84

0800-0805...Introduction-Robert A. Loyd, AMCCOM Safety Office

0805-0830...Problems and Challenges of Deluge Systems-Bill Shirley, Louisana AAP

0830-0910...Design, Installation, Operation, & Maintenance of Deluge Systems-Gene Burns, Lonestar AAP

0910-0915...Break

0915-1000...Installation, Operation, Testing, & Maintenance of Ultra-Violet Detectors-Stan Straker & J.R. Brazell, Indiana AAP

1000-1015...Break

1015-1045...Installation, Operation, Maintenance of Deluge Systems-B. Andersen, Iowa AAP

1045-1115...Site Water Supply For Deluge Systems-Manuel Avelar, Ammann & Whitney

1115-1200...Lunch

1200-1300...Obtaining Properly Designed & Installed Ultra-High Speed Deluge Systems-Louis Joblove, Ammann & Whitney

1300-1330...Installation, Operation, and Maintenance of Infra-Red Detectors-Bob Kimball, Radford AAP

1330-1345... Break

1345-1430...Response Time--An Open Discussion-Robert A. Loyd, AMCCOM Safety Office

1430-1500...Discussion and Summary

INSTALLATIONS AND ORGANIZATIONS REPRESENTED

AMCCOM

Armament Research and Development Center
Badger Army Ammunition Plant
Crane Army Ammunition Activity
Hawthorne Army Ammunition Plant
Indiana Army Ammunition Plant
Iowa Army Ammunition Plant
Joliet Army Ammunition Plant
Lake City Army Ammunition Plant
Longhorn Army Ammunition Plant
Louisiana Army Ammunition Plant
McAlester Army Ammunition Plant
Milan Army Ammunition Plant
Mississippi Army Ammunition Plant
Pine Bluff Arsenal
Radford Army Ammunition Plant
Rock Island Arsenal
Rocky Mountain Arsenal
Sunflower Army Ammunition Plant
Watervliet Arsenal

US Army Defense Ammunition Center and School
Production Base Modernization Agency
Conventional Ammunition Management Office - Pacific
AMCCOM - Safety Office
- Inspector General Office
- Joint Activities Office
- Industrial Readiness Directorate
- Weapon Systems Management Directorate
- Installation Services Directorate
- Management Directorate
- Plant Operations Directorate
- Defense Ammunition Supply Directorate
- Quality Assurance Directorate

EXTERNAL TO AMCCOM

Industrial Base Engineering Activity
Army Corps of Engineers (Huntsville Division, Louisville Division)
Army Materiel Command Installation Services Activity
HQ, Army Materiel Command
Jefferson Proving Ground
Tooele Army Depot
Letterkenny Army Depot

VENDORS AND MANUFACTURERS

Amman and Whitney
Detector Electronics
Automatic Sprinkler
Grinnell
Video Logic
Armtec

RAPID ACTION FIRE PROTECTION SEMINAR

23-24 Oct 84

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NOTE: The new commerical exchange for Rock Island Arsenal is 782. It replaces 794.

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Alan Petersen	Detector Electronics	Vice-President	(612) 941-5665
Bob Wilson	Video Logic	Region Sales Mgr	(312) 969-4980

ULTRA-VIOLET & INFRA-RED DETECTORS

BERNHARD STINGER

&

BILL ROVICK

DETECTOR ELECTRONICS CORPORATION

6901 West 110th Street

Minneapolis Minnesota 55438

Today I would like to discuss application of UV detection systems in radioactive environments, and application considerations of infrared, combination infrared, and combinations of ultraviolet and infrared. We will also review recent developments in high speed single frequency infrared detection systems and their applications to munitions processes.

To understand the techniques used in applying ultraviolet flame detection in hazards involving nuclear radiation, I would like to very briefly review the basic operating principles of UV flame detection.

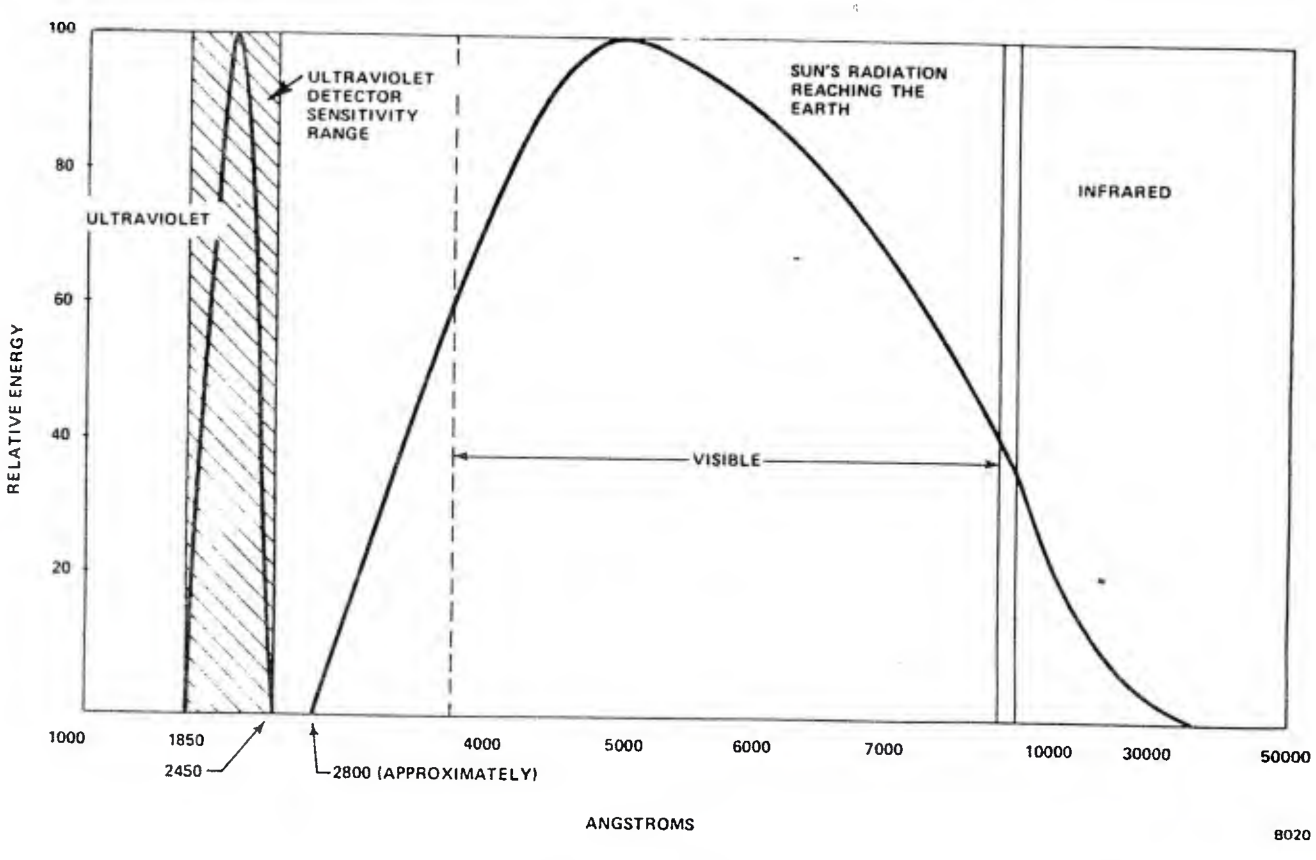
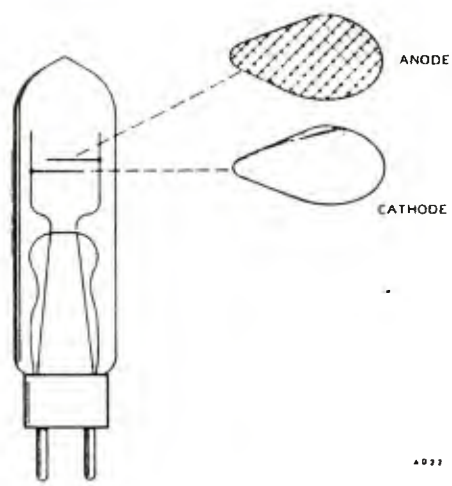


Figure 1

This slide illustrates the general relationship between solar radiation at the earth's surface and the spectral response region of typical gas-filled ultraviolet sensors.

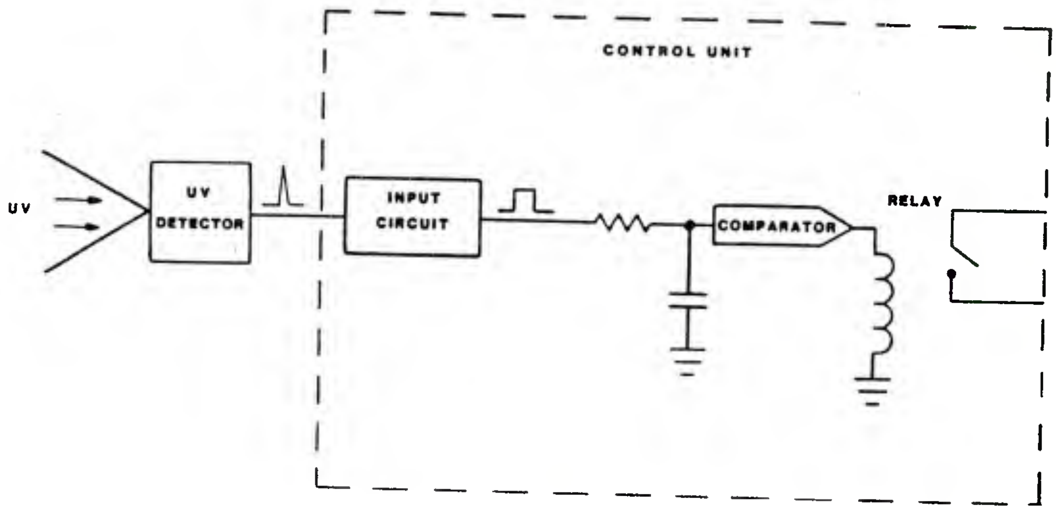
Ultraviolet fire detectors use a gas filled cold cathode sensor tube which is specifically designed to respond to an extremely narrow band of radiation of 1850 to 2450 angstroms. As you will note from the slide, the solar radiation spectrum is between 2850 to 30,000 angstroms. Therefore, the tube does not respond to solar radiation or normal ambient light. The visible region is from 4000 to 7000 angstroms and the infrared, beginning with the commonly defined "near infrared" spectrum begins at 7500 angstroms or 0.75 microns to as high as 1000 microns at the extreme infrared portion of the spectrum.



DET-TRONICS ULTRAVIOLET DETECTOR

Figure 2

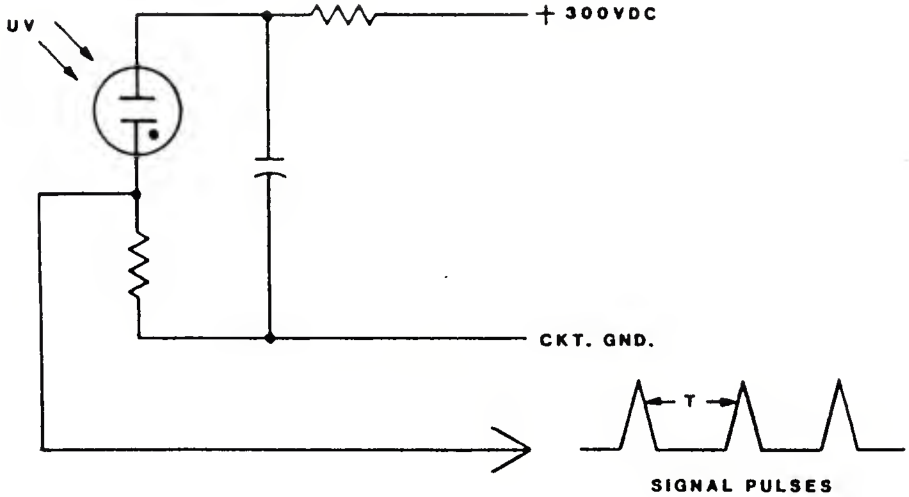
The UV detection tube produces an output of distinct current pulses. Each pulse is produced when photons of ultraviolet energy strike the photosensitive cathode, ejecting an electron. This negatively charged electron is attracted to the anode which is at a plus 290 volt potential. Since the tube envelope is gas-filled, these electrons collide with gas molecules on their way to the anode, releasing more electrons which are also attracted to the anode. The result of this ionization process is a sharp increase in current flow within a few microseconds.



BASIC UV FIRE DETECTOR

Figure 3

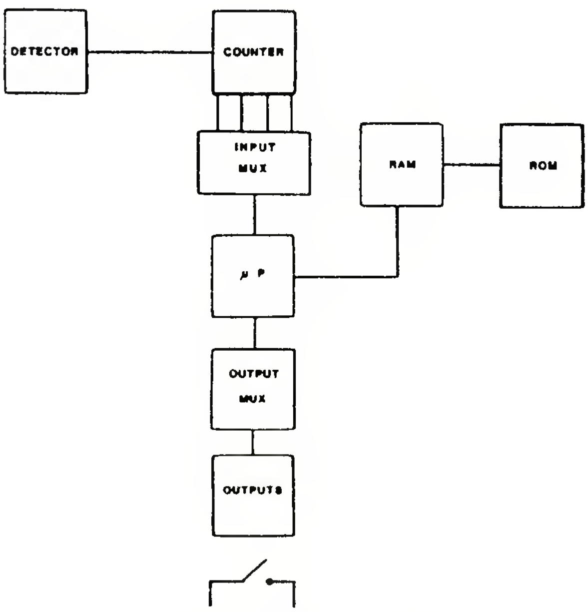
In a typical circuit, a detector tube will conduct current when there is a potential of 250 volts across the electrodes and a photon with the proper energy strikes the cathode. Once the tube begins to conduct, it will continue to conduct unless the voltage is brought below the ionization voltage of approximately 175 volts. The basic tube electronics insures that there is enough voltage to initiate the ionization, and that the voltage decreases enough to extinguish the ionization. The result is an output of distinct pulses whose frequency is proportional to the intensity of the radiation. Therefore, it is necessary to measure a number of discharges per unit time (which sets the sensitivity) before any action is taken. It is important to remember that a single count or ionization can be initiated by normal background cosmic radiation.



TYPICAL UV DETECTOR CIRCUIT

Figure 4

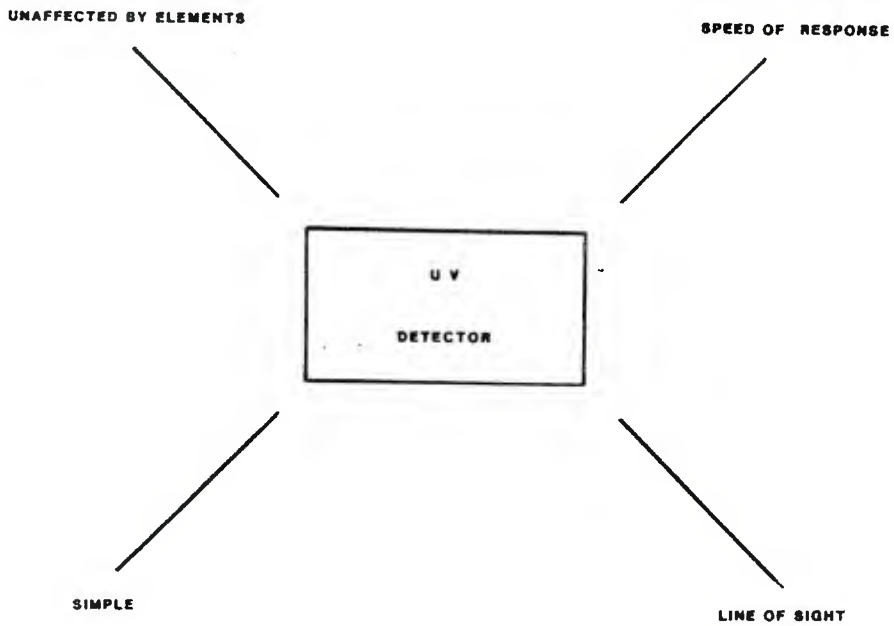
The basic circuitry used for counting pulses in the past has been to take the pulse of the detector tube, amplify and square the pulse into a known time period and use that pulse to charge a capacitor.- After the capacitor is charged to a pre-calibrated threshold voltage, an output signal will energize the alarm relays and deluge systems.



MICROPROCESSOR (µP) BLOCK DIAGRAM

Figure 5

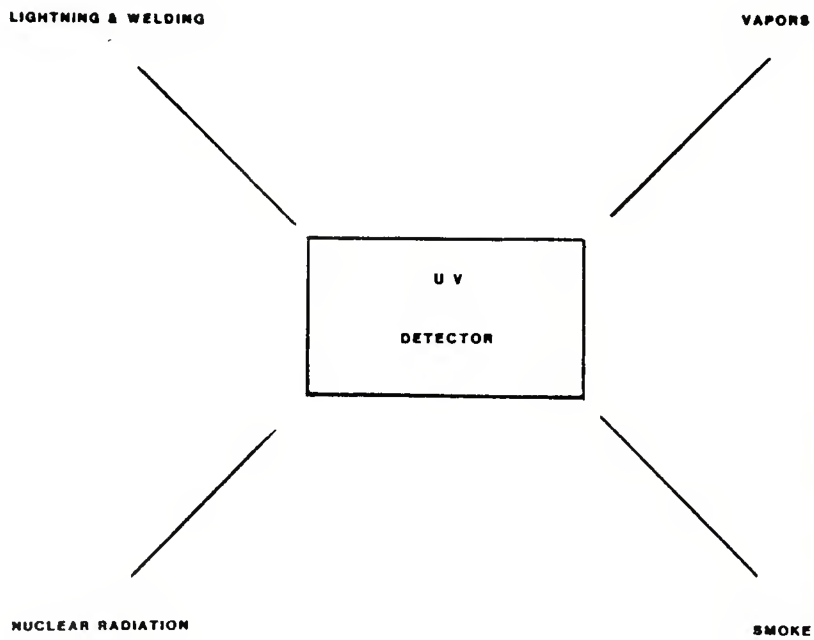
With the advent of microprocessors in the mid-seventies it became possible to count and process the digital pulses from the UV detectors. Now pulses no longer need to be stored in capacitors but can be individually counted, entered into the microprocessor, stored in memory and manipulated like any type of data processing information. This allows the design of flexible ultraviolet fire detectors using programmable memories and switches to provide an infinite number of combinations. Thus we now have a marriage of gas filled vacuum tube UV detection devices which have existed for several years with state-of-the-art microprocessors.



ADVANTAGES

Figure 6

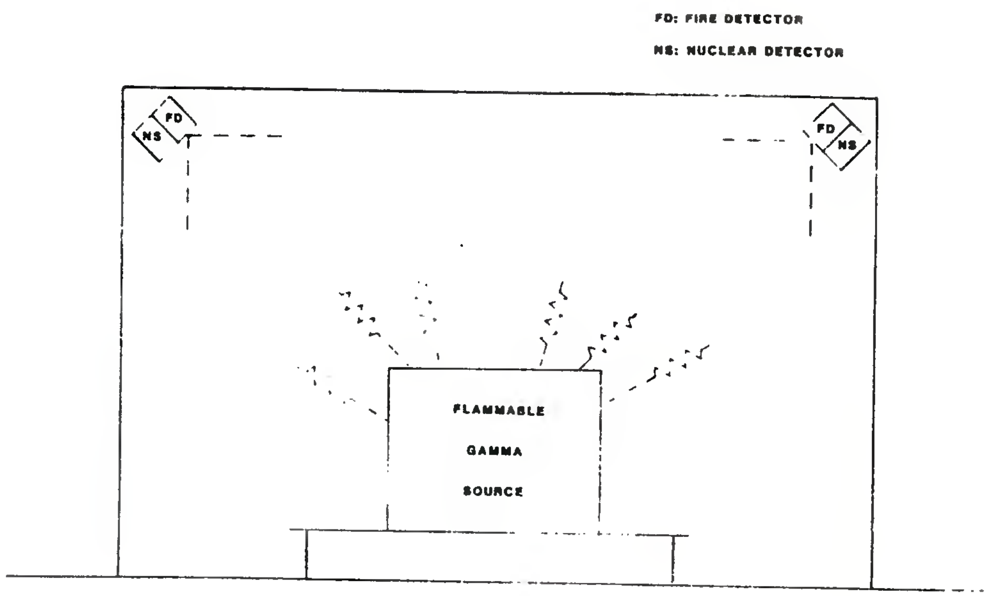
Ultraviolet radiation detectors are good general application devices. The fire signature they seek is the ultraviolet emitted by flames. Because they can be made solar blind and are not affected by heat radiation, they can be applied in a wide variety of applications.



LIMITATIONS

Figure 7

Although UV fire detectors have many advantages, they also have their limitations. Lightning and welding problems have been minimized using a combination of UV and IR detection. These systems require simultaneous sensing of both UV and IR radiation at selected frequencies. Such systems are finding wide use in applications such as aircraft hangars. However, the signal processing time required does not in general, provide the millisecond response needed in most munitions applications. We have pointed out that electromagnetic wavelengths below 1800 angstroms will not penetrate the tube envelope; however, the ultraviolet band is adjacent to that of xrays. This, in turn, is adjacent to that of gamma radiation. Both emit high energy particles that travel at less than the speed of light, and these easily penetrate the tube envelope. Once inside, they eject electrons from the cathode of the sensor in a similar manner as occurs with ultraviolet radiation. By pairing the UV sensor tube with a modern microprocessor, this application limitation has been eliminated through a technique known as nuclear surveillance.



NUCLEAR SURVEILLANCE

Figure 8

In a nuclear surveillance system there are two detectors; one is optically blinded, while the other is viewing the hazardous area. The blinded detector and the fire detector will respond similarly when exposed to nuclear radiation. If there is a fire in the area, the blinded detector will not respond but the fire detector will respond. If there is nuclear radiation in the area, but not enough to saturate the detectors, then the blinded detector will subtract that amount of radiation from the fire detector. The fire detector will still be able to respond to UV radiation from the fire. The nuclear radiation detectors can subtract about 75 milirads per hour of gamma radiation before locking out the system. The system will be automatically rearmed as soon as the radiation level goes below 75 milirads per hour. In a nuclear surveillance system setup of the detectors during initial installation is very important. If, for example, every time a nuclear hazard comes into the area the detectors become saturated and can't see a fire, then the system needs to be evaluated more closely and ultraviolet fire detection may not be suitable for this application. It is also important that both the fire detectors and the surveillance detectors are programmable so that they can take into account differing applications without being unnecessarily desensitized.

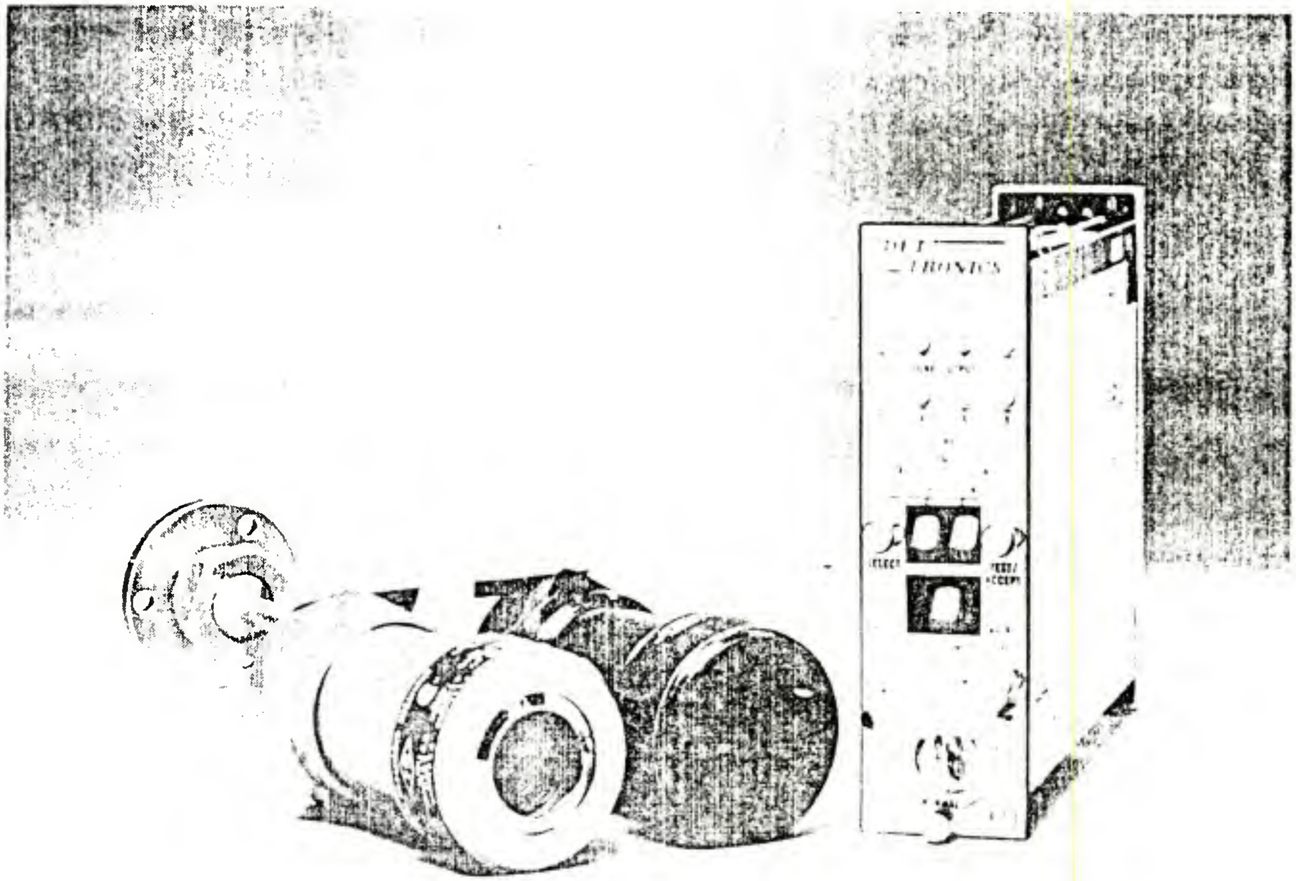


Figure 9

This slide illustrates the equipment used in a typical nuclear surveillance system. The detector consists of a standard UV detector mounted next to a similar detector module with its quartz window capped, making it blind to UV. The microprocessor based controller can accommodate up to 4 sets of detectors. Up to 4 controllers can be interconnected by a common data bus to provide up to 16 zones of detection.

Today's fire protection system designer has a wide variety of detection methods available. While the use of narrow band pass filters is limited in ultraviolet detection by the low signal strength by fires in that region, the opposite is true in the infrared spectrum. Advances in the development of commercially viable solid state sensors combined with excellent narrow band pass filters has led fire detector designers once again to the infrared end of the spectrum. However, as with ultraviolet there are advantages and certainly, limitations.

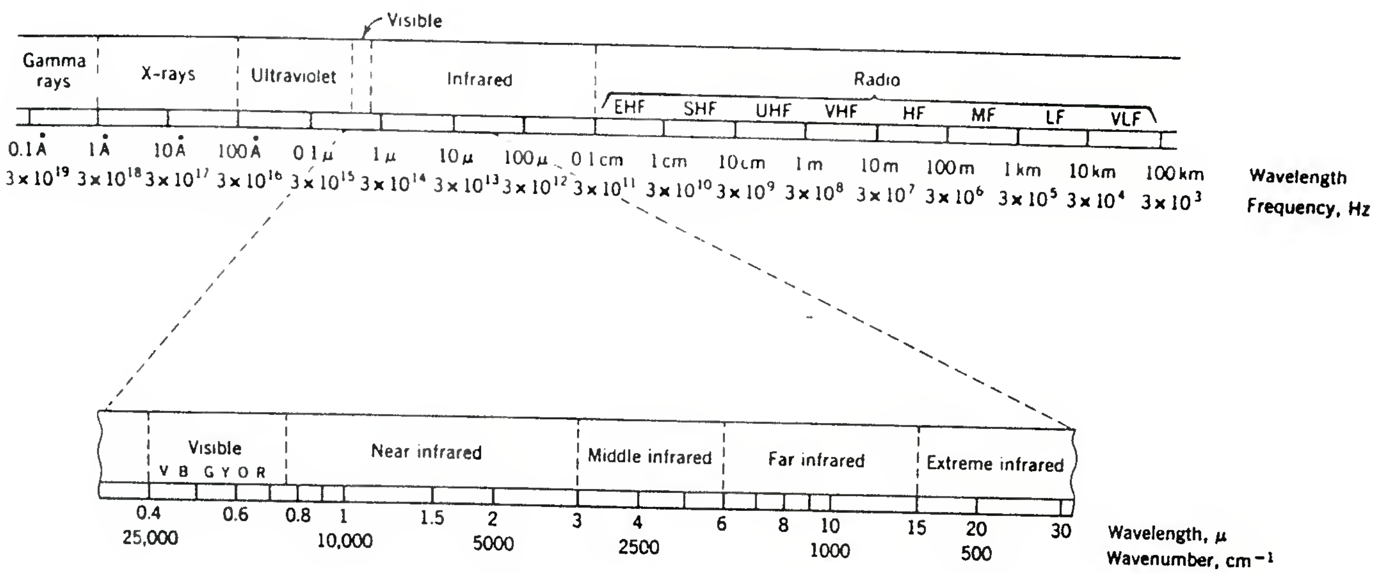


Figure 10

This figure illustrates the IR spectrum more clearly.

Several advantages of IR units make them valuable in certain installations:

1. They do not respond to strong ultraviolet radiation from electric arc welding, and the infrared emitted by the heating of the metal is of low signal strength.

2. Xray and gamma radiation do not extend to the infrared and neither the single frequency or multi-frequency IR units are affected by them.

3. Smoke does not absorb strongly in the IR spectrum, making devices of this type particularly useful where heavy smoke concentrations may accompany a fire. However, care must be taken that IR absorbing dusts are not part of the hazard.

Because of these characteristics, many combinations of UV and IR are now available to the fire protection designer, and properly applied will perform well in many commercial applications. However, it is extremely important to remember that the signal processing techniques necessary for reliable and stable detector operation may slow down the response time. In contrast, the requirements of the munitions industry have become more critical, requiring faster overall detection to extinguishment response times. The IR spectrum is broad and there are many sources of IR which radiate over the entire IR band. Typical are hot manifolds, boilers, processing vessels, engines and the sun itself. The background radiation from a heat source can actually mask the presence of fire and result in failure to respond. Attempts to use the well known flicker principle cannot be totally relied on to discriminate flame from background because of such things as vibrating panels and manifolds. Easily imaginable occurrences such as sun reflecting from moving water will provide flicker frequencies that can confuse a sensing device. Some munitions applications require flame detection in enclosed spaces such as mixers, melters, conveyors and drying hoods, which can deposit materials on the viewing windows of an optical detector.

Figure 11 illustrates a typical enclosed mixer application in which up to four sensors are mounted inside the upper housing viewing the process directly.

Figure 12 shows a close up of the bowl assembly, with deluge piping visible.

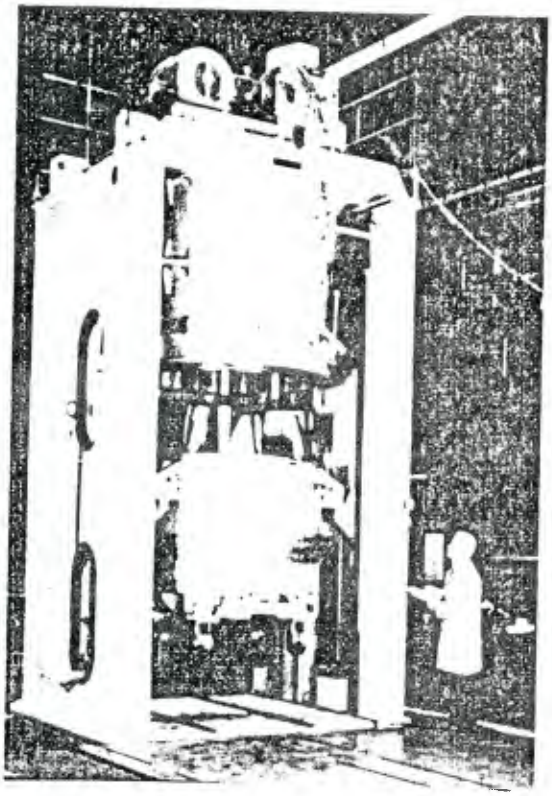


Figure 11

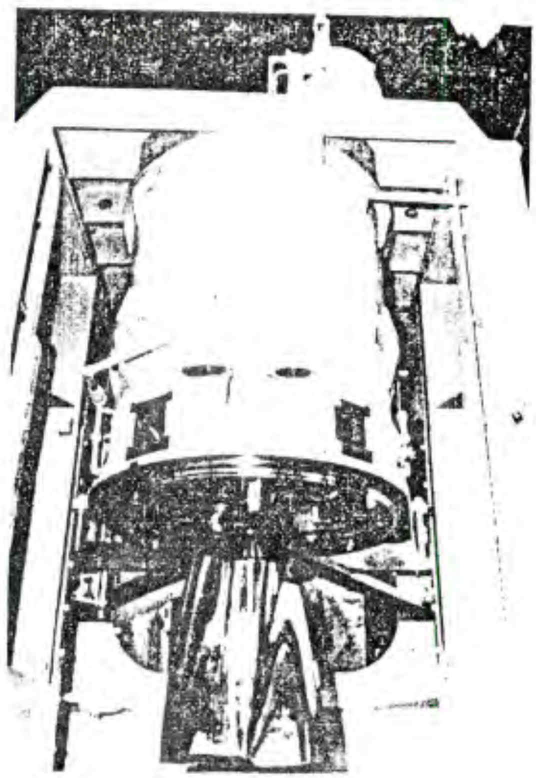


Figure 12

The wavelength of infrared detectors operating in the near IR regions makes them more tolerant to lens contamination, and in general, can see through certain vapors more successfully than ultraviolet. However, to achieve the fast detection times needed, we cannot afford the luxury of the signal processing required to offset the effects of black body radiation and sensitivity to ambient light. Therefore, high speed infrared sensors must be carefully isolated from possible false alarm sources. Such sources include the sun and other black body radiation sources, high intensity lights, flashbulbs, fluorescent and, normal incandescent lighting. Ideal applications for these systems are characterized by strictly controlled, darker environments where a flash fire could originate. While simple high speed infrared systems have been available for several years, modern sensor and filter developments, coupled with state of the art electronics, have resulted in systems tailored for the munitions industry which are more selective within the electromagnetic spectrum, fast in response, and extremely flexible in application to suppression systems.

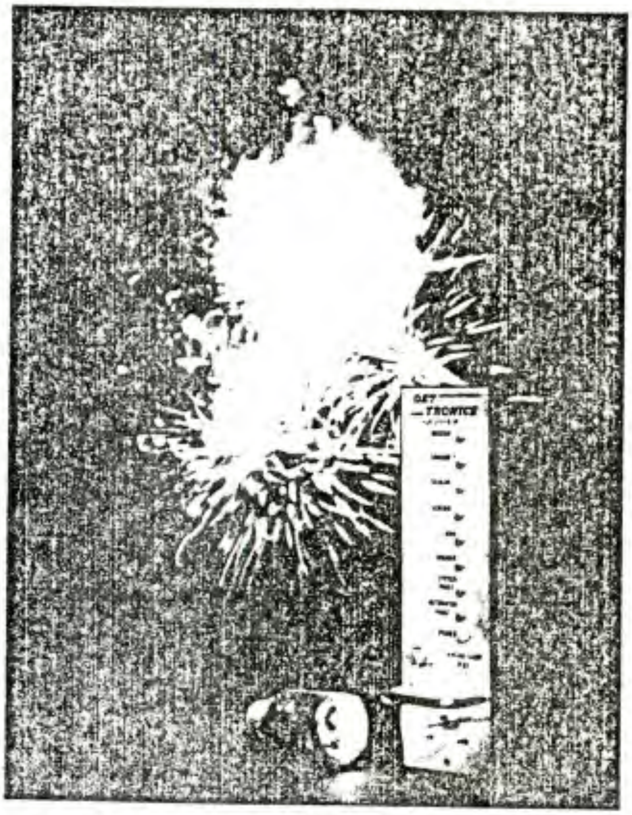


Figure 13

This slide illustrates a typical high speed, single frequency IR detection system which has been designed specifically for applications such as munitions manufacturing and processing. The detector consists of a solid state IR sensor operating in the 0.7 to 0.8 micron range. Since this is in the near IR spectrum, an optical filter is added to minimize extraneous and ambient light sources. The controller can accommodate up to four detectors and will respond when any one of the four senses IR radiation above the alarm threshold. Typically such controllers also electrically supervise interconnecting wiring and explosive squibs or solenoid valves by trickling a small current through the external circuits.

Response time of such systems is a function of ignition size, type of material, ambient air, fumes or vapor composition, distance and orientation of the fire source. Average response times to a high energy IR source can range from a few microseconds to several milliseconds at distances up to 3 feet.

Typically, these systems are recommended to be used in combination with the appropriate high speed ultraviolet systems, combining the advantages of ultraviolet for space protection, with infrared for enclosed areas.

In summary, we have observed that ultraviolet and infrared fire detectors both have definite advantages, but also limitations. Combination detectors may be too slow for some munitions applications. By utilizing microprocessor technology, optical integrity and remote surveillance, previous limitations have largely been overcome. As fire detector manufacturers we feel a responsibility for clearly defining both the advantages and limitations of equipment we supply, which enables the fire protection engineer, and the end user as well, to skillfully and properly determine the correct detection equipment for a given application. A more detailed discussion of detector application is available in Det-Tronics' Detector Selection Guide, Form No. 92-1002.

FALSE ALARM REDUCTION

IN

INDUSTRIAL FLAME DETECTION

Presented by
Roger A. Wendt
Sr. Project Engineer
Armtec Industries, Inc.
Manchester Municipal Airport
Manchester, New Hampshire
October 23, 1984

For years high speed industrial fire detection was accomplished with UV (Ultraviolet) flame detectors. UV detectors are a natural for high speed detection. They respond rapidly to flame, typically within 15 milliseconds (thousandths of a second). UV detectors are a good method of detection because UV is always present in fires, and because extraneous sources of UV are not normally present in sufficient intensity to cause false alarms. In addition, non-fire sources of UV are few and well defined. Many schemes such as time delay, signal processing, voting, inhibit zone and so forth have been developed to compensate for false alarm sources. IR (infrared) detectors began to reappear to eliminate welding as a major false alarm source for UV detectors. IR detectors had been in use before the development of UV detectors. IR detectors, however, had so many problems with false alarm and reliability that UV detectors became the prime industrial detector. New technology in IR sensors have vastly improved detection capability and reliability. IR detectors are, however, not without false alarms, but rather in typical industrial applications have 2 to 4 times the false alarm rate of UV detectors. The solution to eliminating false alarms is then to develop dual or multiple sensor detectors which have sensors that view <u>independent</u> optical regions, spectra, so that the coincidence of two false alarms occurring simultaneously is unlikely.

To design a high speed dual spectrum detector, one must first research the field of false alarm sources for UV and IR spectra to determine which spectra are lowest in potential false alarm energy.

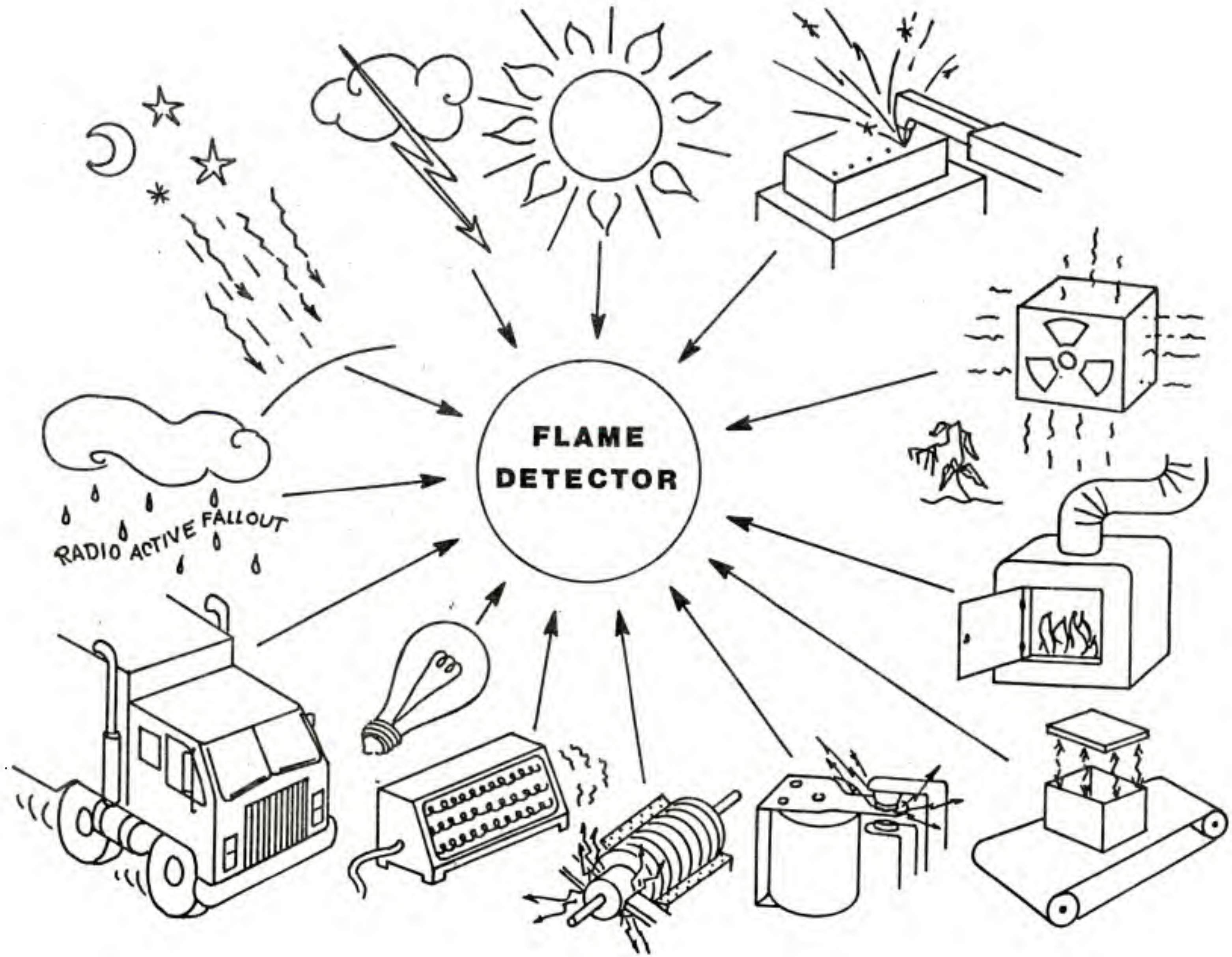


CHART 1

Chart I illustrates the potential sources of radiant energy which could cause false alarms. The false alarm sources may be categorized into three broad categories - Random, Periodic and Continuous.

Random radiant false alarm sources are generally caused by natural occurring phenomenan. Typical random sources of false alarms are as follows:

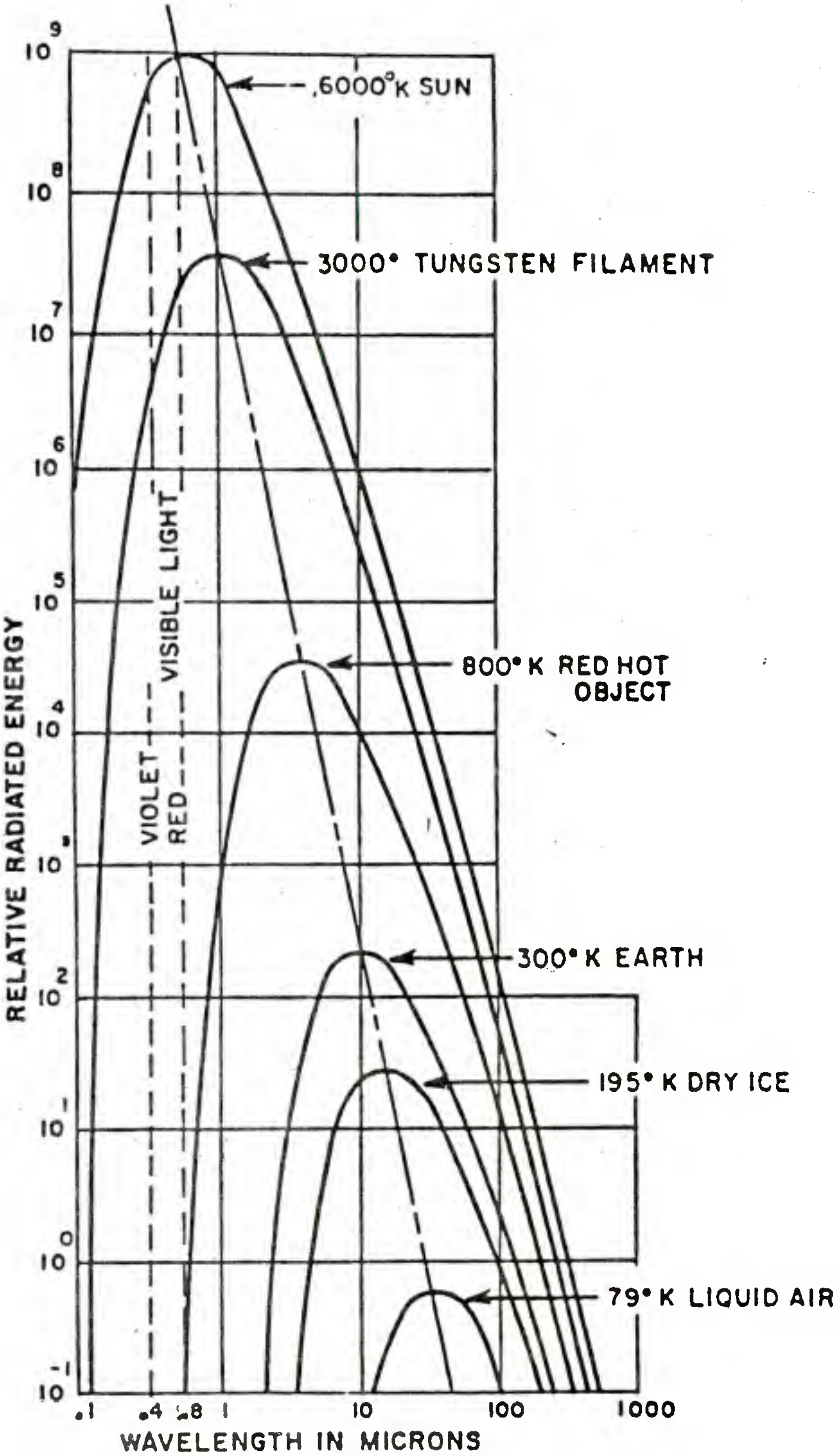
UV	IR
Cosmic Rays	Hot Objects
Radioactive Fallout	Rapid Temperature Changes
Lightning	
Electrostatic Discharges	

Periodic radiant false alarm sources are generally manmade or caused by the sun. Typical periodic sources of false alarms are as follows:

UV	IR
Arcing Brushes	Clouds Moving Across The Sun
Arcing Contacts	Reflected Sun
Electrostatic Discharges (Conveyors)	Shimmering Sun
Welding Reflections	Fan Blades In Front of Heaters

Continuous radiant sources of energy which cause false alarms are typically manmade or the unobstructed sun. The main continuous sources of false alarms are as follows:

UV	IR
Welding	Engines
Radioactive Material	Ovens
X-rays	Furnaces
	Lamps
	Sun
	Hot Body (See Chart #2)



Spectral characteristics of blackbody radiation from objects at different temperatures

CHART 2

As detectors are made less sensitive to false alarm sources, the user typically allows the use of more sources of energy in the protected area which then makes the job of protecting against false alarms much more difficult. The greater the fire detection system discrimination capability, the more it is put to the test, tried, in environments which are begging to alarm the system. It can get to the point where the false alarms are no longer false, but rather real flame sources. The challenge of the designer can become absurd to the point of requiring the system to discern the difference between "friendly" and "un-friendly" flames. One example of this is the use of acetalyne torches in areas with active flame detectors. The designer must determine specifically which false alarm sources his system can guard against. Therefore, systems from different manufacturers guard against different sources of false alarms.

In addition to radiant energy false alarm sources, there are numerous sources of electrical signals which can produce false alarms in the electronic controls, see Chart #3. They may also be classified as Random, Periodic, or Continuous.

Examples of random energy source which can cause erroneous electrical signals are:

EMI (Inductive Equipment Turning On and Off

Power Loss } (Generally occurring at the Power
}---
Power Surges } Station or along the power lines)

Poor Connections

Humidity Producing Unwanted Conduction Paths

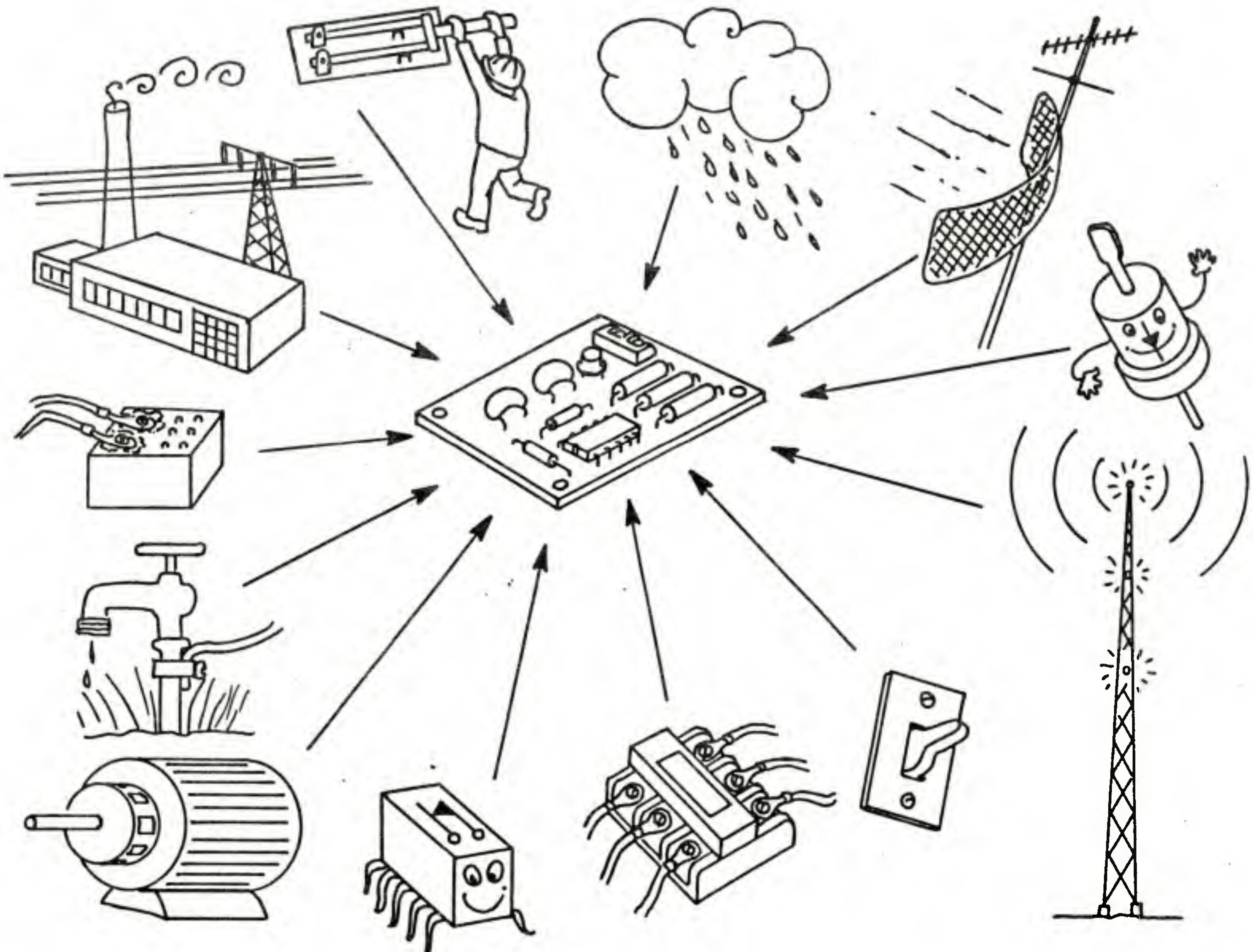


CHART 3

Examples of periodic energy sources which can cause erroneous electrical signals are:

Current Surges (Including Motors Starting)

Contactors Switching

Relays Switching

Examples of continuous energy sources which can cause erroneous electrical signals are:

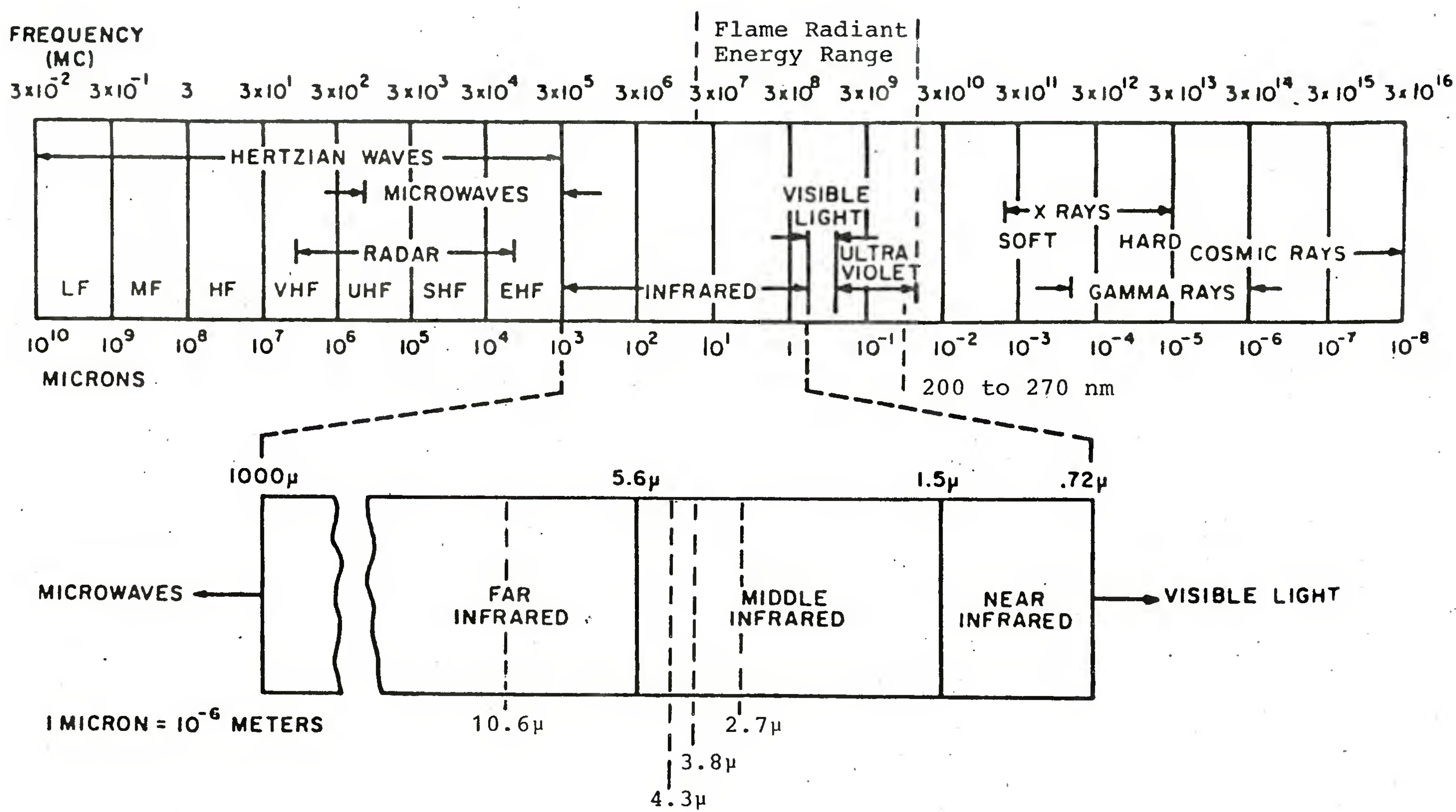
RFI (From Radio Transmitters, TV Stations, Microwave, Radar)

S.C.R. Switching (From Motor Speed Controls and Induction Heaters)

60 Hz Due To Poor Grounding

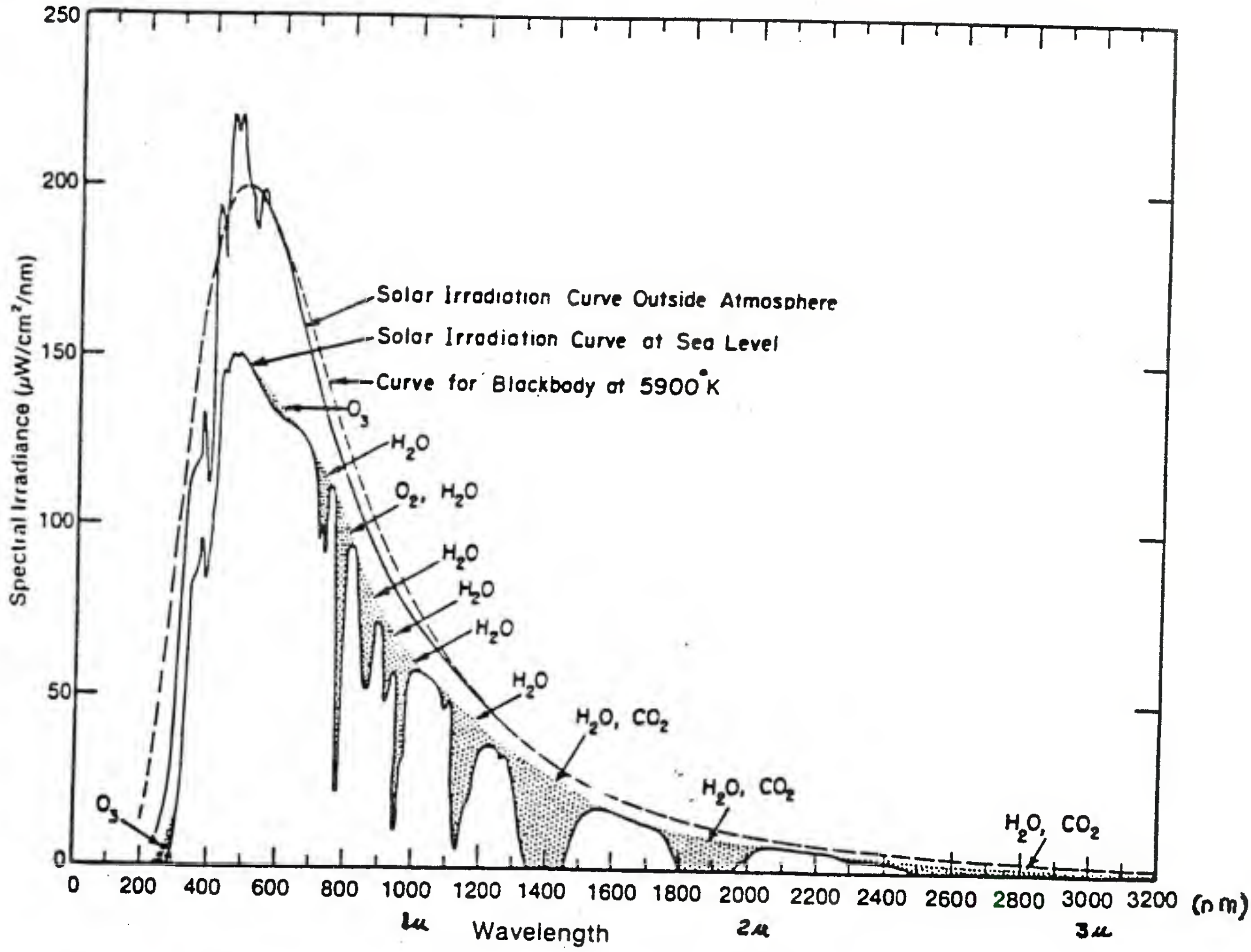
The solution to eliminating false alarms will always be complicated by the human factor. The proper operation of the best single sensor detectors will always be thwarted by occasional mistakes or failures which generate excessive radiant or electrical energy and cause a false alarm. The goal is to design equipment which ignores the vast majority of random problems.

A highly effective method of being selective against false alarms is to utilize two sensors whose spectral response is in two independent spectral areas with respect to false alarm sources. The problem of selecting the spectral areas to be used is apparent when comparing the sun and hot body radiant energy spectra, see Charts 2 & 5. The sun and hot bodies are the major sources of potential radiant energy that will cause false alarms. It becomes obvious that most of the spectral regions are affected by these two sources of false



The location of the flame region in the electromagnetic spectrum.

CHART 4



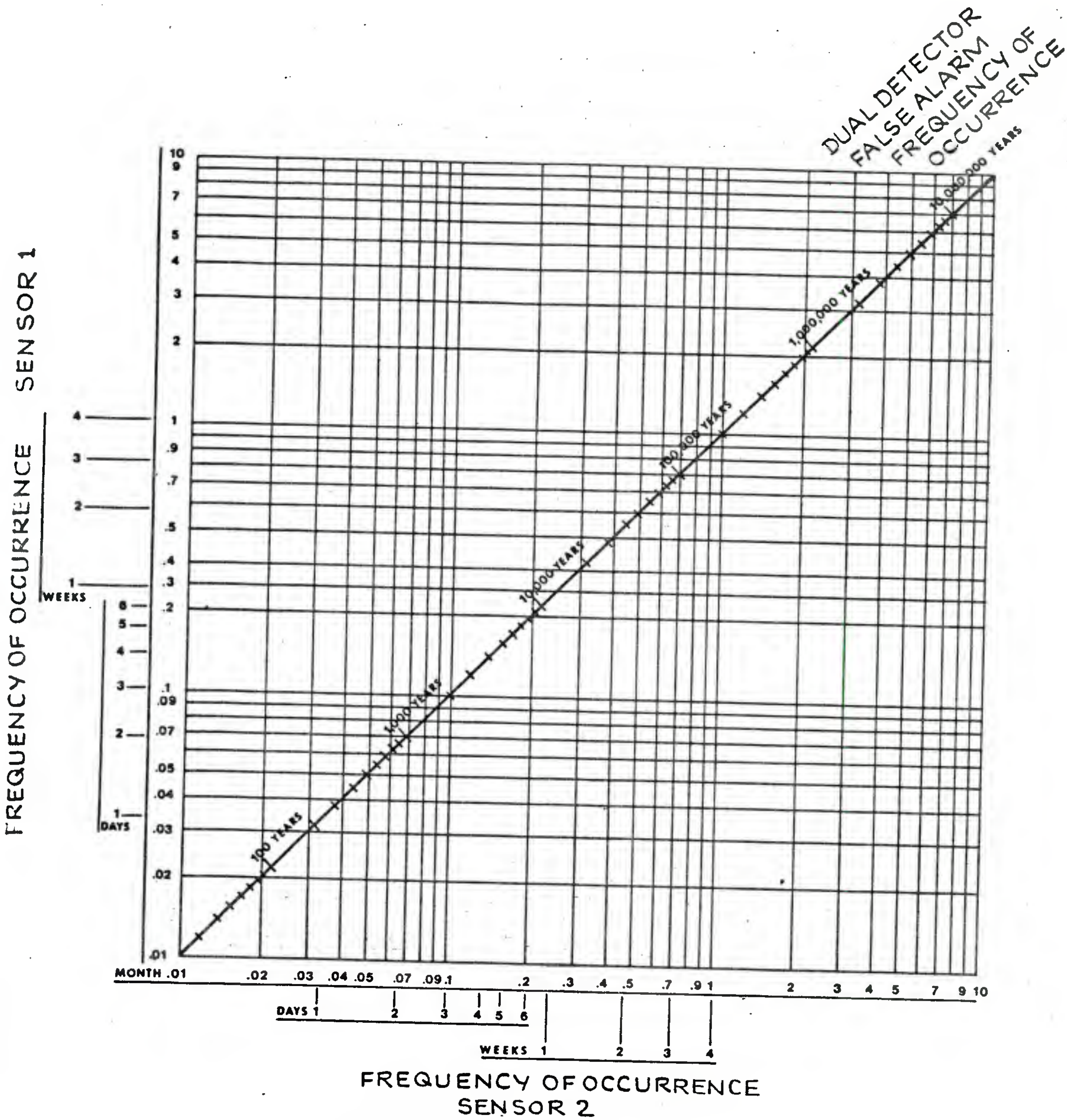
SOURCE: Valley 1965.

Regions Where Molecular Absorbers are Effective (Spectral Irradiance versus Wavelength)

CHART 5

alarm energy. Furthermore, the spectral regions of detector sensitivity must be chosen within the spectral region of the flame. The best that can be accomplished is to select spectra with the least solar and hot body radiant energy compared to flame radiant energy, that is the best signal to background ratio. The detector does, in additon, need to be able to sense a flame.

The electromagnetic spectrum as shown on Chart #4, illustrates the region where radiant energy may be sensed for detecting flames. The reason that only certain spectra are utilized is due to the difficulty in finding "quiet" spectral regions (Quiet in the sense that there is low background false alarm energy compared to the flame energy). Popular spectrum are the shortwave UV (190 to 270 nanometers) and the IR at 2.7, 3.8, 4.3, and 10.6 micron. Since the sun is a major source of potential false alarms, the majority of detector spectra are selected where the radiant energy from the sun is low. Chart #5 indicates the spectral regions where the energy from the sun is attenuated. The criterion for selection of the two spectra to be utilized should then be mutually independent when considering false alarm sources. Two spectra which stand out as meeting this criterion are short wave UV between 190 and 270 nanometers and IR at 4.3 micron. In each spectral region, the radiant energy of the sun is very low, flame produces a detectable signal, and the spectral regions are widely separated so that single false alarm sources do not have significant radiant energy at both wave lengths simultaneously.



DUAL DETECTOR FALSE ALARM RATE

CHART 6

Chart #6 shows the probability of two independent false alarm sources occurring simultaneously. For example, suppose that false alarm sources last for one second and occur once a day. That is to say each of two single sensor detectors would randomly false alarm once a day. In a comparative situation, a dual sensor detector would only have one false alarm every 237 years based on the laws of probability. This is assuming the 2 sensor detection spectra are independent and the sources of false alarm are independent.

The above example of one false alarm every 237 years sounds impressive until you consider, e.g., an installation of 120 detectors. Now the total facility average false alarm rate is about once every 2 years. With the high cost of clean up this false alarm rate may be considered excessive.

The false alarm rate in modern single sensor UV detectors is, for example, 1 alarm every 10 years. This alarm rate again sounds impressive until you consider a user with say 120 detectors. That user would have on the average, one false alarm every month! The solution is dual independent sensor detectors. The probability of two independent false alarms occurring once a month and producing a false alarm in 120 detectors is once in 216,000 years. (Based on the supposition that the false alarm source radiaton occurs for 1 second each month).

Consider the effect of using dual sensor technology in a high false alarm rate environment. When the false alarm rate of a single sensor detector is once every 2 1/4 days, the false alarm rate of a dual sensor detector is only once in 1,200 years. A plant with 120 detectors will have only one false alarm every 10 years. If the single sensor detectors were used, there would have been 194,666 cleanups due to the false alarms. Approximately 194,665 false alarms are eliminated over a 10 year period by using a dual sensor detector.

If two sensors are so good, then why not 3 or 4 or more sensors? Using simple "AND" logic, detection time is limited to the response time of the slowest sensor. With additional sensor discrimination, detector response time is increased due to requirement of 3 coincident signals rather than two. This is due to the decreased probability of three coincident signals occurring instantaneously. As more detectors are used, the closer the spectral bands become closer and the detectors less independent to a single source of false alarms. For example, if one sensor is sensitive at 3.8 micron and the other at 4.3 micron they cannot be considered independent to a false alarm.

Since all sources of false alarms are not independent, especially in cases where there are continuous man made radiant sources to cause false alarms, additional precautions are taken with electronic signal processing. In simple systems, "AND" logic is

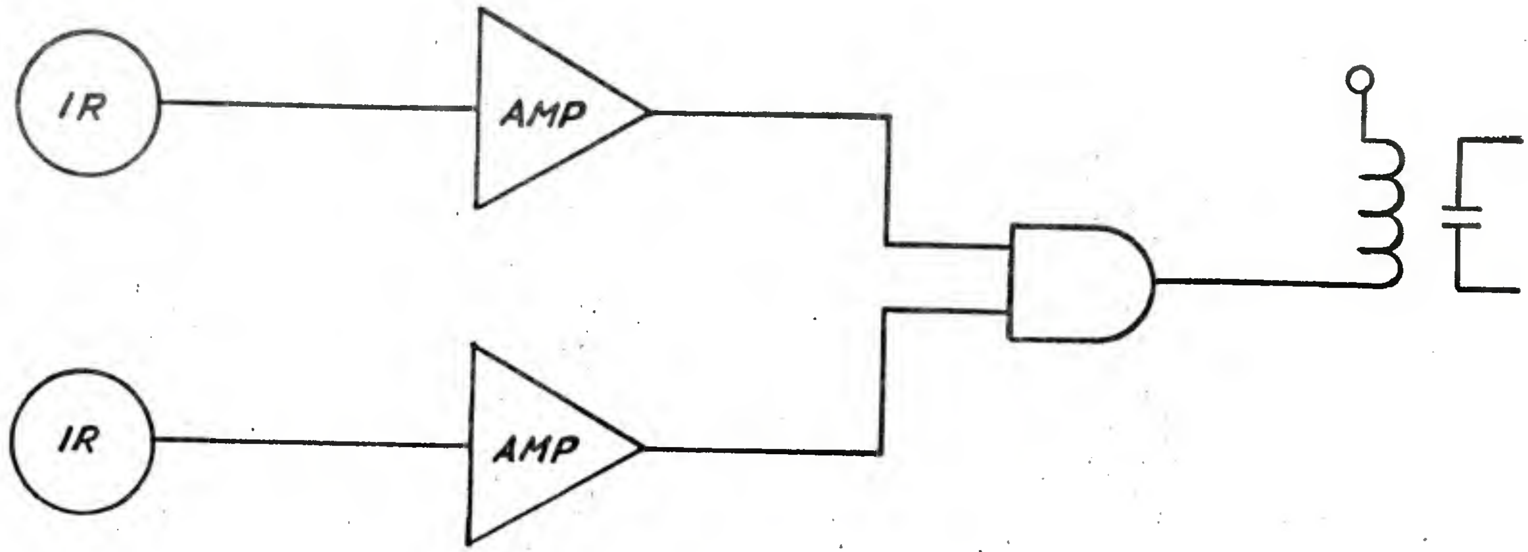


FIGURE 1

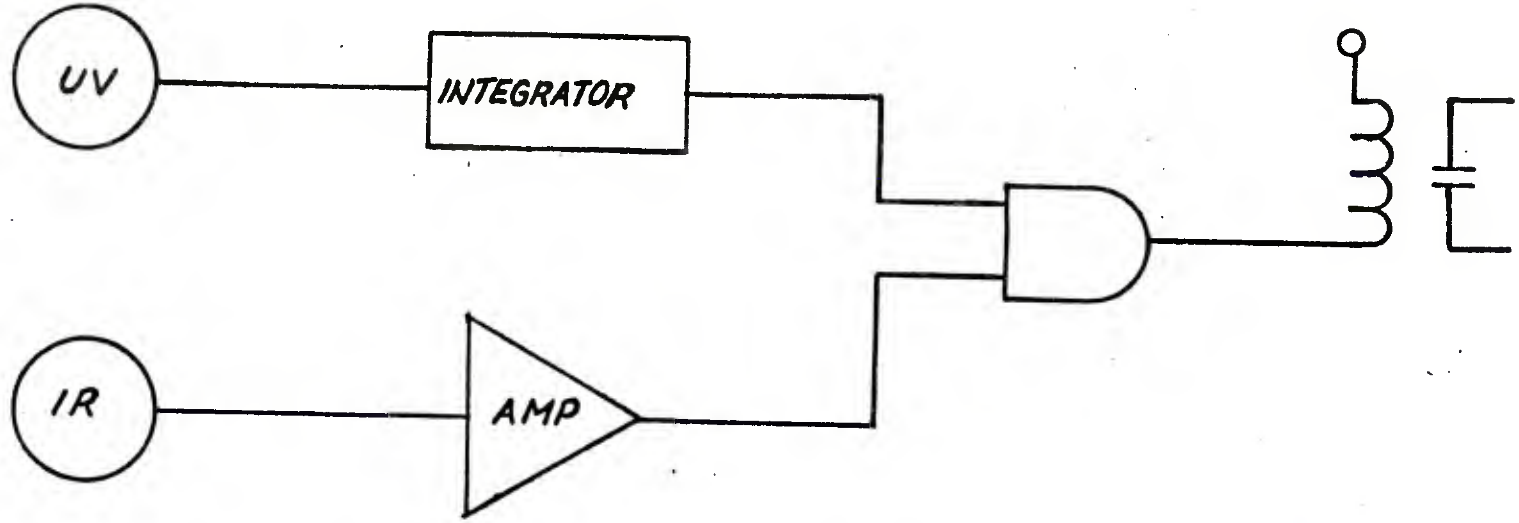
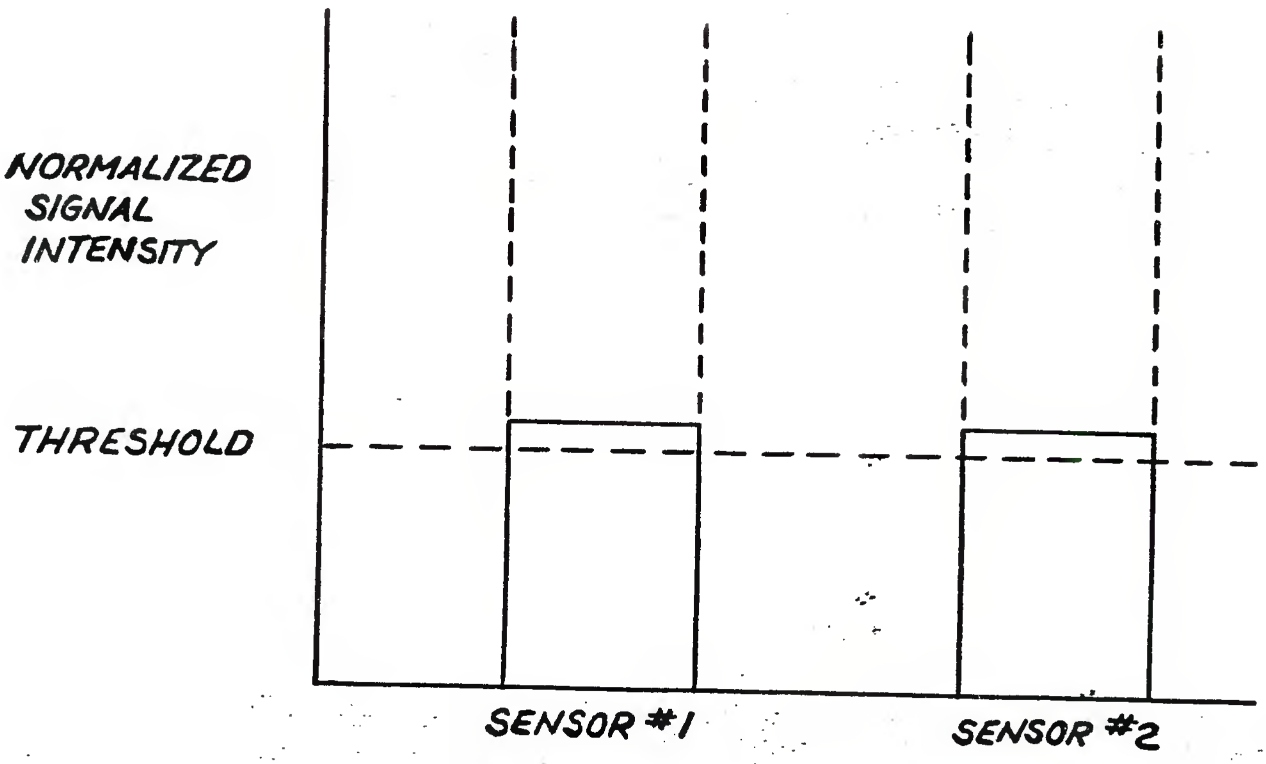


FIGURE 2



"AND" LOGIC

CHART 7

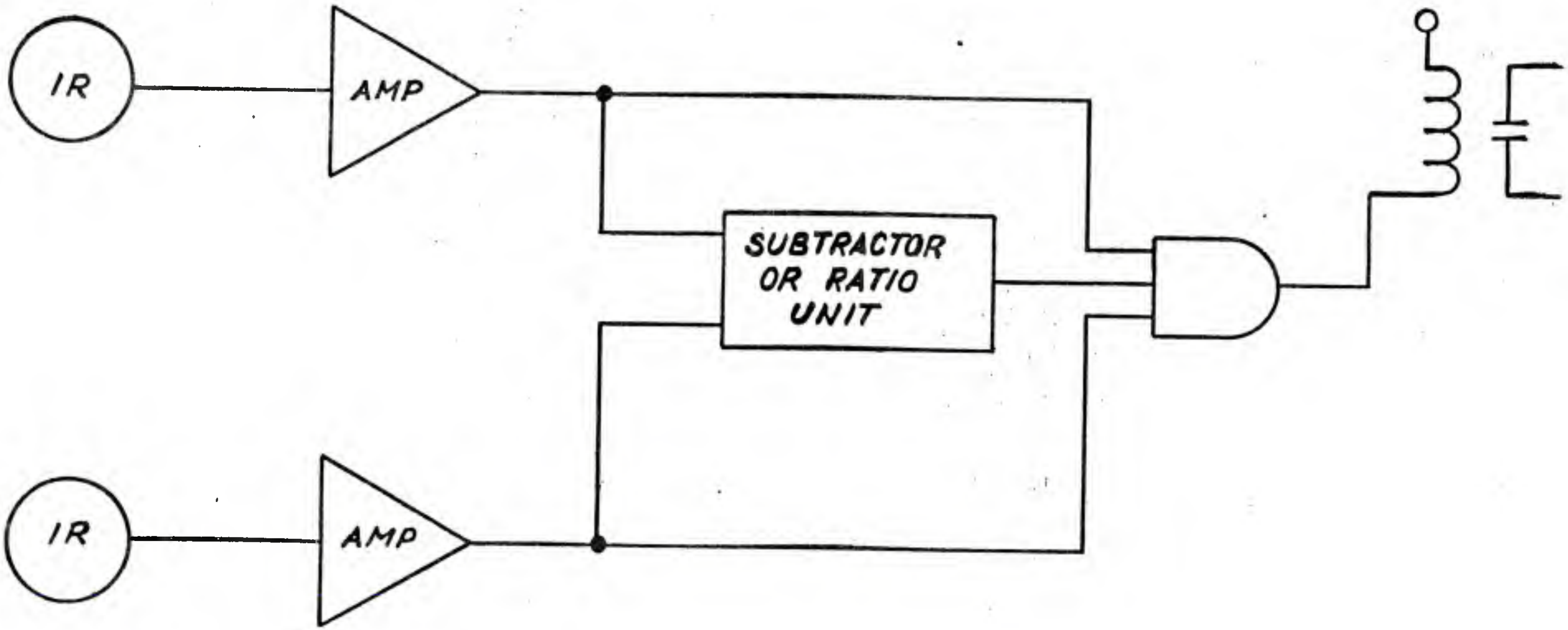
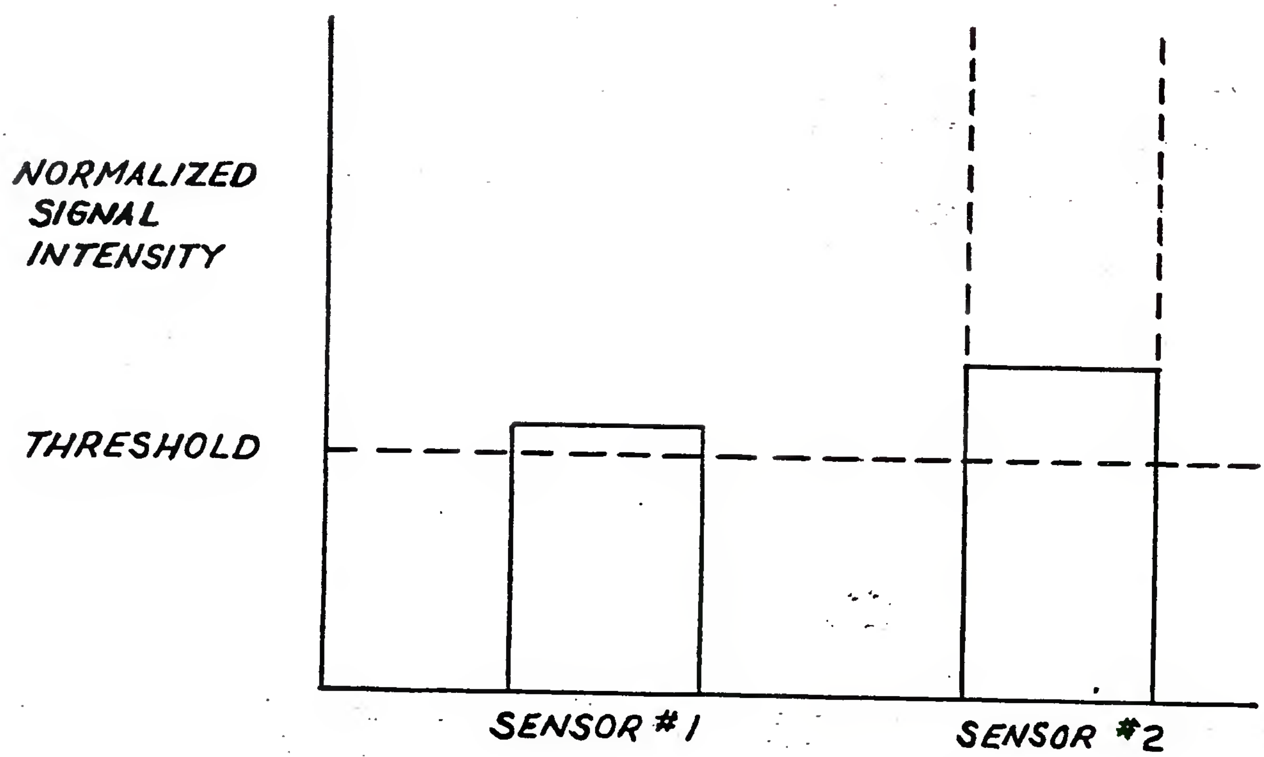
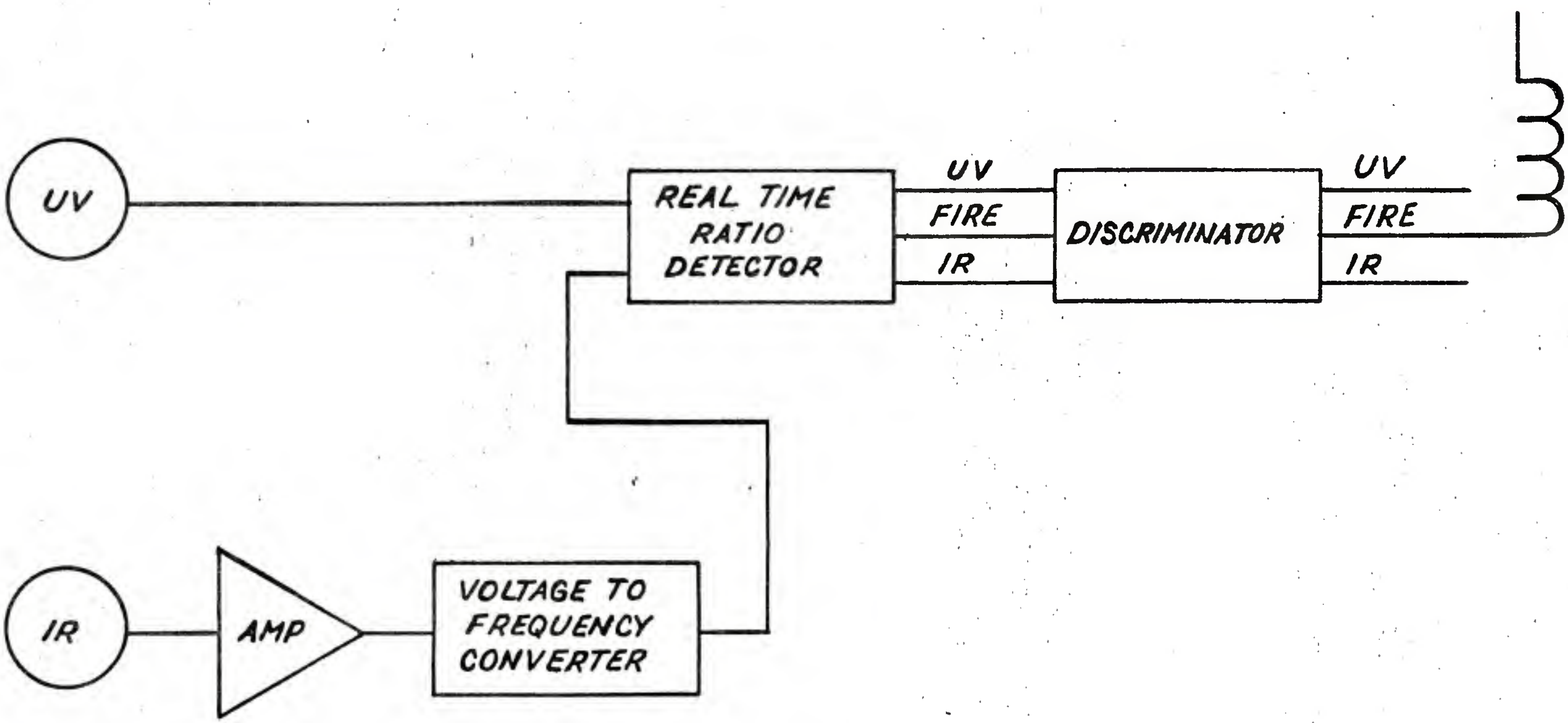


FIGURE 3



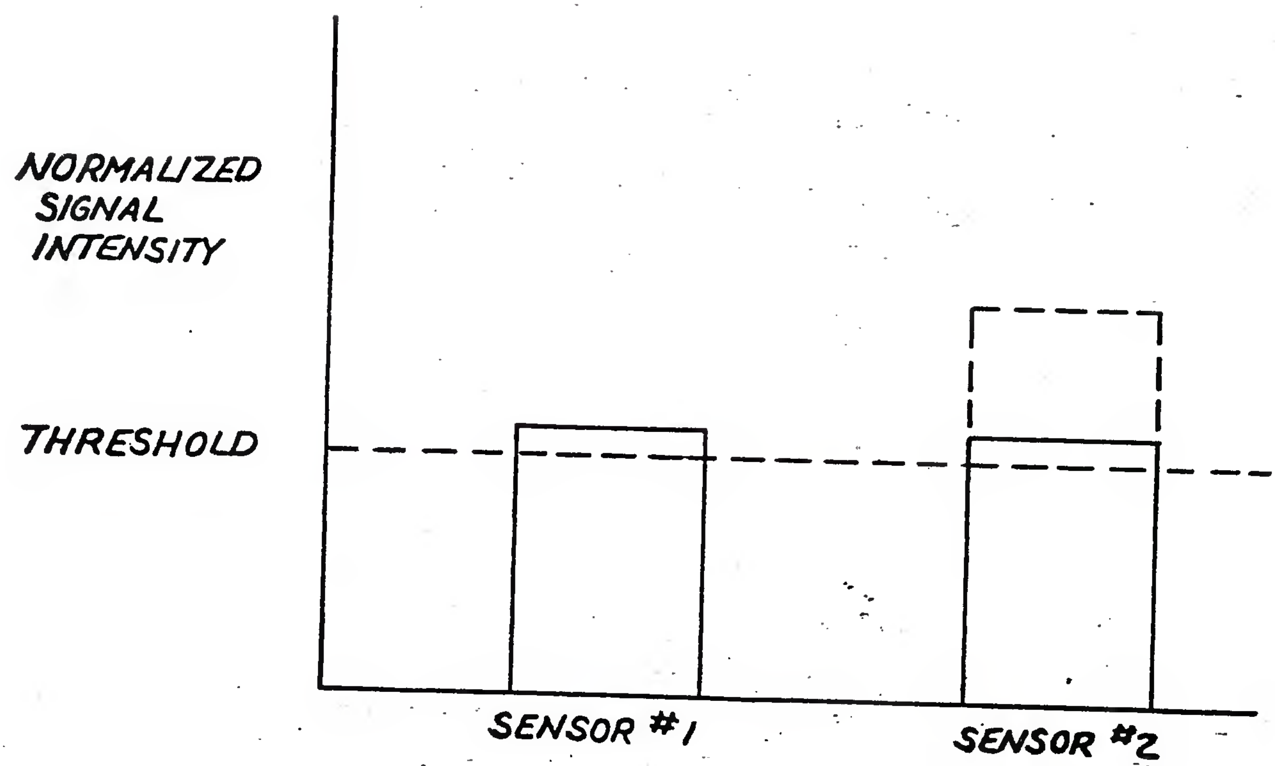
SUBTRACTION LOGIC

CHART 8



UV
REAL TIME
RATIO
DETECTOR
UV
FIRE
IR
DISCRIMINATOR
UV
FIRE
IR
IR
AMP
VOLTAGE TO
FREQUENCY
CONVERTER

FIGURE 4



RATIO LOGIC

CHART 9

used, see Figure #1. If the sensors have widely separated spectra, then there is a high percentage of false alarm rejection, see Figure #2. If the sensor spectra are close, the detector will be nearly as false alarm prone as a single sensor detector, see Chart #7.

Subtraction logic, see Figure #3, is added to the circuit to determine the relative amplitude between two spectra. Spectra are chosen to have opposite ratios of intensities for fire as compared to false alarm sources. This detector has a high rejection to false alarms. A certain temperature range of hot bodies, however, will meet all the logic requirements to alarm, see Chart #8.

The next step to improve false alarm rejection, is to truly ratio the two sensor input signals and establish high and low ratio limits to those signals, see Figure #4. An additional criterion is added requiring one sensor's normalized signal not only to be greater than the other sensor's signal, but not overwhelming greater, see Chart #9. This is the maximum decision capability of a dual sensor system. Only the selection of the ratio limits can be reduced to give greater selection to fire and more rejection of false alarms. The narrower the ratio band selected, the more difficult it is to discern a real fire.

Electronic schemes have been added to dual sensor electronic circuits to cancel the signal produced by ambient background radiant energy. Ambient background signals are always a problem with IR

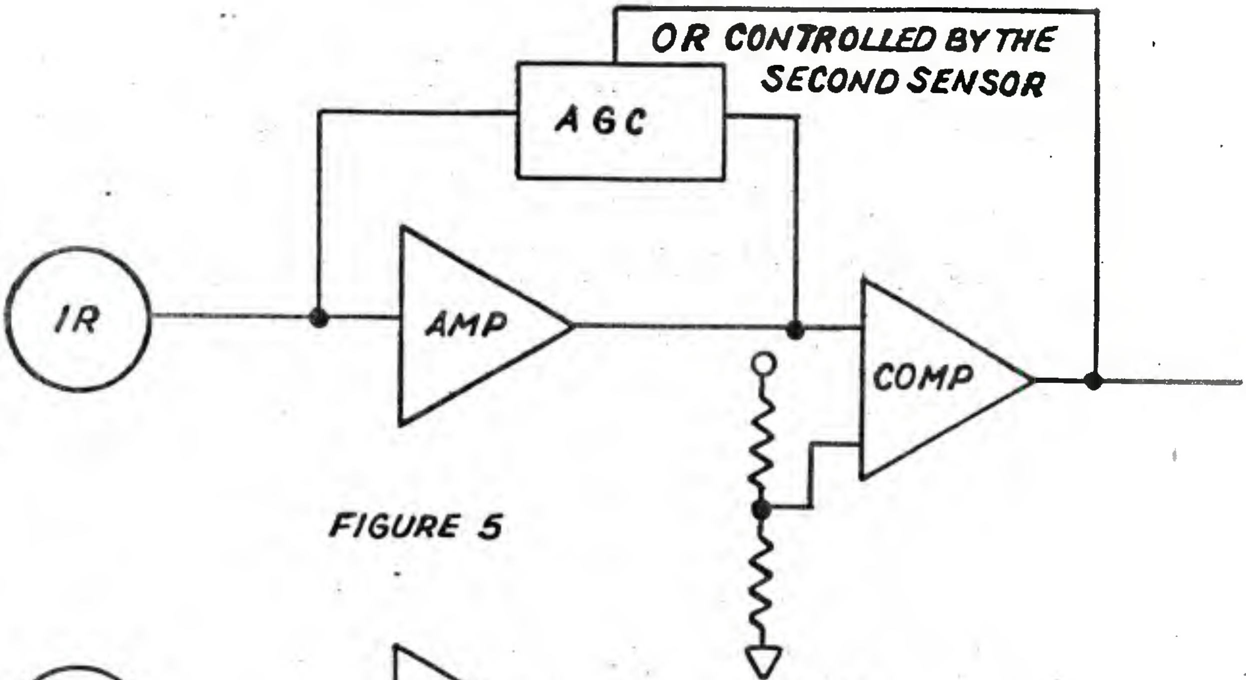


FIGURE 5

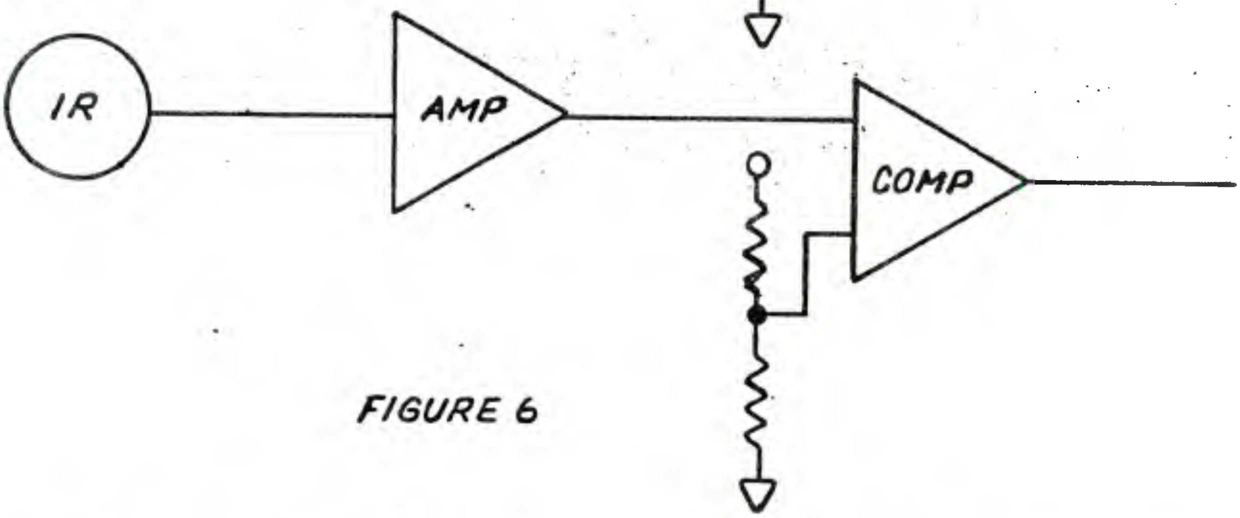


FIGURE 6

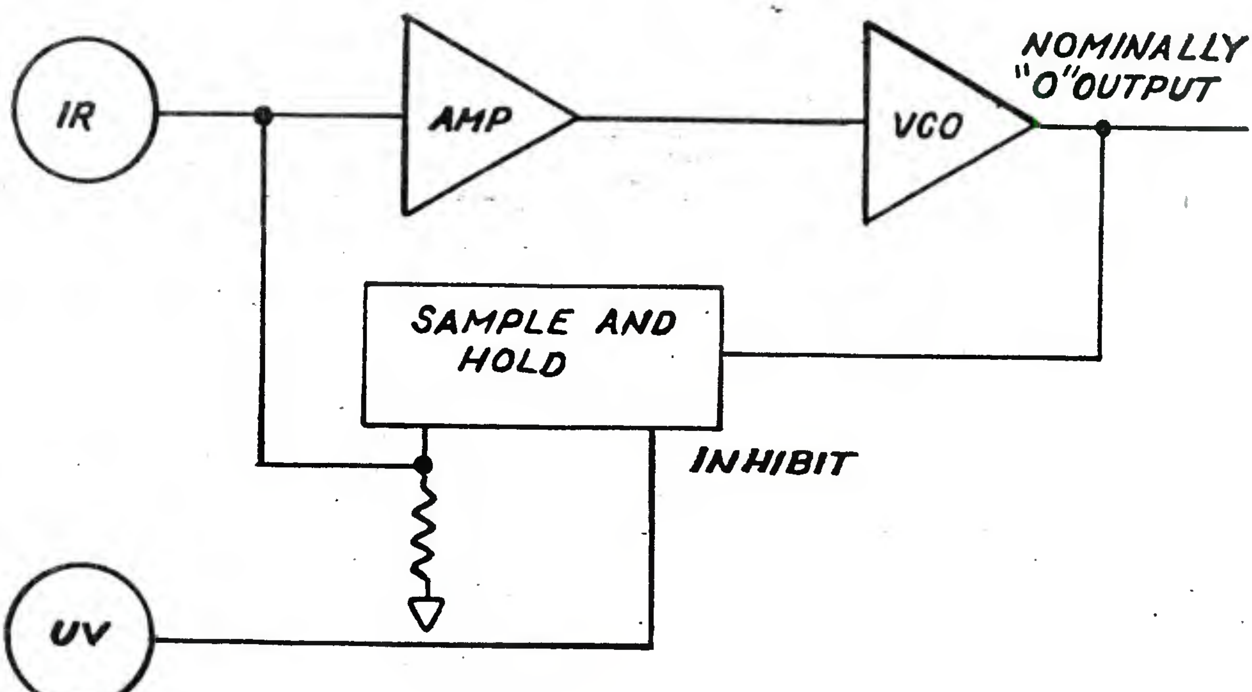
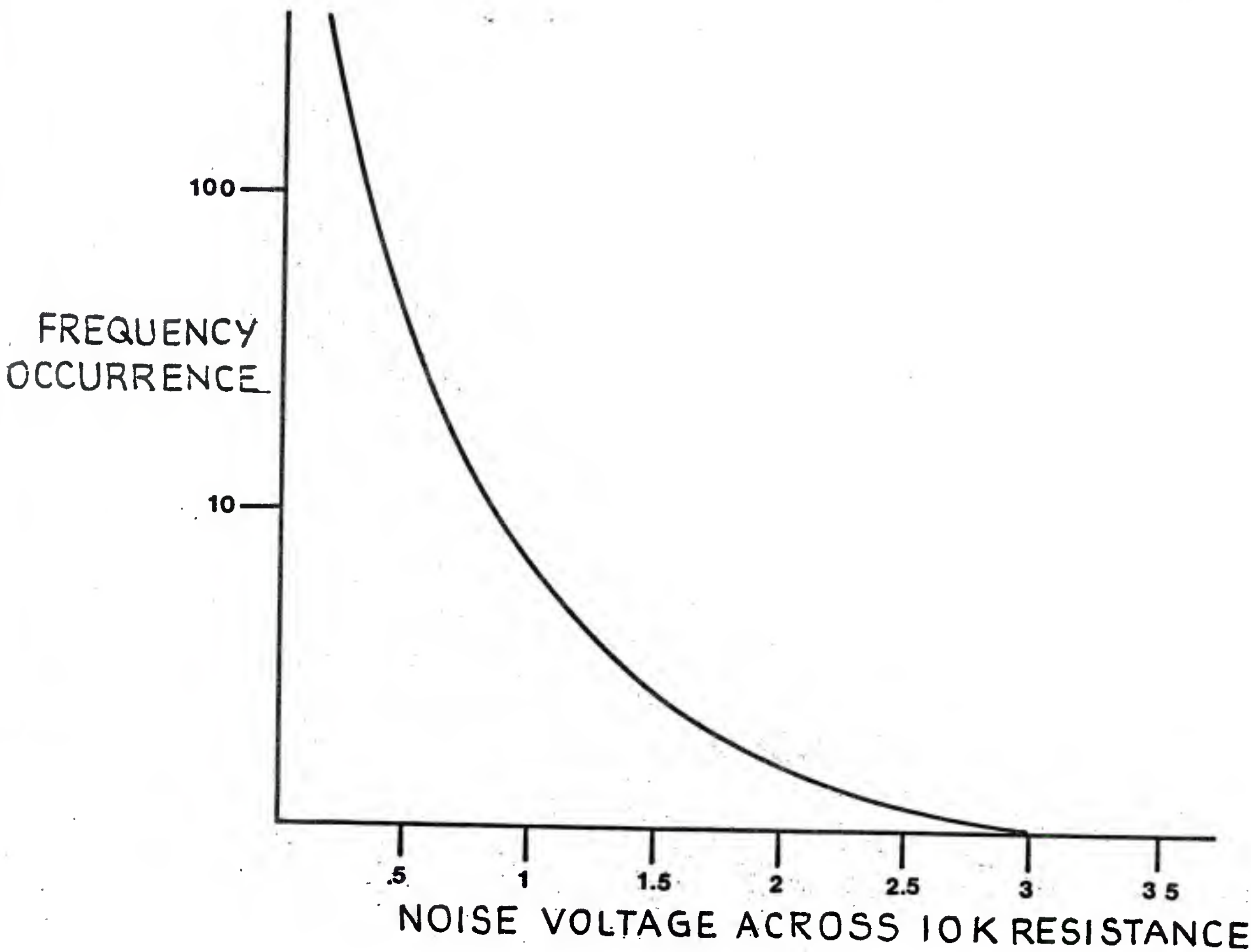


FIGURE 7

detectors and in certain applications, with UV detectors. Some circuits, see Figure #5, reduce the gain of the detector when high background radiant energy is present. Therefore, a larger fire signal needs to be present for detection. Others, Figure #6, simply set a high level which needs to be exceeded before declaring a fire. This could result in a system with reduced sensitivity if the threshold is set high or a system which is prone to false alarms if the threshold is set low.

An improved method is to cancel the signal caused by background radiant energy. The background signal level is adjusted continuously by generating an equal signal level and subtracting it from the background signal to always have zero signal when no fire is present. When there is the probability of flame, the most recent background cancelling signal is held and fire detection begins.

An additional level of false alarm rejection, see Figure #4, is added to modern systems by the use of discrimination circuits, Discrimination circuits make decisions rapidly when radiant energy is present and require a number of decisions to be fire prior to actual alarming. For example, as radiant energy is detected, the data is checked by the ratio detector to determine if it is UV, IR or FIRE. The discriminator requires 4 fire ratio decisions (the amount of required decisions is programmable) before a fire alarm



ELECTRICAL NOISE
IN A TYPICAL INDUSTRIAL ENVIRONMENT

CHART 10

is declared. The speed of the decision making is determined by the data rate which in turn is determined by the intensity of the radiant energy. This adds a great deal of rejection to transient false alarm signals.

The false alarm rate caused by electrical noise must be kept to a level comparable to the false alarm rate of the radiation detection system. Thus, in a typical modern system, the immunity of the electronics to false signals is the limiting factor in improving the false alarm rate. IR sensors require the use of high gain analog amplifiers while the UV signals are digital. Therefore, good grounding is required to eliminate IR amplifier pick up and to eliminate electrical noise pulses which could add to the digital data. Filtering and shielding is also a must. Typically in industrial environments the electrical noise pulses, Chart #10, are up to 3 volts in amplitude. Therefore, the logic level chosen needs to be capable of rejecting 3 volts of electrical noise. Microprocessors operate with 5 volt logic signals and have between 0.7 and 1.5 volts of noise immunity. Therefore, microprocessors have a difficult time operating properly in an industrial environment. Typically, systems with power supplies of 10 volts or more for the processor electronics can function in the industrial environments without false signaling. Electrical noise may cause the system to false alarm or worse yet, stop it from being able to declare a fire alarm. It should also be mentioned that large radiant background energy could render the detector incapable of sensing a flame and that condition should be annunciated so that the user can immediately correct the situation.

Along with the already mentioned design criteria for a detector with an ultra low false alarm rate, the installation must be according to the manufacturer's specifications. Conduit to the detector must contain only detector wiring, the system must have a good ground and continuous radiant sources should be removed or shielded from the sensors.

Users must realize that with continuous radiant sources the probability of false alarms increase. Therefore, welding, hot bodies, and RFI sources should only be allowed when higher rates of false alarms are acceptable. The addition of power line filters and good earth grounds help eliminate false alarm sources.

To sum up, the ultra low false alarm detector must be designed properly. It should include:

Design

1. Dual Sensor - Widely spaced spectral sensitivity
2. Sensitivity not altered by background
3. Ratio signal processing
4. Discrimination
5. High Voltage logic, 10V or above

Installation

1. Proper Shielding
2. Proper Grounding

The user must realize that even with the system operating properly, the probability of false alarms increase in environments where there is a high level of radiant energy or where there is electrical noise interference.

Everything must be suitable from the design of the detector through the environment to successfully operate a ultra low false alarm rate system.

RAPID RESPONSE DELUGE SYSTEM

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ABSTRACT

The development of a rapid response deluge system by the Ammunition Equipment Directorate (AED) for use in suppressing propellant fires during demil shows great promise. Prototype systems have been tested and data acquired on their efficiencies. Present system vs. previous generations and lessons learned will be discussed. A Video cassette of deluge system generation including sections of high speed filming, will be shown.

INTRODUCTION

The Ammunition Equipment Directorate (AED) has developed a rapid response deluge system for use with munition renovation/demilitarization operations. This system provides localized personnel protection from propellant fires on selected APE specifically the APE 1001 and the APE 2000 machines with shields.

The initial application was on two APE 1001 Vertical Pull Apart Shields at Letterkenny Army Depot, where protection from propellant fires occurring inside the shields is required. Tests by AED show that propellant fires inside a 1001 shield could produce significant personnel hazard due to flame venting, although there has never been an accidental propellant fire/deflagration in an APE 1001 Operational Shield.

RAPID RESPONSE DELUGE SYSTEM TEST RESULTS

Two generations of rapid response deluge systems evolved during development at AED. These were titled the prototype deluge and the production model deluge systems. Tests were run on actual propellant fires inside the APE 1001 shield with both of these systems.

Prototype Tests

The prototype deluge contained 5 gallons of water, precharged to 500 psig, which dumped through an explosively ruptured, non-fragmenting diaphragm and through a nozzle mounted on the large, side access door of the 1001 shield.

The nozzle directs two sprays into the shield: one 180 degree fan at 15 degrees above horizontal and above the case, and one 90 degree fan at 45 degrees below horizontal, onto the case. Figure 1 shows the test set up and Table 1 summarizes the test results.

The results of Table 1 indicate that about 75% of the M30 propellant can be prevented from burning providing that the water solution has access to the propellant. For the M10 propellant, 35% to 75% of the propellant can be prevented from burning; a function of how much propellant is blown outside of the case and how much water enters the case through the perforations. The perforated cases did not rupture.

Production Model Tests

The production model deluge contains 15 gallons of a water-calcium chloride solution with sodium chromate corrosion inhibitor, pressurized to 360 psig, which dumps through a non-fragmenting rupture diaphragm and through a nozzle centrally mounted at the top of the shield. Two smaller auxiliary nozzles are plumbed to locations alongside the cartridge case, to provide additional localized quenching for perforated cartridge cases (which may not rupture). The main nozzle has a 120 degree full spray angle which covers the full cross-section of the shield, blanketing any flames attempting to vent out through the top of the shield. The calcium chloride provides freeze protection down to -40 degrees Farenheit. One half percent sodium chromate is added to inhibit corrosion. Figure 2 shows the setup, and Table 2 summarizes the test results.

An electrically actuated initiator at the base of the container generates a shock wave which ruptures a non-fragmenting diaphragm, releasing the water. The initiator is functioned by a quick response firing circuit (less than 1 millisecond) designed and fabricated by AED which in turn is triggered by one of three methods. The fastest method is by a blast pressure switch mounted near the top (inside) of the shield (2 milliseconds); the next fastest method is by two ultraviolet (UV) flame detectors (10 milliseconds); and the slowest method is by a manually actuated switch mounted outside the shield in front of the operator. The blast pressure switch is suspended from the top baffle of the 1001 shield by four steel cables and vibration isolation mounts to prevent false triggering of the switch. The two UV detectors are wired in series; thus both detectors must see flame before they can trigger the firing circuit. This is done to reduce false triggering. Each UV detector has an integral self-check feature which assures that the detector lens is clean and that the detector tube and associated circuits are functional. In the first production models, this check had to be performed by the operator each time electrical power was applied to the circuit. In the latest production model deluge systems this function is performed automatically. Relay logic is used to isolate and ground the initiator during functional checks. This is done to prevent dumping the deluge system when it is not needed.

The deluge system is locked out so it cannot function until the load/unload door in the front of the 1001 shield is closed. This is done to prevent possible operator injury by the high energy water spray. A pressure gauge, mounted at the bottom of the container indicates container pressure, and must be checked occasionally by the operator.

The results of Table 2 indicate that about 88% of the M30 propellant can be prevented from burning providing the water solution has access to the propellant. For the M10 propellant, 60% to 70% of the propellant can be prevented from burning. The functionality expressed previously on the results of Table 1 are also applicable here.

Sunlight did not function the UV detectors on any of the performed tests or during the preparation for these tests.

LESSONS LEARNED

From the results of the testing performed on the prototype and production model deluge systems, the following lessons were learned:

1. The prototype system initially had a bladder inside the tank. This bladder would tend to seal off the tank opening shortly after initiation of the blast valve, thus restricting the amount of water which could be dumped into the shield.

2. The first two production model deluge systems had an emergency dump switch on them for manually initiating the deluge. This method of initiation caused more problems than it solved. Therefore, the switch was deleted from further production models. It seems that people have a tendency to push buttons which, in the case of the deluge system, would thus dump the pressurized water into the shields.

3. If initiation of propellants such as M10 or M30 is not suppressed with a deluge system, catastrophic results can occur.

Having now discussed the rapid response deluge systems, a video cassette of the tests performed on these will be shown.

CONCLUSIONS

1. A properly operating deluge system can significantly reduce the quantity of propellant that would ignite and burn in the event of an incident in a protective shield.

2. Suppression of propellant fires can definitely be accomplished thru the use of a properly designed deluge system.

TABLE 1
PROTOTYPE DELUGE TEST RESULTS ON APE 1001 SHIELD

TEST DATE (FILM NO.)	MUNITION	PROPELLANT TYPE	NOM. WT. LBS.	WEIGHT OF PROPELLANT RECOVERED LBS.	WITH OR WITHOUT DELUGE (1)	OBSERVATION
9 Aug 79 (080979-1)	105mm M392	M30	6	3	With	Case did not rupture.
9 Aug 79 (080979-2)	105mm M392	M30	6		Without	Case ruptured at 30 to 50 millisec after initiation, filling shield with flame. Camera knocked over at 700 millisec, shield still filled with flame.
16 Aug 79 (081679)	105mm M323	M10	7.95	3	With	Munition functioned before camera up to speed. Flame out approx 1-1 1/4 sec after initiation.
13 Sept 79 (091379-1)	105mm M323	M10	3.98	3 1/4	With	Flame gone at 900-1,000 millisec after initiation.
13 Sept 79 (091379-2)	105mm M323	M10	3.98	1/2	Without	Flame gone at 1 1/4 sec and all illumination inside shield gone at 2 1/4 sec after initiation.
13 Sept 79 (091379-3)	105mm M392	M30	12.0	9 3/4	With	Case fragmented but shield intact, thus suggesting deluge prevented shield failure (Ref. Test 25 May 77, which blew 1001 side doc open).

(1) 5 gallons water, precharged to 500 psig, see Fig 1 for setup.
(2) Based on high speed (2,000 frame/sec) color movies of shield interior and post test observations.
(3) Electric primer.
(4) Used half charge of propellant so APE 1001 Shield would not fail.
(5) Percussion primer initiated by electric blasting cap. Perforated case did not rupture.

TABLE 2
PRODUCTION MODEL DELUGE TEST RESULTS ON APE 1001 SHIELD (DELUGE USED ON ALL TESTS)

TEST DATE (FILM NO.)	MUNITION	PROPELLANT TYPE	NOM. WT. LBS.	WEIGHT OF PROPELLANT RECOVERED LBS.	OBSERVATIONS
24 July 80 (072480 A&B)	None				Test determined system dump times. Tank emptied in about 4.9 sec. Water appeared at bottom side nozzl and at top side nozzle 59 millisec and 71 millisec after water at mair nozzle, respectively. Used std. diaphragm backing ring.
18 Aug 80 (081880A&B)	105mm M323	M10	7.95	4.94	Both pressure switch and UV detectors operable on this test. System triggered off the pressure switch. 24.8 milliseconds after ca flash (initiation), the water solution was coming out the large nozzle. 100.6 milliseconds later the flame was quenched. A second partial flame flareup started 0.57 seconds after initiation but was gone 0.35 seconds later. Used standard diaphragm backing ring.
21 Aug 80 (082180 A&B)	105mm M323	M10	7.95	5.31	Blast switch made inoperable on thi test. Only UV detectors used. Hig speed films were of little value on this test because smoke etc., obscured the inside view of the shield after initiation. From some instrumentation measurements the water solution was at the top large nozzle 23.64 milliseconds after initiation. Flame appeared to begi subsiding approx. 0.6 sec later. Used square opening backup plate behind diaphragm (to insure larger opening after diaphragm rupture). The 0.4 seconds later the flame appeared to be quenched.

TABLE 2 (Cont)

PRODUCTION MODEL DELUGE TEST RESULTS ON APE 1001 SHIELD (DELUGE USED ON ALL TESTS)

TEST DATE (FILM NO.)	MUNITION	PROPELLANT TYPE	NOM. WT. LBS.	WEIGHT OF PROPELLANT RECOVERED LBS.	OBSERVATIONS
25 Sept 30 (092580A&B)	105MM M392	M30	6.0	5.25	Blast switch made inoperable for this test also. Only UV detectors used. After initiatio there was a period of about 0.56 seconds before a small amount of flame became visible. Water quench began about 1 second late with the fire being quenched in the next 0.27 seconds. A pressure transducer in the top large nozzle indicated lapsed time of 1.41 seconds before bein affected by heat and an interval of 0.13 seconds when water quenc began.

(1) 15 gallons water-calcium solution, precharged to 360 psig, see Fig 2 for setup.
(2) Based on high speed (1000 & 2000 frames/sec) color movies of shield interior, some trial instrumentation and post test observations.
(3) Electric Primer
(4) Used half charge of propellant so APE 1001 shield would not fail.
(5) Percussion primer initiated by electric blasting cap. Perforated case did not rupture.

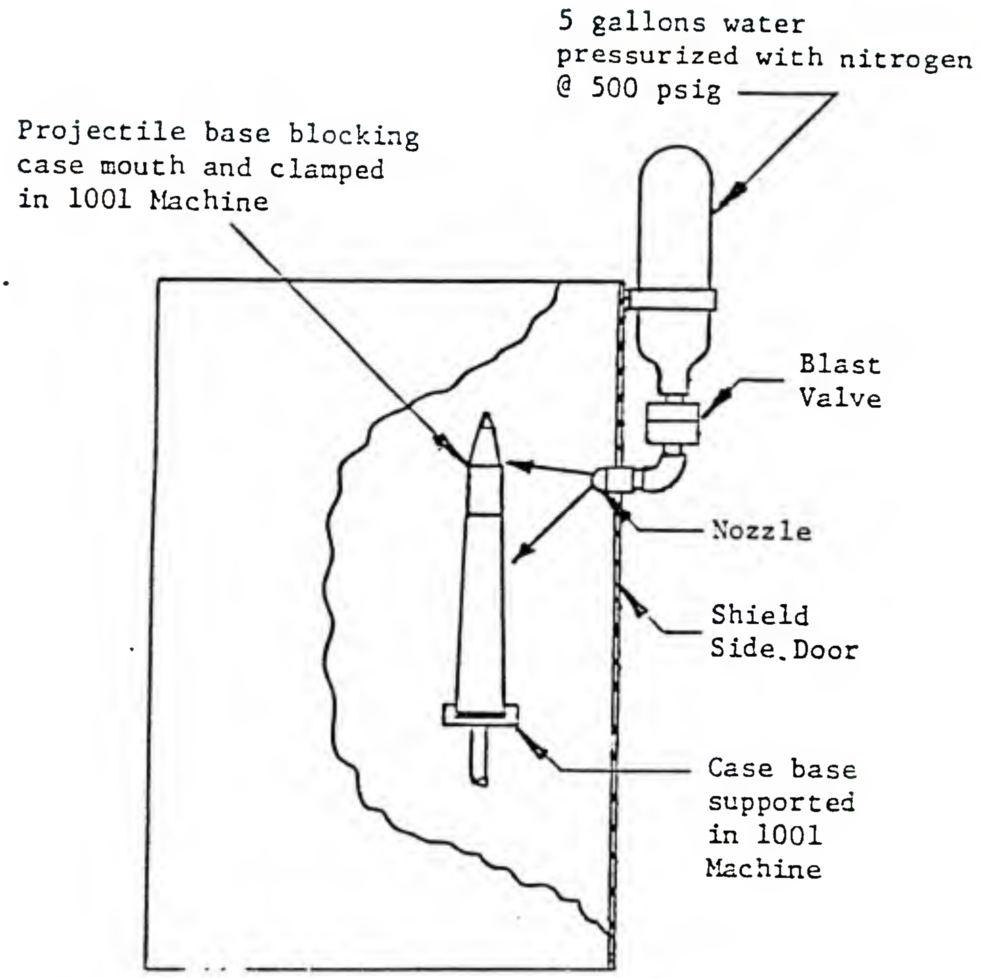

FIGURE 1: PROTOTYPE DELUGE ON APE 1001 SHIELD

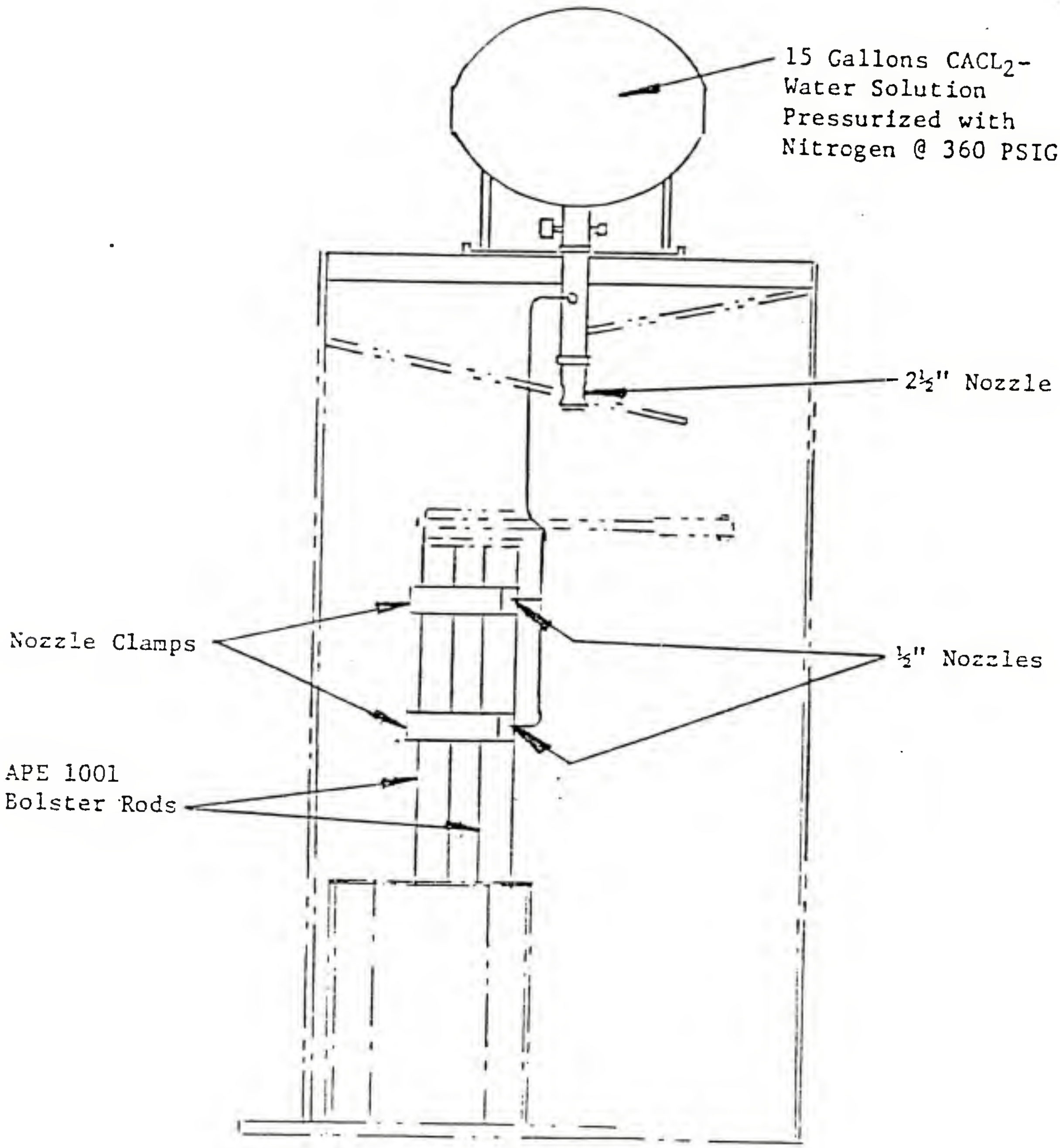

FIGURE 2 PRODUCTION MODEL DELUGE
ON APE 1001 SHIELD

PILOTEX
ULTRA HIGH SPEED DELUGE
FIRE PROTECTION SYSTEM

W. Alan Cozby

&

Gary Fadorsen

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Special Hazards Department
Cleveland, Ohio 44147
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"Automatic" Sprinkler
CORPORATION OF AMERICA

OUTLINE OF THE
HISTORY OF HIGH SPEED SYSTEMS

I. Conventional Wet & Dry Pipe Systems

A. Wet Systems - 3-5 minutes to set off sprinkler
B. Dry Systems - Water to sprinkler head 60 seconds after sprinkler head is set off

II. Deluge Systems

A. Open Head Systems - 15 seconds to 2 minutes depending on detection
B. Primed Deluge System - with U.V. detection this system could be as fast as 1-2 seconds
C. Squib Operated Primed Deluge - with flame detectors this system can be made to work under 1 second

"Automatic" offered squib operated valve - "Spectronic" from 1960 to 1968. However, due to high maintenance and cumbersome resetting operation the valve was dropped.

III. Pilot Operated Systems

Pilotex nozzle originally developed as an "on-off" sprinkler for archives in Washington.

System could be used manually or with rate-of-rise release.

With advent of sophisticated electrical detection and control equipment we operate using a solenoid release valve. Features:

1) System can be set up using any of the modern electrical detection and alarm system including ultra violet, infra red, gas detectors or pressure sensors.

2) System can be discharged in the event of a total power failure.

3) System is reset with a push of a local or remote push button. No squibs to replace, no rupture discs or caps to replace, no re-priming of the system piping to be done. No replacement parts after a discharge.

4) System has full supervision of the electrical circuits unlike squib operated systems where you cannot supervise the squib.

OUTLINE OF THE
HISTORY OF HIGH SPEED SYSTEMS - Cont.

5) At any given test pressure Pilotex will outperform any squib operated valve.

6) System operation is consistantly under 100 millisecond operation from detection signal at control panel to water discharge at nozzle.

7) Due to quick reset feature a large number of system can be tested in a short amount of time.

Description

The PILOTEX Pilot Operated Nozzle is a discharge device that incorporates a pressure differential valve.

The PILOTEX nozzle is designed to seal off fire main pressure at the nozzle by use of pilot pressure. When pilot pressure is relieved, all PILOTEX nozzles connected to one pilot line open instantly and simultaneously. When pilot pressure is restored, the nozzles close.

A PILOTEX nozzle consists of a two-piece body threaded together and sealed with an O-ring (See Figure 5.021). The upper body has a ½" NPT male connection for installation in standard pipe line fittings, and a ¼" NPT female connection for the pilot line. It is through this pilot line connection that the cylinder and poppet that make up the differential valve receive pilot pressure. The poppet has an O-ring seal and a rubber face which seats against the orifice located in the lower body half of the nozzle. The lower body is interchangeable to accommodate various types of discharge devices. Figure 5.011 shows the upper body with a standard sprinkler discharge device. Figures 5.031 and 5.032 show the upper body assembly provided with special adapters for connection to other discharge devices.

Model 165
Series 6000

Figure 5.011

Applications

The PILOTEX nozzle is used where rapid discharge of water is required, such as in high hazard applications where speed of operation measured in milliseconds is needed to control or extinguish the combustion reactions of high energy fuels, liquid or solid fuel propellants, gaseous fuels, metal powders, munitions products and others.

Operation

When the PILOTEX nozzle is in its normally closed position, the poppet is held against the discharge orifice by the pressure within the poppet cylinder. When pilot line pressure drops, the fire main pressure overcomes the differential, forces the poppet up, and instantly starts full discharge.

When pilot pressure is restored, the poppet reseats, even against fire main pressure.

Model 165

The Model 165 is shown in Figure 5.021 with the 165-6000 series sprinkler lower body. Discharge variations available for other applications are shown on following pages.

Wide Cone Sprinkler Pattern
- 165-6850 with 7/16" discharge orifice
- 165-6250 with 17/32" oischarge orifice

Narrow Cone Spray Pattern
- 165-7850 with 7/16" discharge orifice
- 165-7250 with 17/32" discharge orifice

Flat Spray Nozzle
- 165-8451 with 90° discharge angle
- 165-8452 with 180°discharge angle

Male Adapter
- 165-9075 for ¾" NPT female nozzles
- 165-9100 for 1" NPT female nozzles
- 165-9125 for 1¼" NPT female nozzles

Female Adapter
- 165-5075 for ¾" NPT male nozzles
- 165-5100 for 1" NPT.male nozzles
- 165-5125 for 1¼" NPT male nozzles

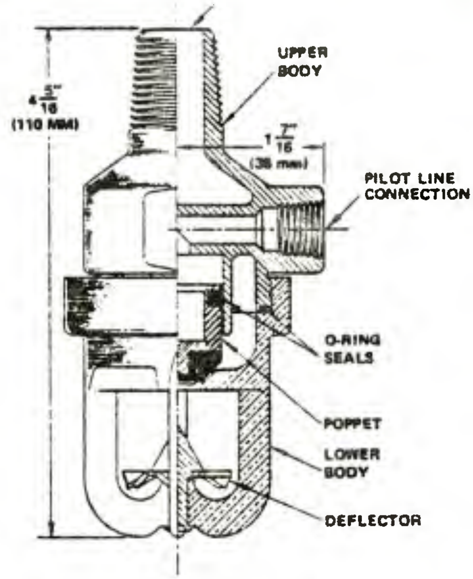
Model 170

The Model 170 is shown in Figures 5.071 and 5.072. It operates in the same manner as the Model 165, but has a 1 7/8" - 20 straight thread upper body which is connected with a screwed union to a ½" female brazing connection. The Model 170 is available with the same discharge variations as the Model 165:

Wide Cone Sprinkler Pattern
- 170-6850 with 7/16" discharge orifice
- 170-6250 with 17/32" discharge orifice

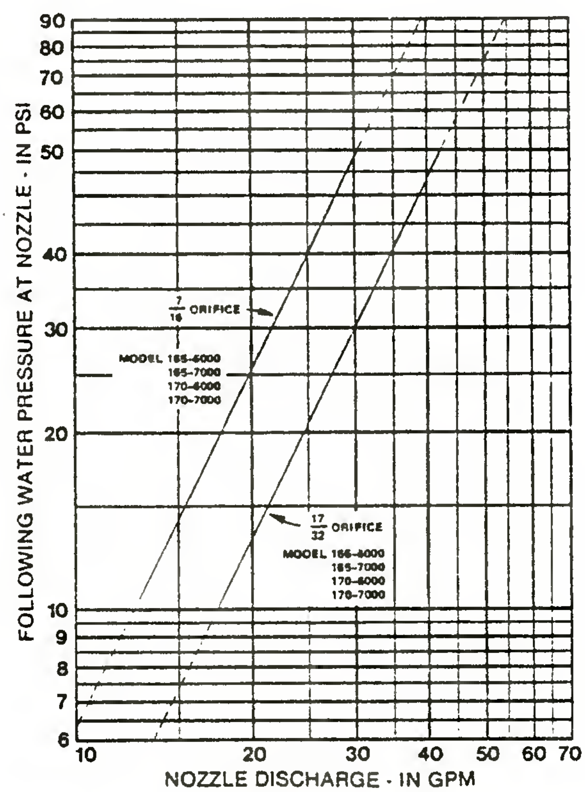
Narrow Cone Spray Pattern
- 170-7850 with 7/16" discharge orifice
- 170-7250 with 17/32" discharge orifice

Flat Spray Nozzle
- 170-8451 with 90° discharge angle
- 170-8452 with 180° discharge angle



165-6000 Series

Figure 5.021



6000-7000 Series
Discharge Characteristics

Figure 5.022

18 JAN 1985

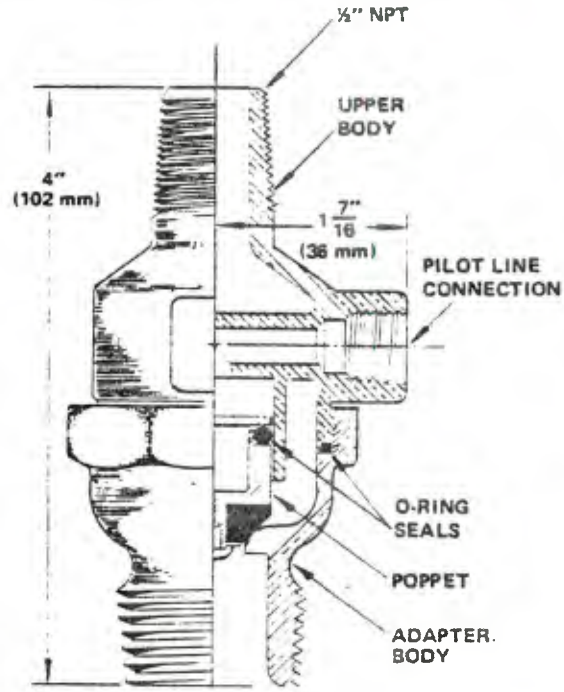
Model 170 (Continued)

Male Adapter
- 170-9075 for ¾" NPT female nozzles
- 170-9100 for 1" NPT female nozzles
- 170-9125 for 1¼" NPT female nozzles

Female Adapter
- 170-5075 for ¾" NPT male nozzles
- 170-5100 for 1" NPT male nozzles
- 170-5125 for 1¼" NPT male nozzles

Series 9000
Male Adapter

This variation using the PILOTEX nozzle upper body with a male adapter will accept ¾", 1, or 1¼" female threaded nozzles. The male adapter can be used with either Model 165 or Model 170 series nozzles.

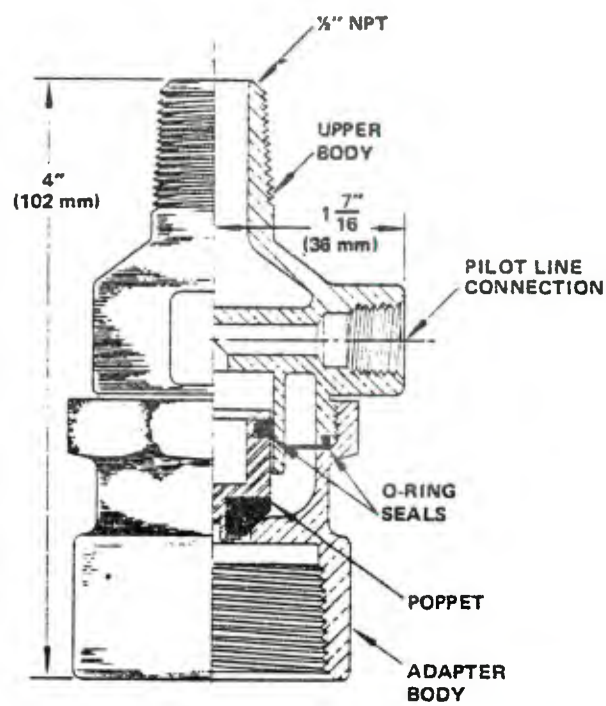


Series 9000

Figure 5.031

Series 5000
Female Adapter

This variation using the PILOTEX nozzle upper body with female adapters will accept ¾", 1" or 1¼" male threaded nozzles. These sizes are standard for mounting with AUTO-SPRAY nozzles, which are available in 21 different orifice sizes and discharge patterns. The female adapter can be used with either Model 165 or Model 170 series nozzles.

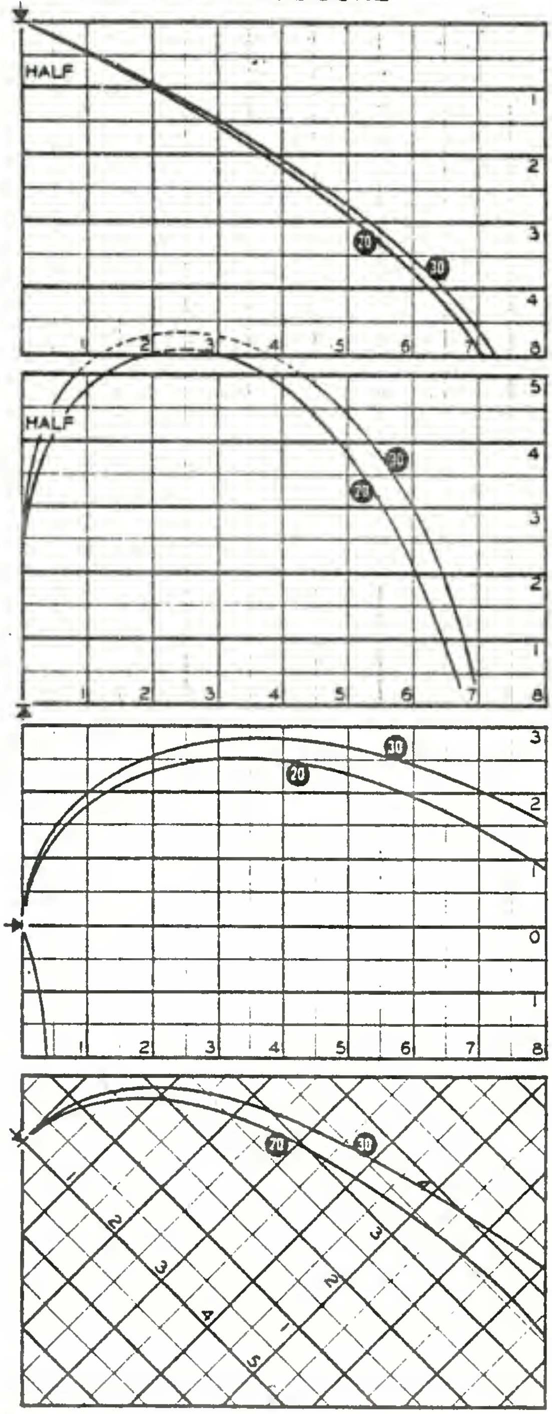


Series 5000

Figure 5.032

AUTO-SPRAY Pilot Nozzle-Spray Patterns
Operating Pressures of 20 and 30 PSI
7/16" and 17/32" Orifice

MODEL 165-6000 WIDE CONE



MODEL 165-7000 NARROW CONE

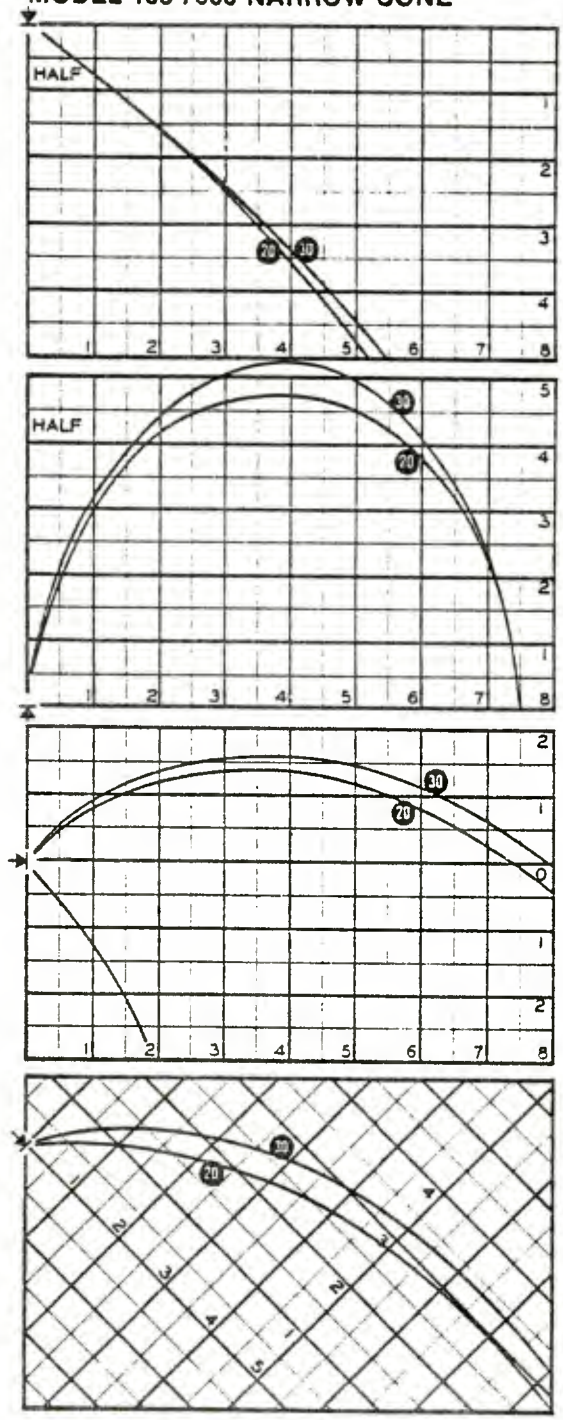


Figure 5.041

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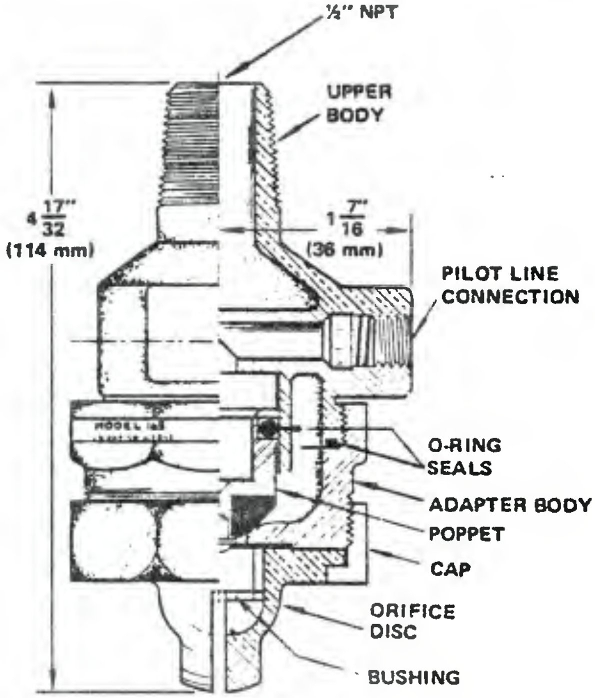
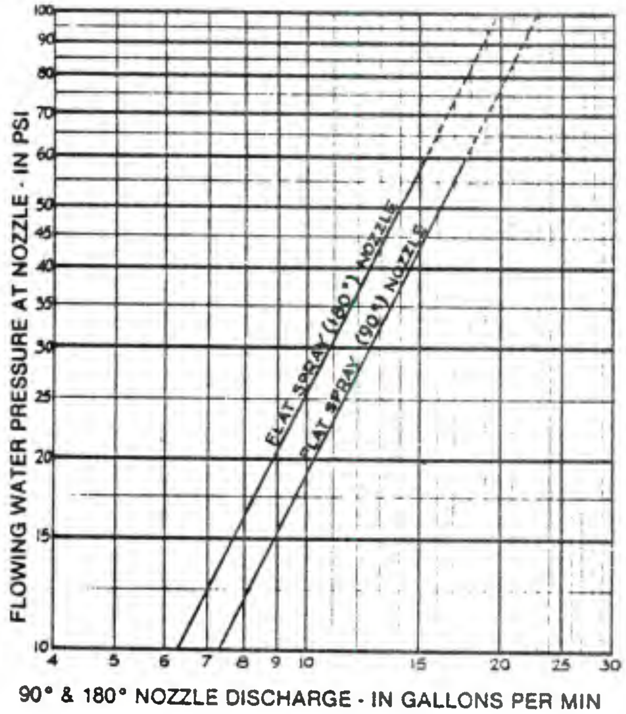


165-8000 Series

Figure 5.051



Series 8000

Figure 5.052

Series 8000
Flat Spray Nozzle - 90° or 180° angle of discharge

A variation of the PILOTEX nozzle is the attachment of a special nose in place of the regular sprinkler deflector. It produces a flat spray pattern capable of reaching into narrow spaces and is available in 90° or 180° angle of discharge.

The orifice disc can be rotated within the cap so that the flat pattern can be adjusted to provide better coverage of the hazard. This flat pattern is useful for applications that must cover narrow, hard to reach spaces.

Material Specifications

All PILOTEX nozzle body parts, upper and lower, meet specification MIL-C-22229 (2); (CDA836)-bronze. The Poppet meets Federal Specification QQ-N-281-Monel. O-ring seals meet Specification:

MIL-R-3533 Type 1, Grade B
MIL-R-1149 Class 5, Type 2 and
MIL-G-21569, Class 1

Military Specifications

The Model 170-7000 PILOTEX Nozzle series is in accordance with Specification MIL-H-19387 for 7/16" and 17/32" orifices with 180° angle deflectors.

The Model 170 Nozzle series with 7/16"-20 straight thread gasket sealed pilot connection available on special order is in accordance with MIL-MS16142.

Flat Spray Nozzle Discharge Characteristics

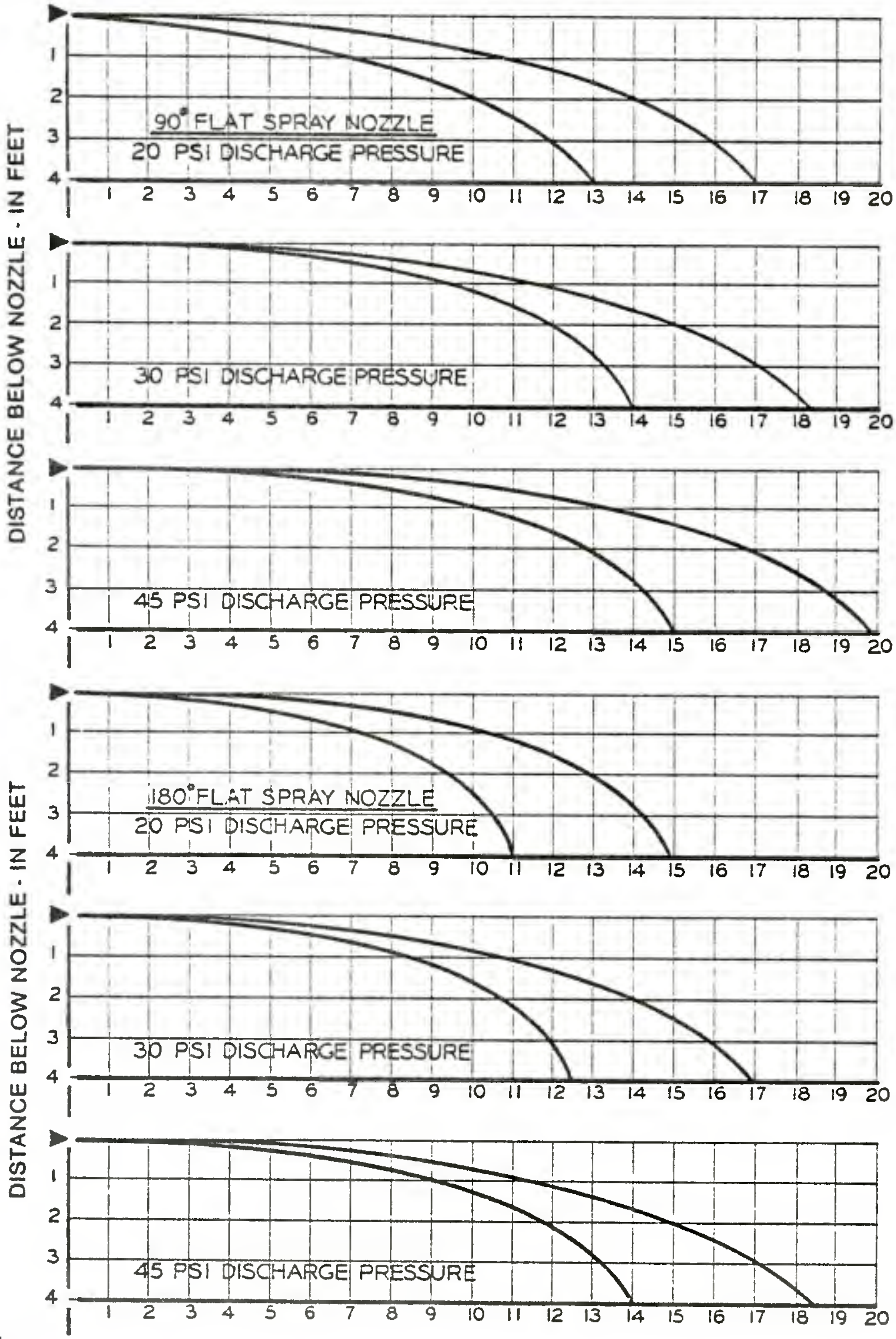
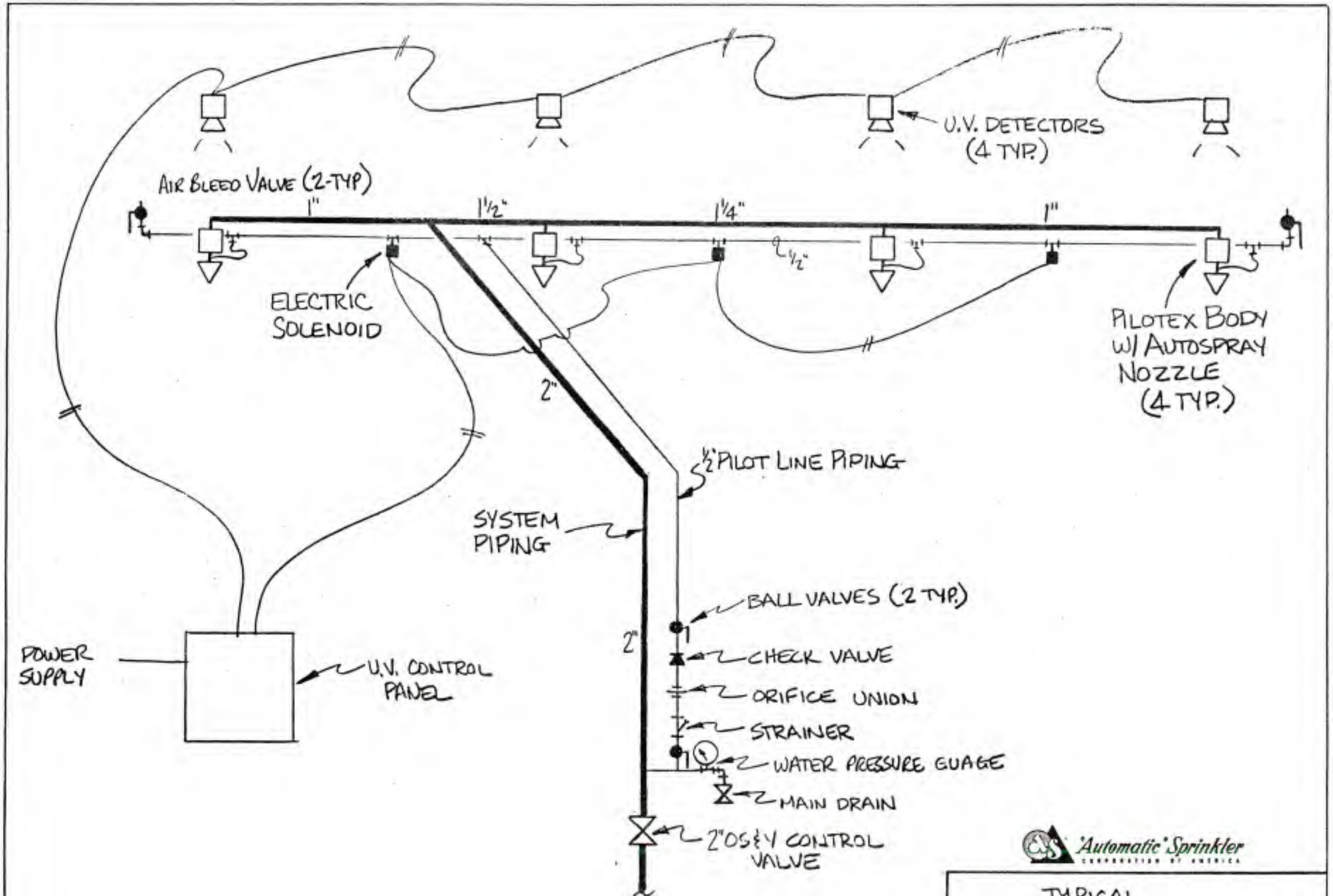


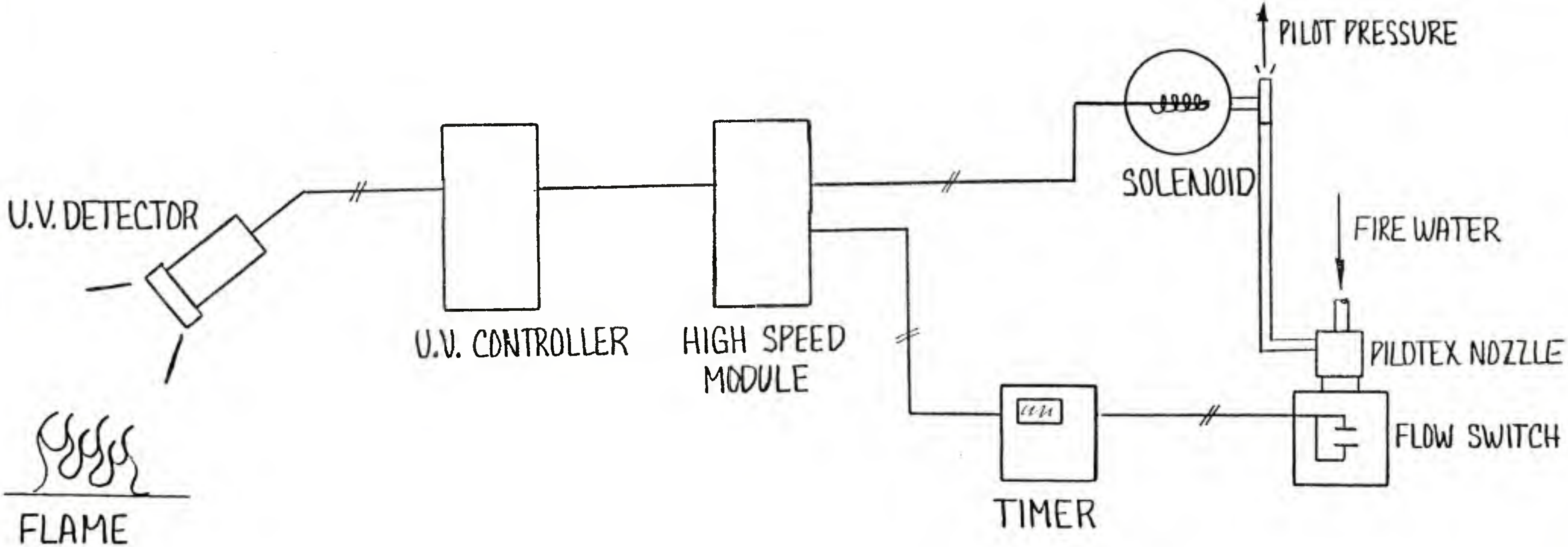
Figure 5.061

18 JAN 1985



Automatic Sprinkler Corporation of America

TYPICAL "PILOTEX" SYSTEM	
DRAWN BY: AZ	DATE: 3/1/84
DRWG N°: HS-6	SHEET N° 1 OF 1



Automatic Sprinkler Corporation of America

PILOTEX TESTING

DRAWN BY: AC	DATE: 3/1/84
DRW'G N°: HS-3	SHEET N° 1 OF 1

PROPOSED SPECIFICATION FOR THE
HIGH SPEED DELUGE SYSTEMS

1.0 PURPOSE

The purpose of this specification is to define the technical, component and material requirements for the fast response water spray fire protection systems for the protection of ____________ ____ in sufficient and adequate detail to permit a Vendor to submit a comprehensive contractural proposal for their procurement and complete installation as approved operable systems.

2.0 SCOPE

The work shall include, but is not limited to, the following major items:

a. Detection - A narrow band, self-monitoring, millisecond response (infra-red) (ultra-violet) flame and flash detection system with optical supervision, for certain areas with special protection requirements as described herein.

b. Alarms - Pre-wired alarm and supervisory panels capable of continuous and unattended verification of the systems readiness and integrity, and the ability to isolate and indicate by digital coded read-out, the specific system problems as they occur. Also at the same time, to notify the appropriate authorities by audible and visual alarms that a system malfunction or a fire condition exists.

c. Extinguishment - A High-Speed System consisting of a pressurized primed water connected to a series of strategically spaced discharge nozzles.

3.0 DESCRIPTION

The sprinkler deluge system is an instantaneous response (millisecond) high-speed system controlled by (ultra-violet) (infra-red) flash and flame detectors.

4.0 SEQUENCE OF OPERATION

When the flame detector detects a fire within its scanning range, notification that a fire condition exists is sent to the control panel. The control panel in turn sends an electrical impulse to either fire a squib in an explosive charge operated valve, or to open a solenoid in a pilot operated system. At the same time signals are sent to operate audible and visual alarms and to shut down process equipment. Fire protection system is to be capable of being shut down by the process equipment operator from his control station.

5.0 EQUIPMENT DESCRIPTION

5.1 (ULTRA-VIOLET) (INFRA-RED) DETECTORS

The detectors shall be constant scanning and capable of responding and signaling when a flash or flame radiated ray of (ultra-violet) (infra-red) light is detected. Radiation from normal artificial lighting or from sunlight should not affect the detector. Each detector shall have a method for automatic or selective remote verification of optical supervison and cleanliness.

Detectors are to have an 80° cone of vision.

5.2 CONTROL PANEL

The control panel is to be a self supervised controller which provides independent relay contacts, field adjustable sensitivity, plug-in modules and relays, and to have switches to put the unit in by-pass. The control panel/rack assembly shall have coded digital read-outs of the system faults as they occur displayed prominently on the front panel. The assembled panel/racks shall also contain the necessary instrumentation to monitor detectors, controllers and flow control components, to energize the audible and visual alarms in the event of systems actuation or malfunction, to transfer these signals to remote designated locations and to automatically stop the process equipment in the affected area, or areas when actuated. The control panel is to be complete with 24 hour battery backup.

5.2.1 Emergency power with the ability to sustain the control systems monitored by the panel for not less than 24 hours in the event of a power failure shall be provided as part of the control panel/rack assembly. The emergency power system shall actuate automatically when power fails and de-activate automatically when primary power is restored.

5.3 NOZZLES

Spray nozzles shall be installed in water spray fixed systems with pressurized priming water being held back at nozzle with blow-off caps, rupture discs or the nozzle poppet when utilizing pilot operated nozzles. System shall be primed to a minimum of 15 P.S.I.G. Nozzle discharge rates and spray patterns shall be designed to meet hazard conditions.

5.4 CONTROL VALVES

Control valve to consist of either a squib operated deluge valve when using blow-off caps or rupture discs with the nozzles, or electrical solenoid valves when utilizing pilot operated nozzles.

5.5 MANUAL TRIPPING DEVICES

System is to be equipped with a manual system discharge device that will allow operation of the system in the event of a complete power loss.

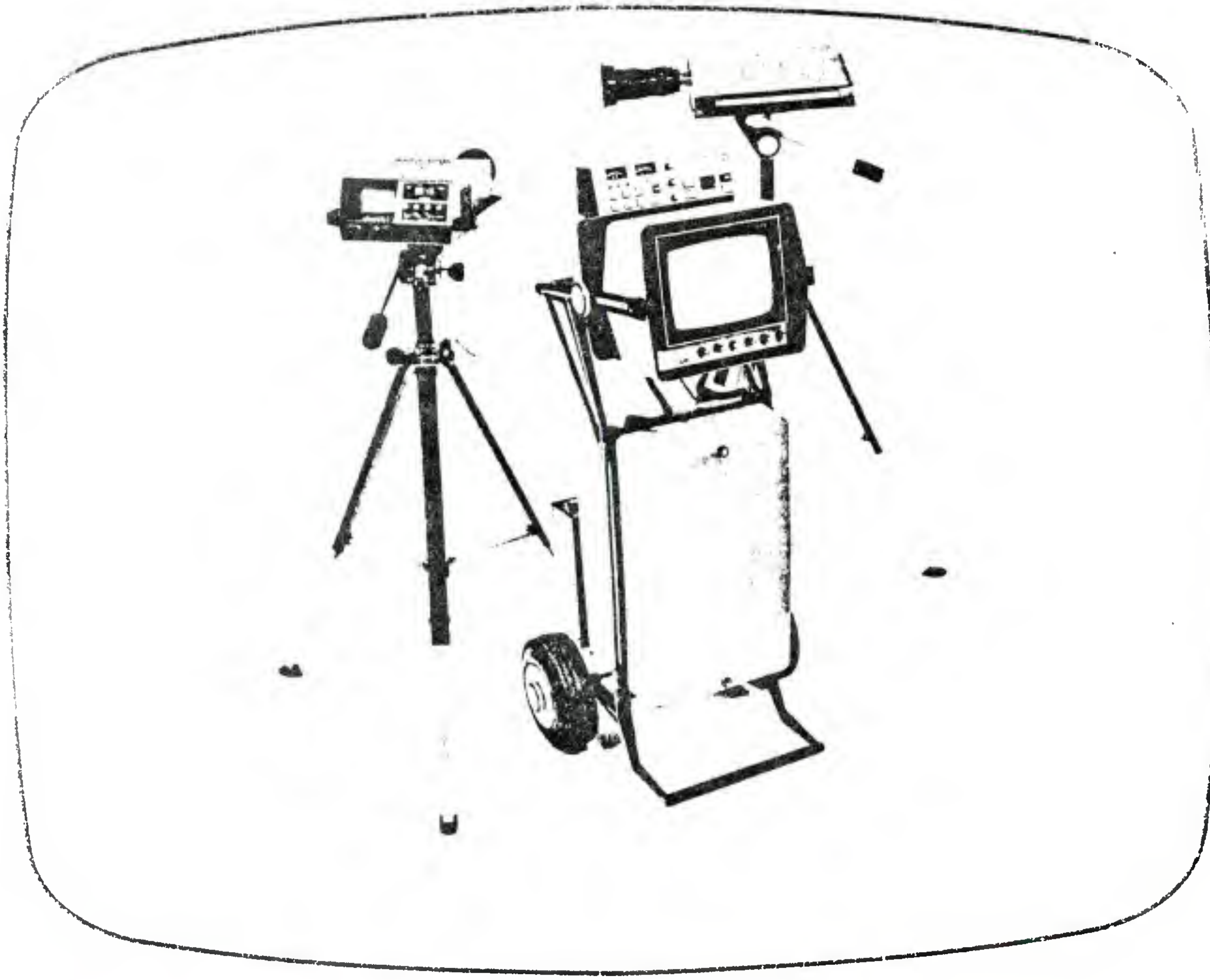
6.0 ACCEPTANCE TESTING

In addition to a hydrostatic pressure test as described elsewhere, all detectors and automatic and manual releasing devices shall have an operational test.

After completion of all operational testing, system is to be time tested to meet a speed of 100 milliseconds from the time the detection signal is received at the controller until the time water is discharged at the nozzle.

VIDEO TEST RESULTS #

PILOTEX
ULTRA HIGH SPEED DELUGE
FIRE PROTECTION SYSTEM



INSTAR BY VIDEO LOGIC

INSTAR®: Motion Analysis in Perspective
Until recently, production and research problems involving mechanical motion have been solved largely through trial and error. In the mid-sixties, Video Logic began to develop the potential of television as an industrial tool to solve motion related problems. The research that followed lead to the first and only motion analysis system for industrial use, INSTAR. Due to the technical advances made by Video Logic and incorporated in INSTAR, the costly and cumbersome method of trial and error trouble-shooting has become obsolete. Today, INSTAR is one of the most valuable tools available to industrial and mechanical engineers.

Industrial motion analysis is still quite young; and its acceptance as an analytical tool has been dependent, largely, on the education of potential users. To quicken this learning process, Video Logic is making a major educational effort.

What is a Motion Analysis System?
A Motion Analysis System can be thought of as a closed circuit television system which records motion for subsequent viewing. In most other respects, a motion analysis system forms its own discipline. Critical aspects of motion analysis are: frame rate (pictures per second); picture quality; and slow motion and stop action ability. INSTAR

INSTAR
BY VIDEO LOGIC

can record 120 FULL SCREEN pictures per second or (240 split-screen pictures per second). Playback picture quality is superb in variable speed slow motion or stop action.

Why Use a Motion Analysis System?
INSTAR's ability to act as an aid to the human eye is its greatest asset. The human eye has an exposure time of approximately 0.1 second. If a brewery engineer looks at a beer can moving at the rate of 1,200 feet per minute, he sees a "picture" with 24 inches of blur. The ability to replay that action in slow-motion with 120 CLEAR FULL SCREEN pictures per second makes INSTAR a very powerful tool for diagnosing operating problems. By significantly enhancing the capacity of the human eye and by producing a repeatable, measurable record, INSTAR can provide valid and immediate data about various phenomena, unobtainable by any other means.

Applications
INSTAR's broad acceptance suggests there are few sophisticated manufacturing facilities which would not derive considerable cost savings from analysis of their manufacturing processes. The examples below are a few of the cases in point.

—A U.S. Army arsenal currently uses INSTAR to monitor a machine that packages ammunition at the rate of 1,200 rounds a minute. At 20 rounds a second, any hitch in the transport mechanism is likely to jam the point of one round into the primer of the next, starting a small war. INSTAR pinpoints problems and, from a safe distance. . . .

—The Engineering Systems Division of a major corporation in San Jose, California, uses INSTAR to find out why letters jam in its custom mail sorting machine. INSTAR visually slows down the 400 letters a minute so that they "no longer look like a white stream." INSTAR is credited with trimming two to four weeks from the debugging process and about 10% from the machine's cost. . . .

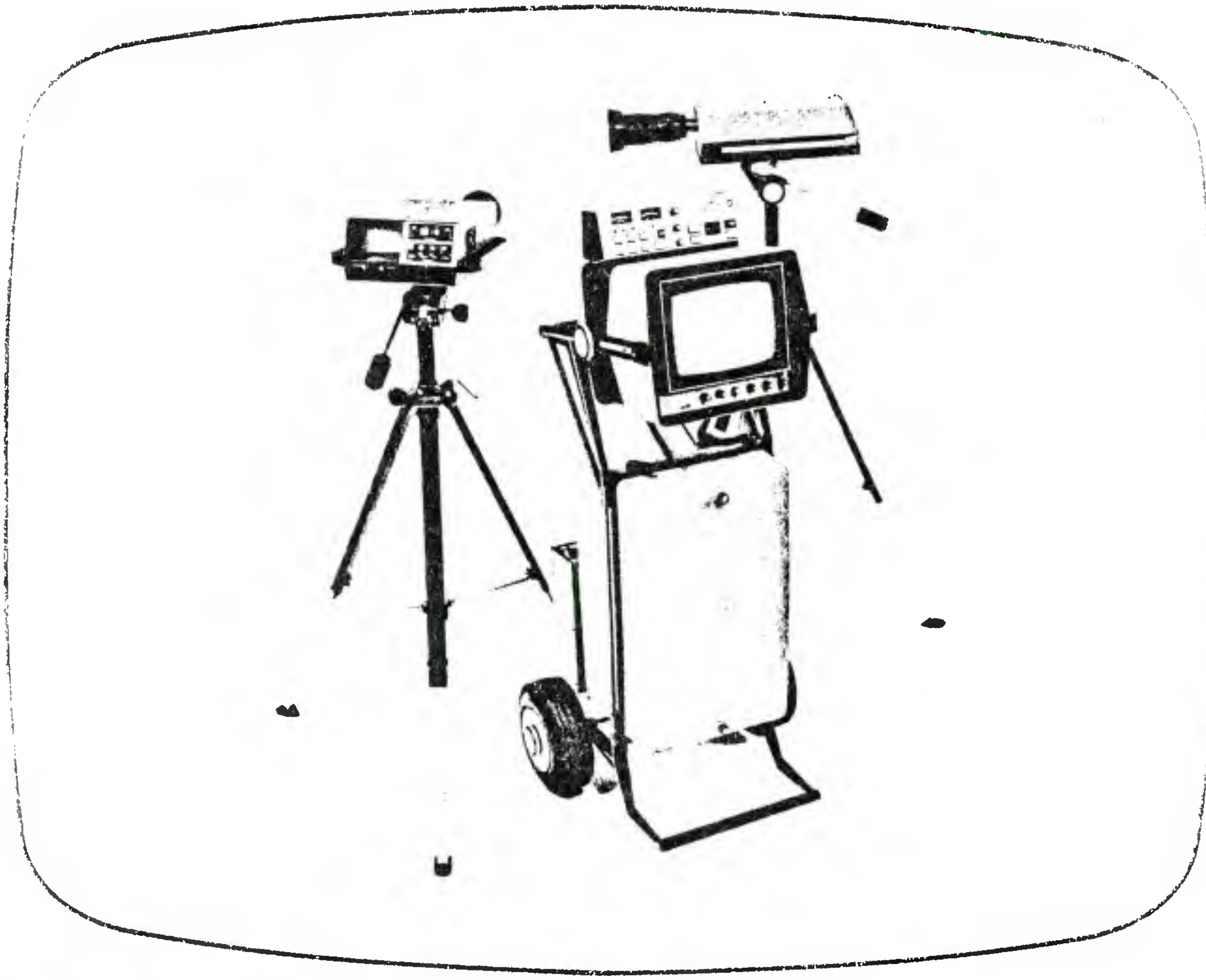
—The Lamp Division of a major lighting company used INSTAR to find out what was wrong with a loading chute that was breaking many glass tubes. A review of the tape in slow motion mode helped engineers design a better loader. As a result, production yields went up, and down-time for troubleshooting was estimated to have been cut in half. . . .

Important Features of the INSTAR Motion Analysis System:

- High sampling rate: 120 FULL SCREEN pictures per second; 240 split-screen pictures per second.
- Variable speed slow motion playback with high motion resolution. (3% to 15% infinitely variable).
- Scene & Frame Identification (SAFI).
- Total system integration.
- Low operating costs.
- Reliability under adverse environmental conditions.
- Wheel about mobility.
- Human engineered for ease of operation.
- Complete factory service, support, and training.

Please contact **Video Logic Corporation** Sunnyvale, California, for a demonstration.

Video Logic Corporation / 597 N. Mathilda Avenue / Sunnyvale, CA 94086
(408) 245-8622 / Telex: 35-7400 / Cable: VIDEOLOGIC



INSTAR BY VIDEO LOGIC

The Recorder/Monitor

The INSTAR* Recorder/Monitor is one of the primary components of the well integrated INSTAR System. Specifically designed for INSTAR's unique video format, it is equipped with special control logic circuitry designed to prevent damage through misuse. INSTAR records up to one hour of video information on magnetic tape that can be replayed later for analytical viewing.

Specifications:

Signal Noise Ratio:	43 dB
Bandwidth:	5 MHz
Voltage Requirement:	115 VAC ± 10V 60 Hz + 0.5 Hz
Current Consumption:	Less than 5 amps
Recording Medium:	1″ high energy tape
End-of-Tape sensing:	Optical sensor to prevent tape runoff

Electronic Operating Controls:	Record, Play, Slow, Forward, Still Frame, Slow Motion Rate, Slow Back-up, Frame Sequencing (FS), Stand-by, Fast Forward, Fast Rewind, Continuous Record (CR)
Construction:	Cast Aluminum frame assembly (portable)
Auxiliary Output:	Strobe sync outputs; remote monitor output (optional)
Picture Size:	11″ Diagonal
Size:	26″ × 51″ × 20″
Weight:	150 lbs.
Optional:	Power converter for use with 220–230 volts and line voltage variations

INSTAR
BY VIDEO LOGIC

Camera

The INSTAR monochrome video camera employs a lead oxide camera tube which eliminates image retensity or "ghosting." The INSTAR video camera was designed specifically for the extremely high requirements of motion analysis and is manufactured by Video Logic.

Specifications:

Tube:	1″ Lead Oxide (monochrome)
Video Bandwidth:	>5 MHz
Resolution:	>400 T.V. Lines, limiting, horizontally
Camera Tripod Mount:	¼″—20 threads
Lens Mounting:	C—Mount
Housing:	Aluminum
Size:	15″ × 12″ × 5″
Weight:	13 lbs.
Model:	C-3, C-4, or C-5

Viewfinder

The viewfinder displays the camera's output signal on a 4″ monitor contained inside the camera case. It allows the operator to precisely and quickly position the camera when the Recorder/Monitor is several feet away. The viewfinder is optional on any INSTAR camera.

Specifications:

Tube:	4″ CRT
Internal Controls:	Vertical size; vertical linearity; horizontal focus
External Controls:	Brightness and contrast

Camera Shutter

The INSTAR shutter, designed to reduce motion blur under high ambient light conditions, allows light to pass to the camera pickup tube for 1000 microseconds. Other shutters are available at speeds of 500 to 100 microseconds.

INSTROBE

The INSTROBE 90 is a small portable stroboscope which provides high intensity lighting and eliminates motion blur. It emits an intense 10 microsecond pulse which flashes 120 times per second in synchronization with INSTAR's picture rate. The compact and lightweight flash head was designed to get into tight places. Flash heads can be tripod-mounted or hand-held. The INSTROBE power module, used to energize the strobe head, mounts conveniently on the INSTAR. For additional lighting the INSTROBE AB dual strobe is also available.

Specifications:

Tube:	Helical-Xenon filled
Cooling:	Forced Air (head and module)
Cable Length:	25 feet
Size and Weight:	
Flash Head:	10″ × 4.75″—5 lbs.
Power Supply:	15″ × 14″ × 5″—16 lbs.

Reusable Shipping Containers

The reusable shipping containers, fitted with high impact polyester foam, are specially designed to securely cushion the units of the INSTAR System. They conform to an ATA (Air Transport Association) category 300 rating. Outside dimensions allow transporting in most station wagons.

Specifications:

Unit	Size	Weight
Recorder/Monitor	31″ × 24″ × 57″	112 lbs.
Camera/Tripod	39″ × 13″ × 24″	33 lbs.
INSTROBE	39″ × 13″ × 24″	33 lbs.

Additional INSTAR Capabilities

Remote Camera

Some INSTAR applications require the camera to be physically located at substantial distances from the Recorder/Monitor. The remote camera was developed to transmit via microwave or up to 1000 feet of cable back to the Recorder/Monitor.

Remote Monitor

Some users find it desirable to have a remote monitor. For these applications Video Logic offers the RM1 monitor equipped with its own internal controls. The remote monitor is used where there is a need to observe the analysis some distance from the INSTAR operator.

Editing and Duplicating

Editing and duplicating services are offered by Video Logic where tape composites and copies for training and concise executive review are necessary.

Please contact **Video Logic Corporation** Sunnyvale, California, for a demonstration.

Video Logic Corporation / 597 N. Mathilda Avenue / Sunnyvale, CA 94086
(408) 245-8622 / Telex: 35-7400 / Cable: VIDEOLOGIC

HIGH SPEED VIDEO TEST RESULTS

SCENE #4 - Calibration of digital timers.
Video tape = 8.333 milliseconds per frame.

Run digital timer for 90 seconds.

Start Frame Number - 1,516
End Frame Number - 12,317

12,317
-1,516

10,801 Frames

10,801 frames x 8.333 millisecond/frame = 90.004 seconds

SCENE #5
- Pilotex "Auto-Speed" Test No. 1
- System pressure = 50 PSI
- Ignition via electric match in smokeless powder
- No digital time recorded

Event	Frame No.	# of Frames	Video Elapsed Time (# of Frames x 8.333)
Ignition	1652		
U.V. Controller Output	1659	7	58 MS
First Water - 3"	1666	7	58 MS *
Water - 1'-0"	1670	4	33 MS
Water - 1'-6"	1671	1	8 MS

SCENE #6
- Pilotex "Auto-Speed" Test No. 2
- System Pressure = 175 PSI
- Ignition via electric match in smokeless powder
- Digital time = 31 MS

Event	Frame No.	# of Frames	Video Elapsed Time (# of Frames x 8.333)
Ignition	1360		
U.V. Controller Output	1367	7	58 MS
First Water - 3"	1372	5	41 MS *
Water - 1'-0"	1375	3	25 MS
Water - 1'-9"	1377	2	16 MS

HIGH SPEED VIDEO TEST RESULTS

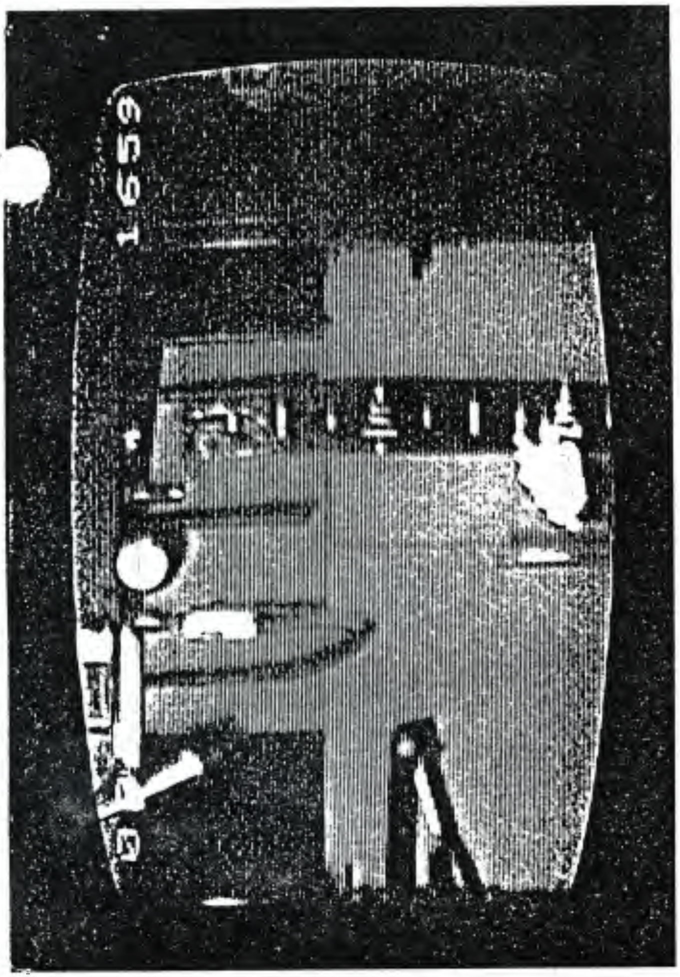
SCENE #7
- Pilotex "Auto-Speed" Test No. 3
- System Pressure = 170 PSI
- Ignition via Smokeless Powder
- Digital time = 32 MS

Event	Frame No.	# of Frames	Video Elapsed Time (# of Frames x 8.333)
Ignition	1505		
U.V. Controller Output	1512	7	58 MS
First Water - 2"	1516	4	33 MS *
Water - 9"	1519	3	25 MS
Water - 1'-3"	1520	1	8 MS

SCENE #8
- Pilotex "Auto-Speed" Test No. 4
- System Pressure = 170 PSI
- Ignition via strobe light
- Digital time = 32 MS

Event	Frame No.	# of Frames	Video Elapsed Time (# of Frames x 8.333)
Ignition	1039		
U.V. Controller Output	1045	6	50 MS
First Water - 2"	1050	5	41 MS *
Water - 1'-0"	1053	3	25 MS
Water - 1'-6"	1054	1	8 MS
Water - 2'-0"	1055	1	8 MS

* Times to be adjusted for water travel to obtain "first water" at nozzle time.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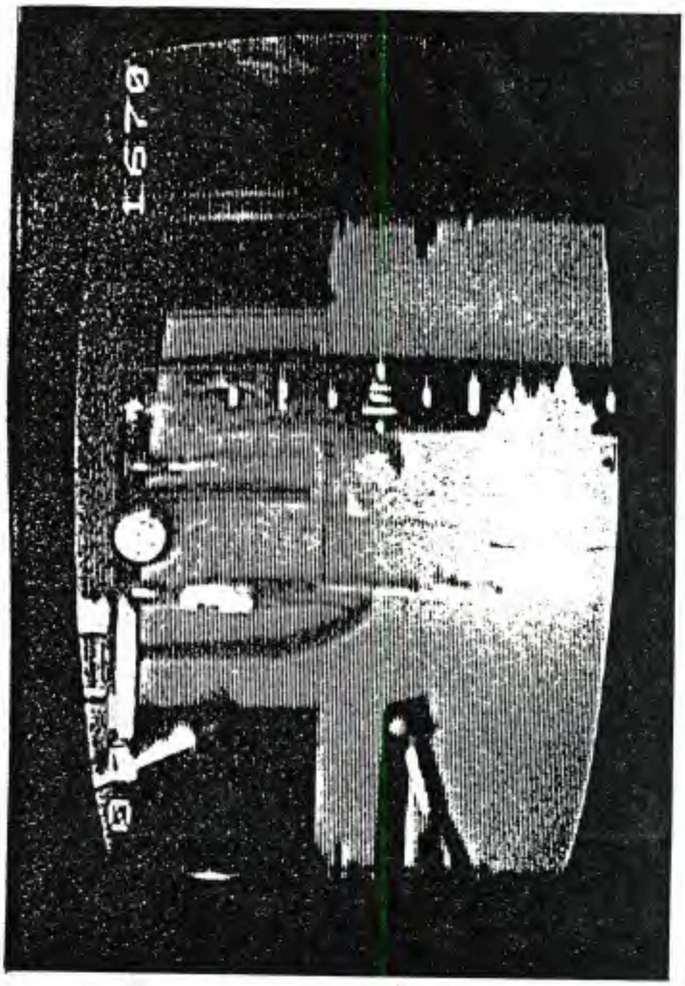
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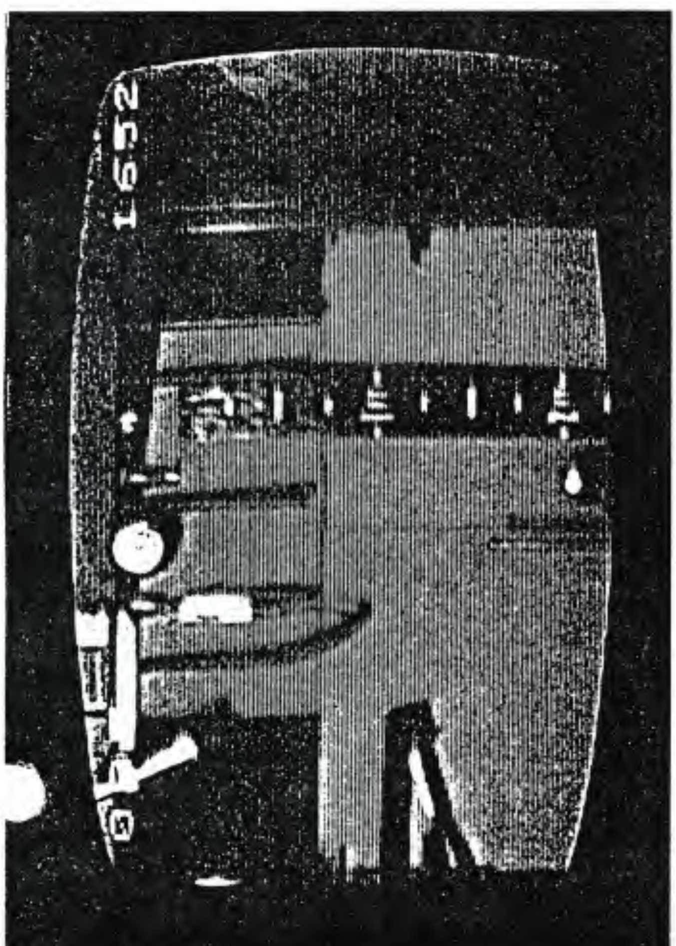
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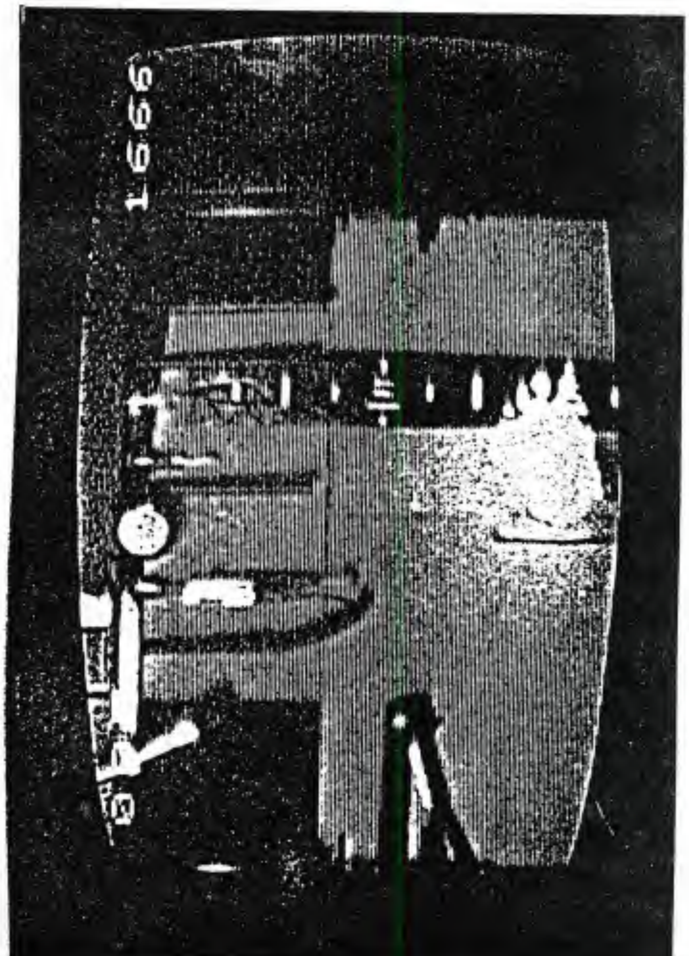
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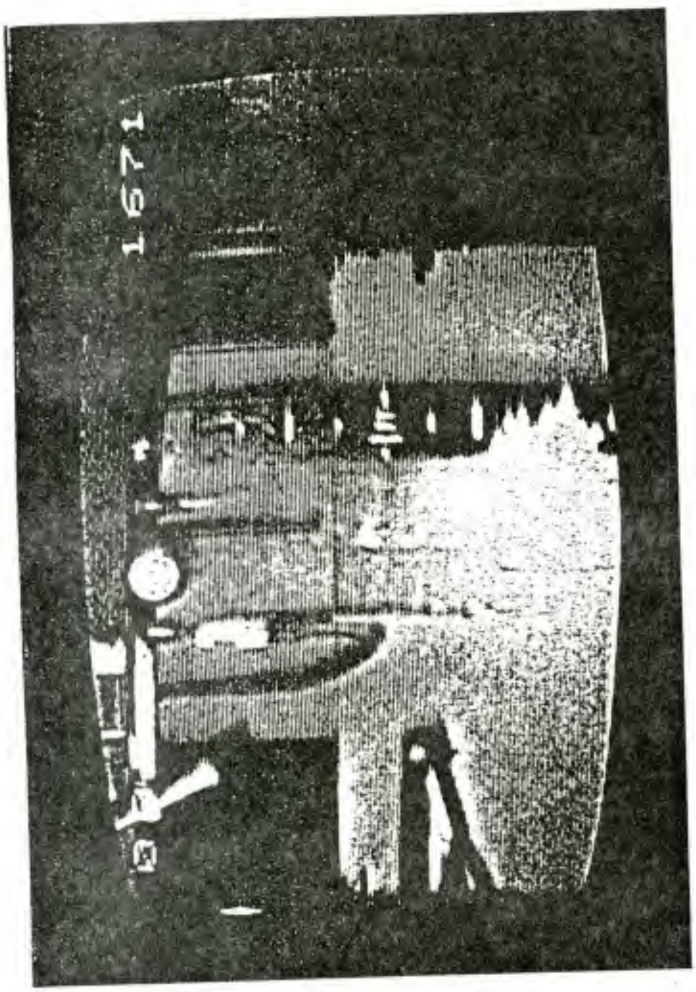
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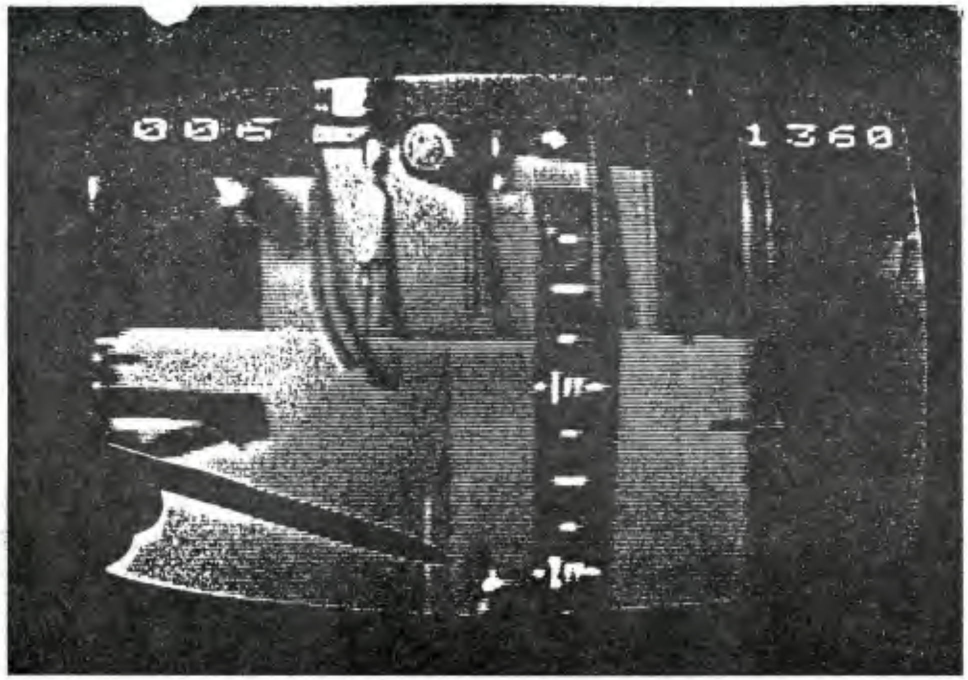
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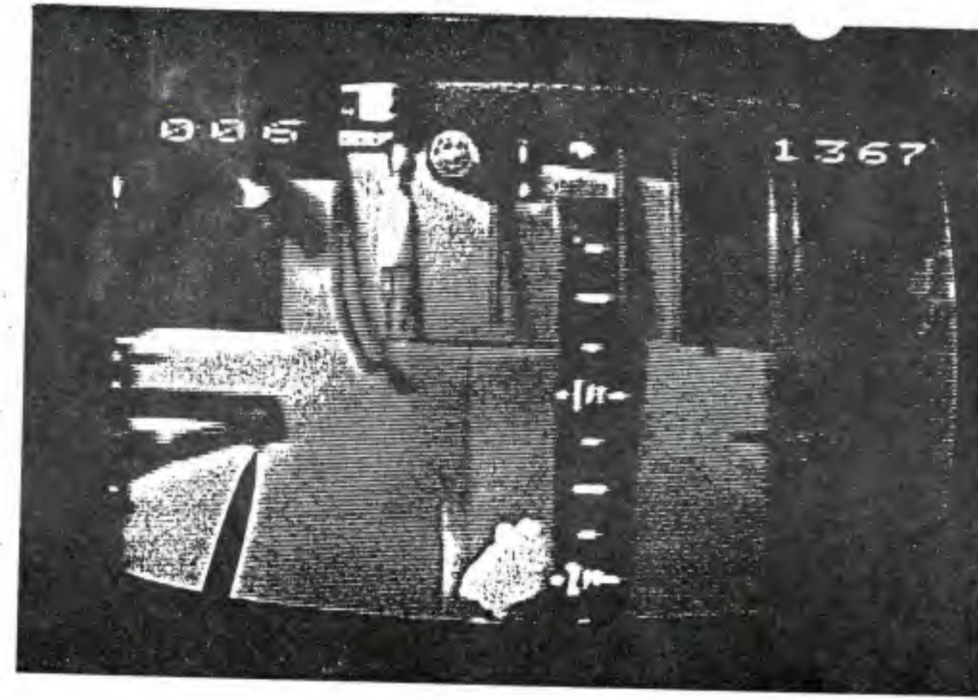
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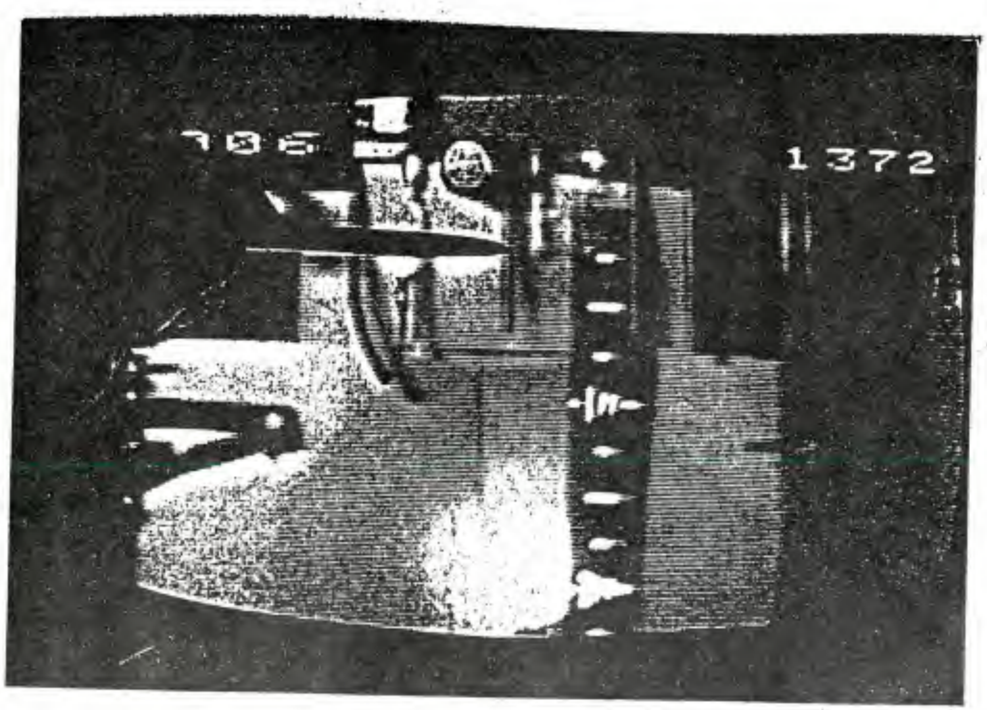
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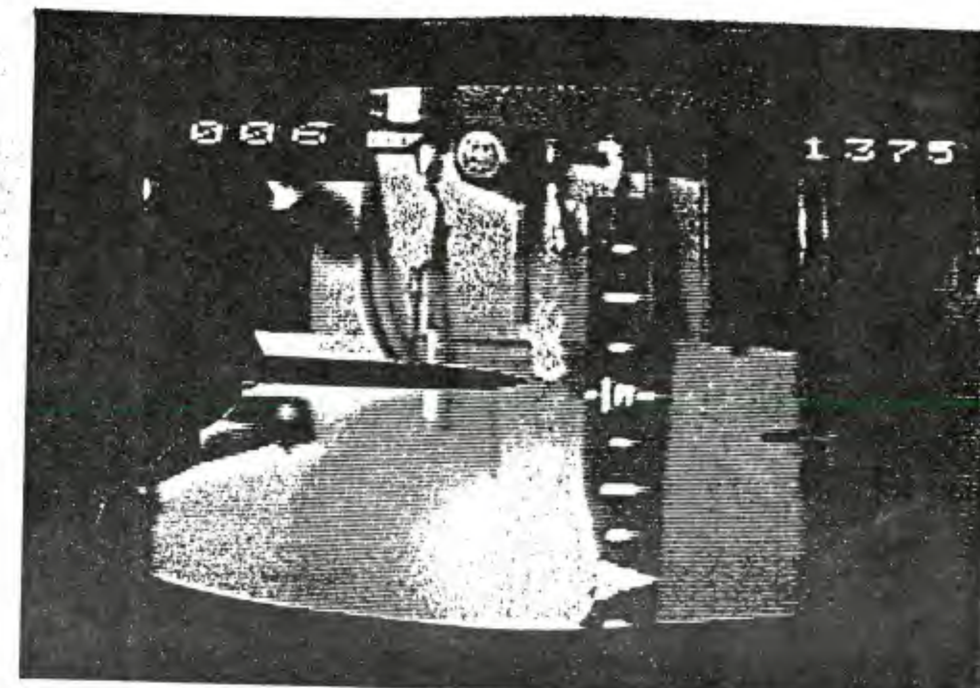
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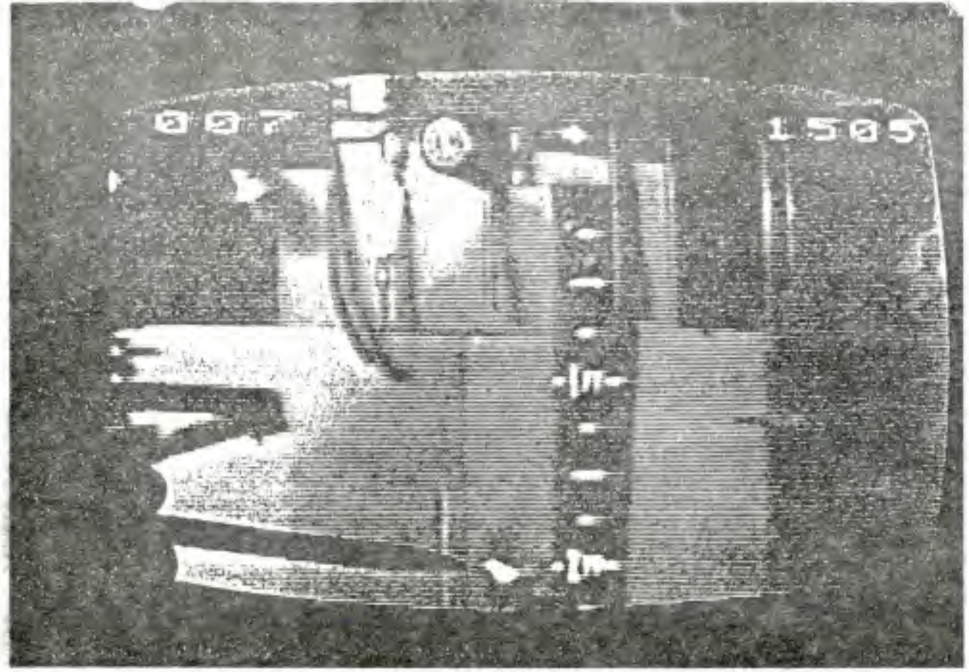
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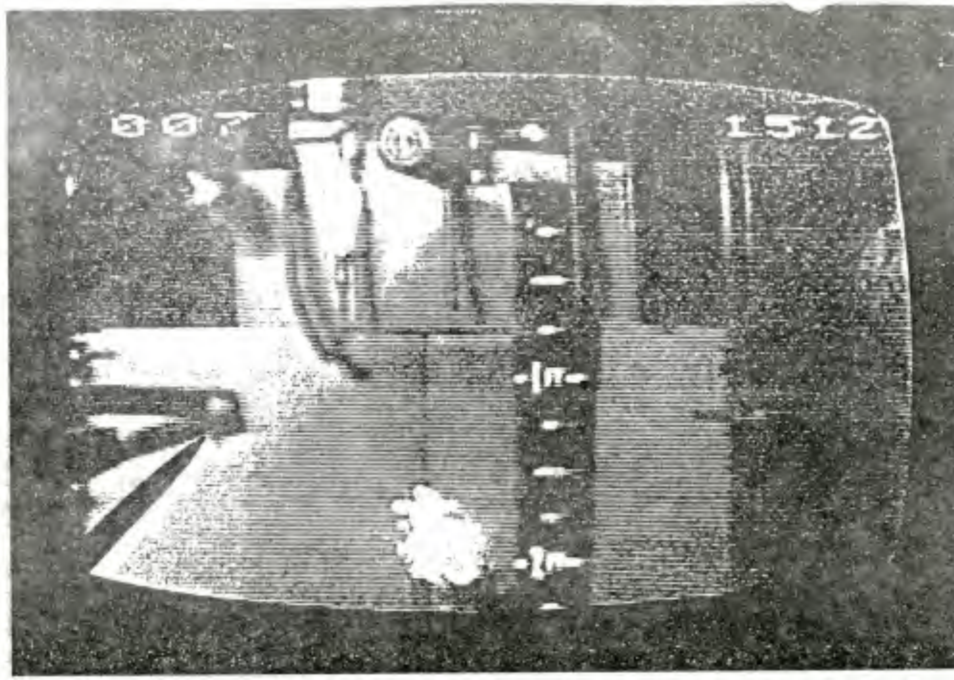
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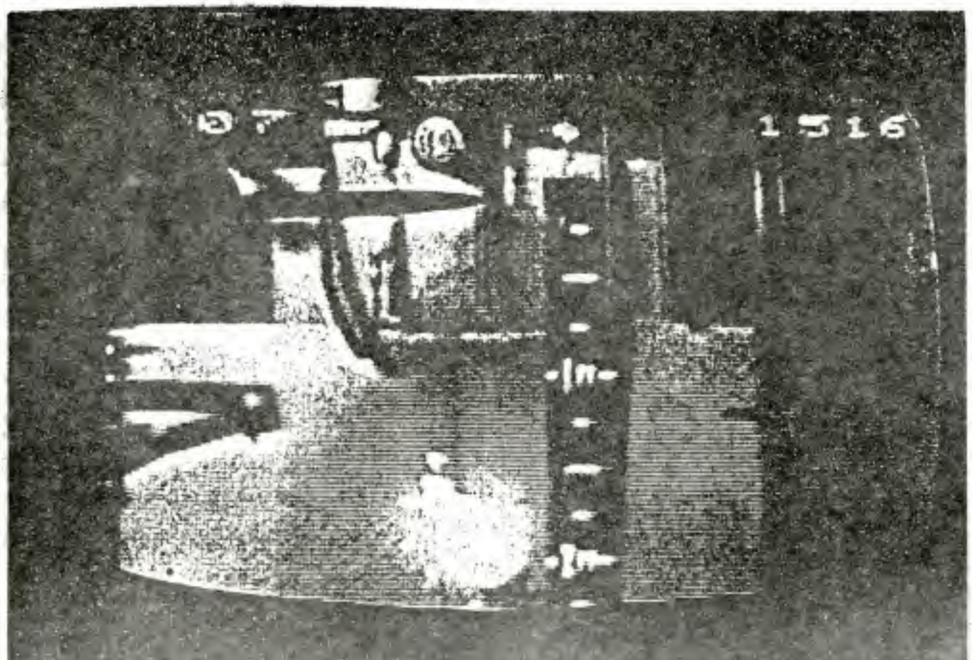
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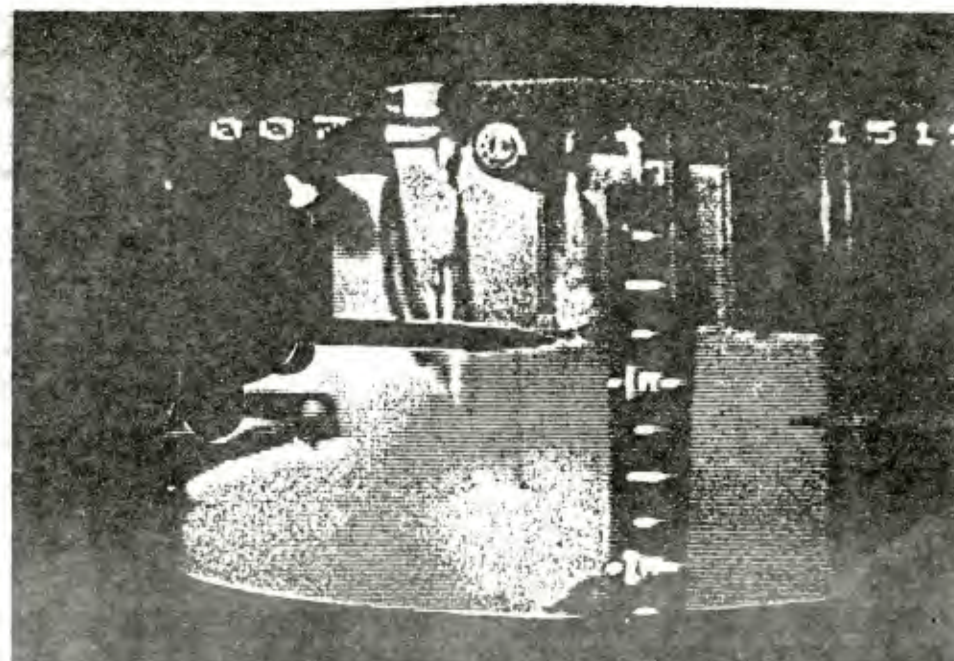
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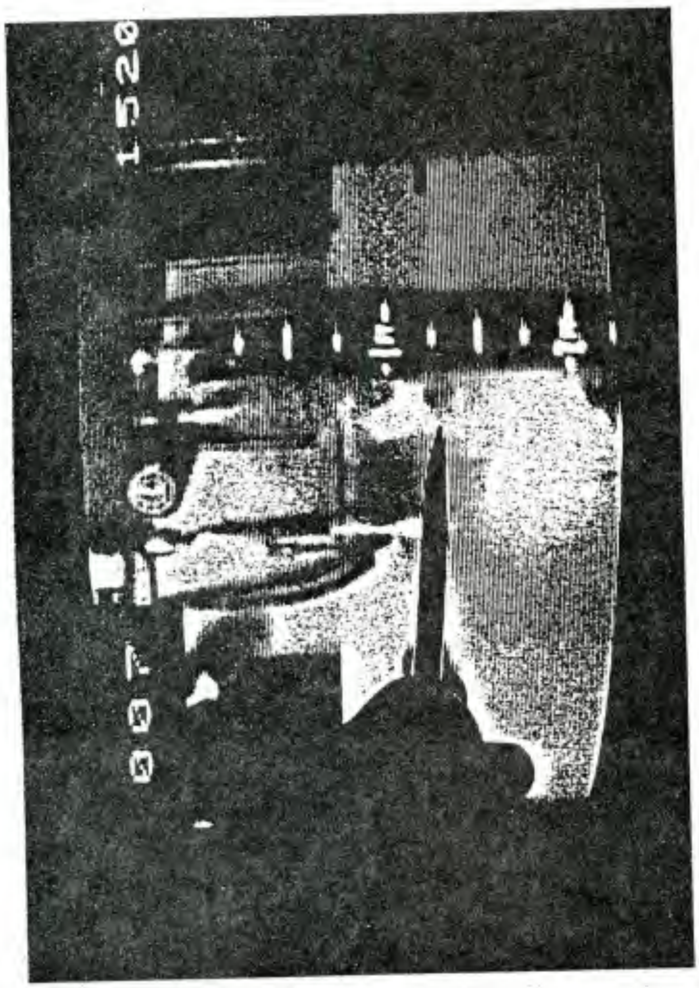

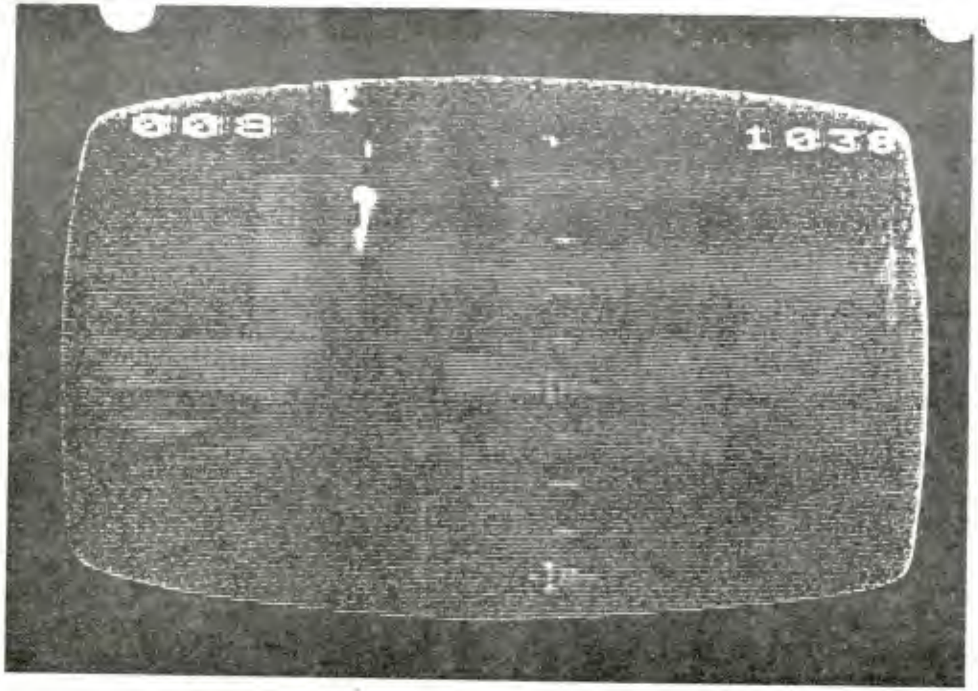
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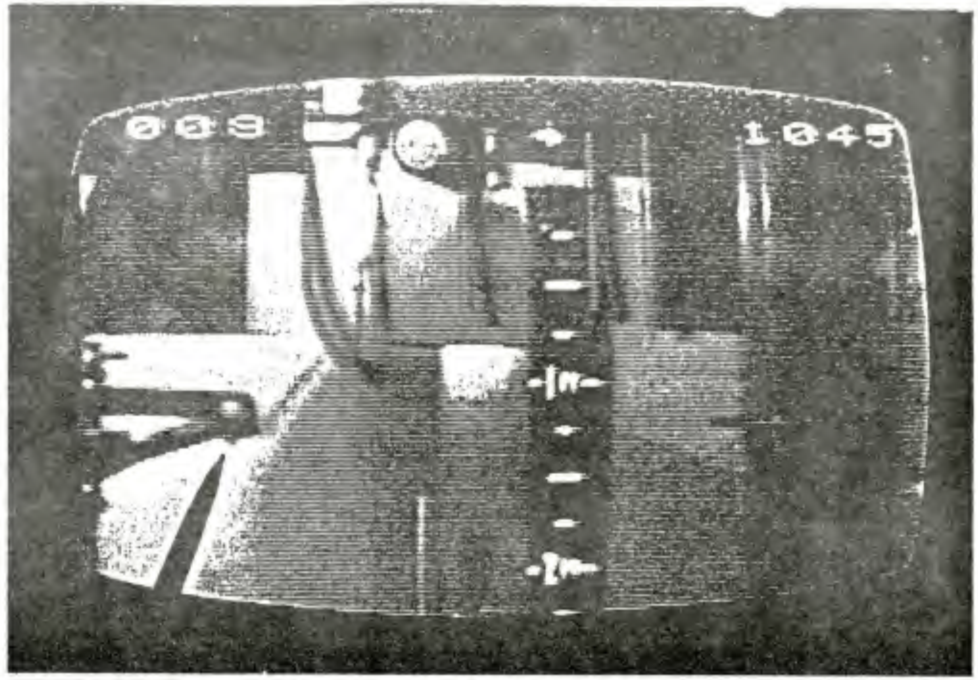
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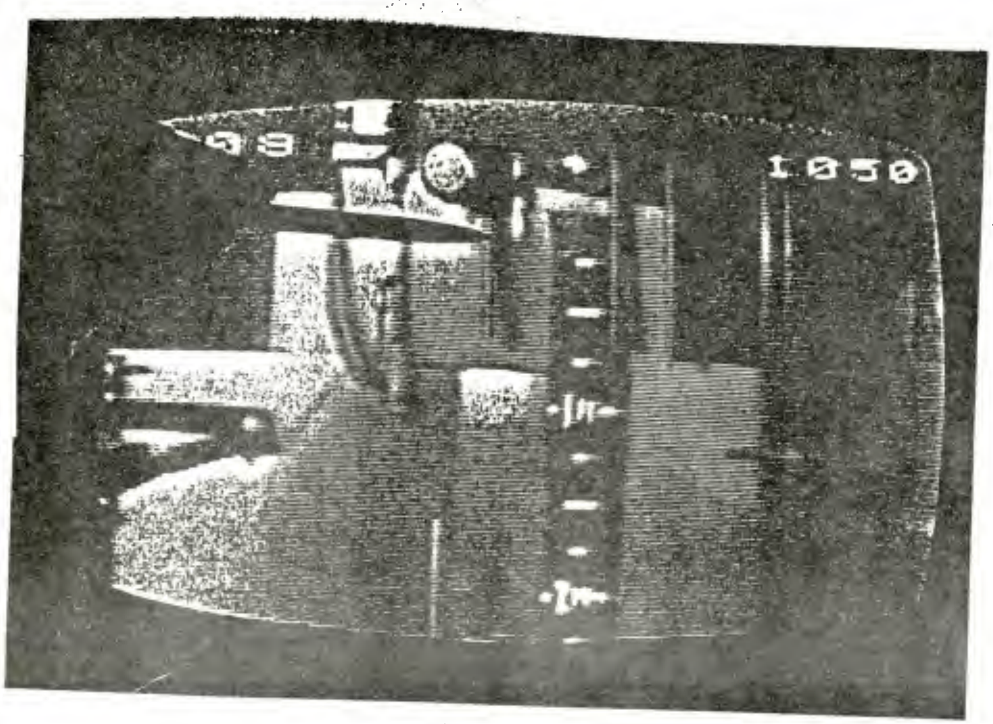
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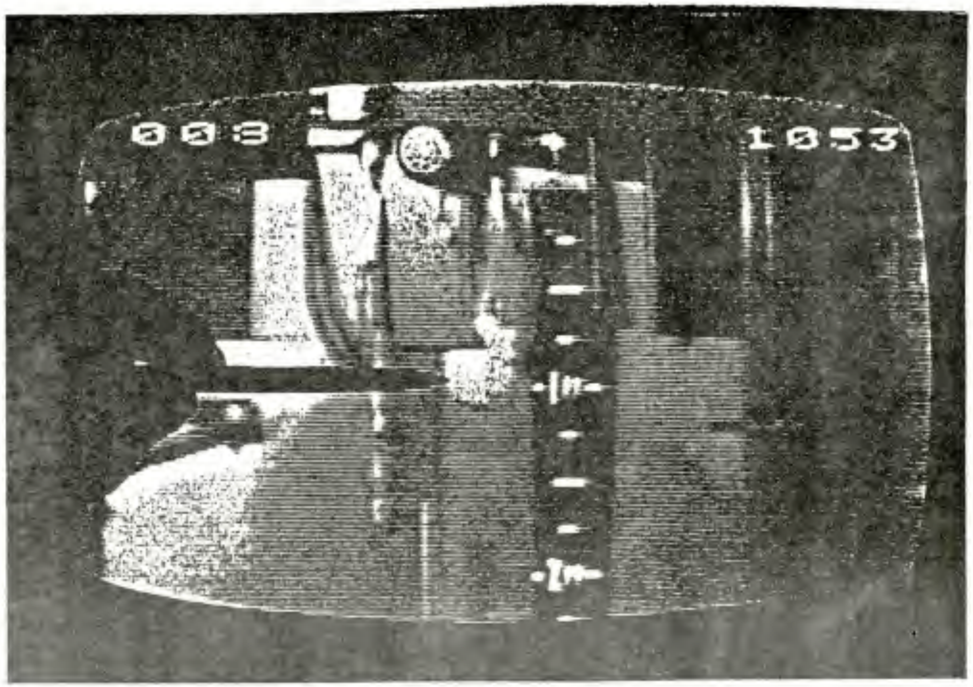
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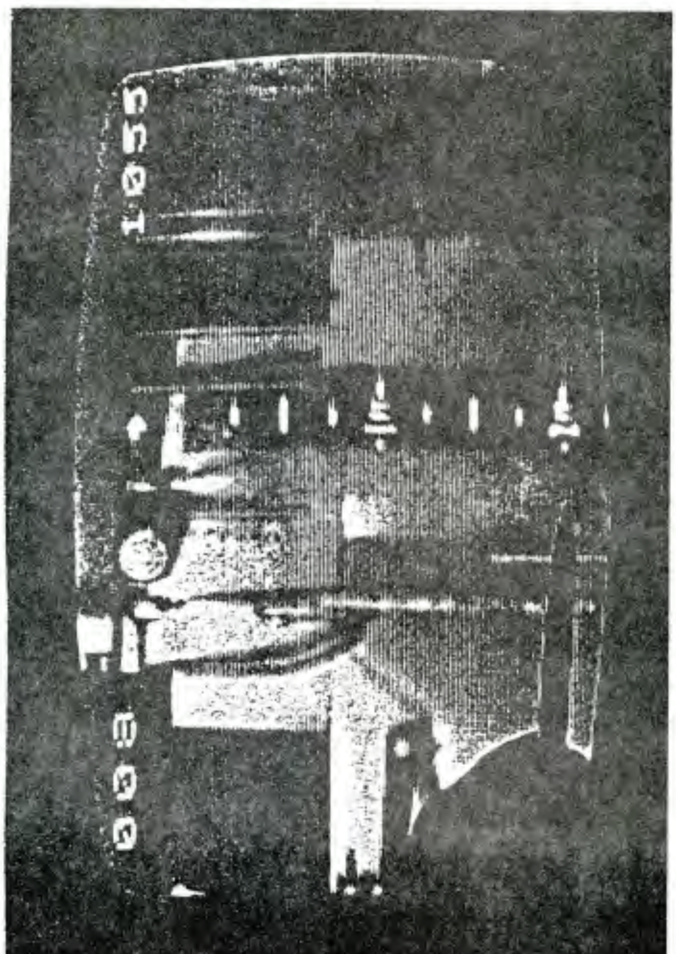


AMCCOM SAFETY OFFICE RAPID ACTION FIRE PROTECTION SEMINAR
Rock Island, Illinois
Schedule-24 Oct 84

Primac Systems

All Primac valves operate on the same principle. The explosive force of the primer releases a latch (2-2½) or a ball (4-6) so that the full line water pressure under the seat is then impressed on the previously primed water that has filled all the piping downstream of the control valve. This pressure is capable of rupturing or blowing off the cpas, discs or struts at the discharge nozzles which up to this point have retained the priming water in the piping. Water now flows from the nozzles out to the hazard at full line pressure.

We can divide operation time into parts:

1) Detection
2) Water application

The second part, the time required from primer firing to the time water makes its exit from the nozzles is the source of most of the time consumption and is dependent on several factors.

This second part can be divided into three additional basic parts:

1) Valve open
2) Pressure travel time from supply to nozzle
3) Burst disk or cap

The first two parts can be defined and the time estimated from known results. However, part No. 3 is more complex.

One of the most important areas of this part No. 3 and also the area in which we have the least amount of information is the completeness of water prime of the piping system from the explosive valve to the nozzle closures.

Our tests show this to be a vitally important factor since, in general, our research indicates that an air pocket constituting about 5% of the total volume of the system will cause about a 100% increase in operating time.

Water supply pressure is another very important factor in determining water delivery time. Both theory analysis and actual tests show that all other factors being equal, the water delivery time is proportional to the square root of the water supply pressure. This would mean, for example, that if the supply pressure on a specific system were increased from 50 psi to 100 psi, the water flow from the nozzles would be reduced by about 30%.

Since our test times are concerned with the period from water at rest to water flow from nozzles, friction factors and coefficients obtained during full flow do not apply in between flow.

Water delivery time thus is independent of pipe line friction loss and head elevation but is neither static nor flowing and almost solely due to inertia effects.

Our tests have shown that time is affected by:

1) No. of nozzles and orifice size
2) Static water supply pressure
3) Cap or disc blow-off pressure
4) Length of pipe - from valve to nozzles and No. of fittings
5) Size of pipe - cross section area
6) Air pockets

Let us first study valve principles of operation.

2-2½" Model F460 Primac Valve

Basic Parts

1) Body
2) Housing with access cover and gasket
3) Junction box with cover and terminal strip
4) Bonnet with nut
5) Plunger and shaft assembly
6) Latch with shear pin

Principles of Operation

When the Primac system is initially set for service, the F-460 Primac Valve is placed in the set position. The latch which is prevented from swinging by a shear pin holds the plunger and shaft assembly in the seated position, where the plunger o-ring creates a seal so that the supply pressure does not enter the system piping.

An electrical signal from the control panel fires the dual primers in the primer holders. The force exerted by only one of the primers is enough to pivot the latch and break the shear pin. The latch swings into the tripped position and the supply pressure lifts the plunger and shaft assembly out of its seated position.

The shaft o-rings prevent the priming water from entering the housing. The primed system is instantly pressurized by the water supply, and water is discharged out of all the nozzles after the disc or cap ruptures.

A vertical installation is preferable, but a horizontal installation is acceptable. The valve works by the same principle in both.

The system piping is primed by means of the priming valve in the by-pass.

Primers

The primers utilized with the F-460 are electrically actuated explosive devices.

Explosive lead styphnate (120 grams) is enclosed in a brass cylindrical shell having No. 22 AWG solid copper tinned wire leads. The primer plugs are 100% x-rayed for continuity. The primer leads are approximately 8" long - 7" of red nylon insulation and 1" twisted ends. The ends are twisted to prevent accidental firing during shipping, storage and installation.

The wire bridge resistance of two primers connected in parallel varies from 1.5 to 3.5 ohms and the recommended firing current is 0.4 to 5 amps.

4-6" Primac Valve

Model A-4 Multimatic Valve with F461 Primac Release

The valve is a standard Grinnell 4 or 6" Multimatic Deluge Valve which has been modified by the addition of a Primac Release mounted to the left hand side of the valve body.

Basic Parts

1) Body with cover
2) Seat ring and clapper assembly
3) Primac release with cover and junction box with cover
4) Pilot chamber with diaphragm and restriction
5) Basic trim with priming valve

The junction box is the same as the 2-2½" valve.

Principles of Operation

When the Primac system is set for service, the Primac-Multimatic clapper assembly is seated, the piping has primed with water thru the ½" connection in the lower left hand side of the valve body and the pilot chamber has been pressurized to a pressure equal to that of the water supply.

The Primac-Multimatic is a differential type valve depending on water pressure in the pilot chamber to hold the clapper assembly seated against the water supply pressure. The valve has a trip ratio of approximately 2½ to one.

The spacer retaining latch, which is prevented from pivoting by a shear pin, holds a spacer between the flange and push rod and the latch push rod. With the spacer in place, direct communication between the pilot chamber and the clapper latch is maintained so that the clapper assembly remains seated and the water supply does not enter the system piping.

An electrical signal from the control panel fires the dual primers in the primer holder. The force exerted by only one primer is enough to pivot the spacer retaining latch and break the shear pin.

With the spacer taken out from between the push rods, the communications between the pilot chamber and clapper latch is broken.

The bearing force exerted by the clapper latch against the clapper assembly is eliminated and the force of the water supply is free to unseat the clapper assembly.

Our R & D facilities are now conducting a complete new series of Primac system tests. Recently completed testing of the opening or un-latching time of the Primac valves confirmed data that water pressure is a function of unlatching time and our valve opens in less than 10 milliseconds. There is approximately a 3 millisecond differential between the two valves at virtually all pressures.

As part of the present test program, we constructed a typical small Primac system at our R & D test facility using the latest Model 2½" Primac valve, 4 new F series Mulsifyre nozzles with our new caps using our latest design criteria.

The purpose was to establish up-to-date relationship between elapsed time in milliseconds and water pressure for inclusion in the new Primac system data sheets now being prepared.

This lab test documented what we have learned from our many field tests that is very difficult to obtain any time below 50 Mil with less than 100 psi supply pressure.

Care and Maintenance

The principle concerns in the care and maintenance of the Primac system are integrity of:

1) Control panel and detection system
2) Priming water
3) Primac valve

1) Control panel - Refer to manufacturer's instructions for details.

2) Priming water - In order to maintain fully primed systems, at least once every three months or more often if possible:

    1) Open vent valve
    2) Crack open priming valve
    3) Allow water to flow for a few minutes, then close priming valve first, then vent valve.

A quarterly or as necessary, inspection of the system piping should be made including all caps, discs, vent valves, priming valves.

Rupture of caps or discs could mean a pressure build-up due to leaking priming valve or plunger o-ring failure.

3) Primac valve - At lease once a year the valve should be operated by firing of the primers. This will assure:

    1) Primac valve is functional
    2) Primers are replaced annually

We maintain a full line of deluge spray nozzles and sprinklers that are also used for Primac system by utilizing a cap, disc or strut.

Most common nozzle used is our:

Mulsifyre Line

Scroll Type
High Pressure - Min. 30 psi
Medium size droplets
Projection - long throw/directional
High velocity
Outdoor and indoor extinguishment and cooling
Basic narrow angle
Fixed limited orifice
Wind resistant
Available with cap - can also be used with disc

Also used are:

Protectospray and EA-1

Deflector type
High pressure - 20 min. indoor
30 min. outdoor
Fine size droplet
Directional/shorter throw - deflector not projector
Medium velocity
Indoor extinguishment and cooling
Outdoor cooling
Wider angle - variable orifice
Less wind resistant
Must be used with disc

½" Sprinkler

Upright and pendent
Standard sprinklers
Not directional - umbrella pattern
Low velocity
Area protection rather than equipment
Hallways etc.
General floor area
Can be used with either struts or discs

Our present research program has under development new nozzles, caps, discs and unions. Our new Mulsifyre nozzles are bronze coated with an abrasive resistance Teflon coating.

3/4" IPT with Caps interchangeable

Our new caps are poly olefin higher grade of plastic. Will have uniform blow-off pressures and closer differential between leak tight and blow-off.

Our new rupture disc unions will be bronze with S.S. hardware. Flange connection not union.

The new rupture disc is an aluminum alloy coated with a special resin. Goal is burst at 25 psi.

Primac System Design

The following design criteria is unique to Primac Systems:

1. Although the Primac valve may be installed vertical or horizontal, vertical installations are recommended.

2. Keep the number of turns or changes in direction in the system piping to a minimum.

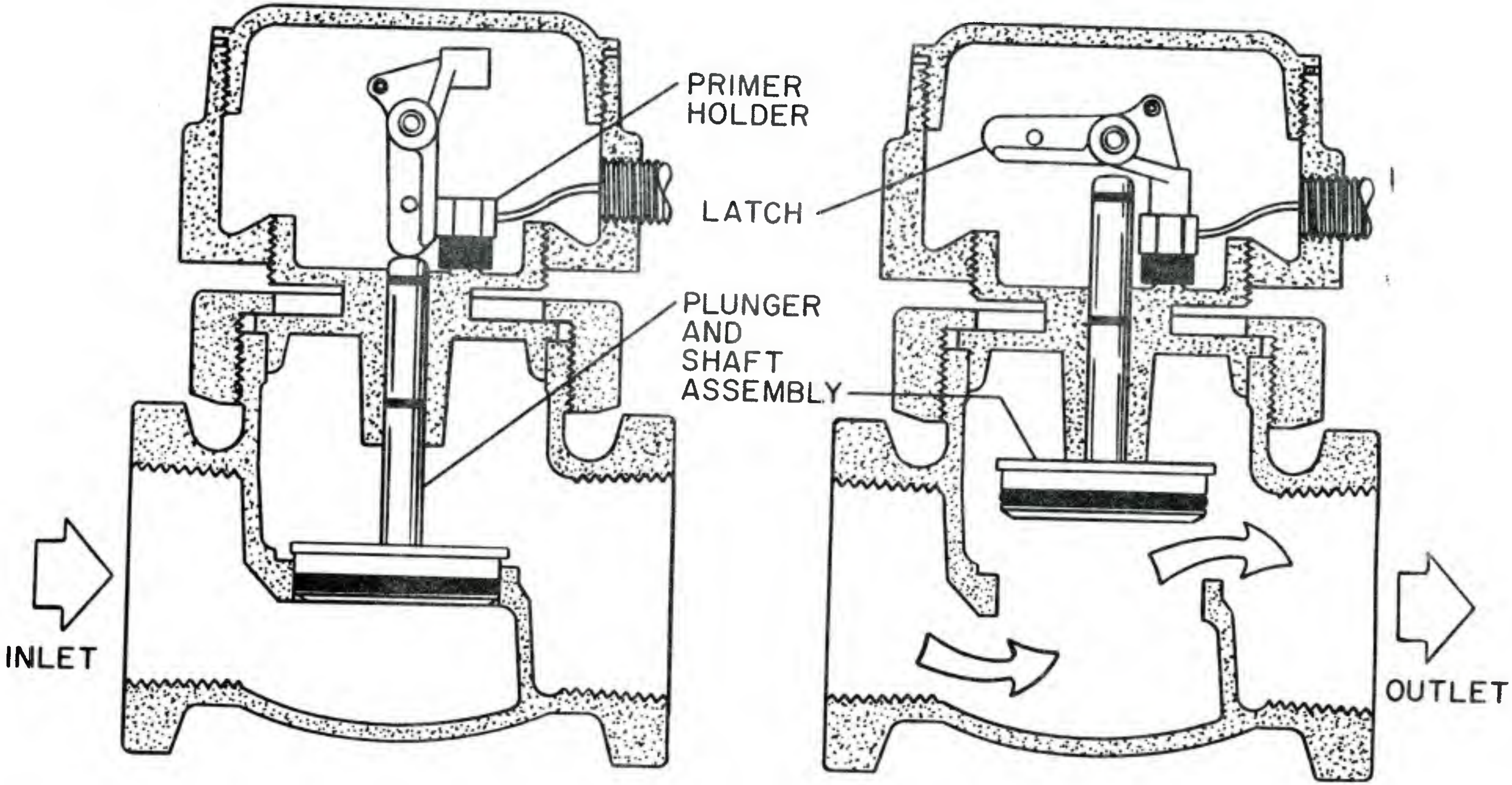
3. Design the piping configuration so that all horizontal lines are sloped continuously upwards towards a vent valve.

4. Design the piping configuration with the nozzles fed in clusters.

5. Provide vent valves to vent air from the system.

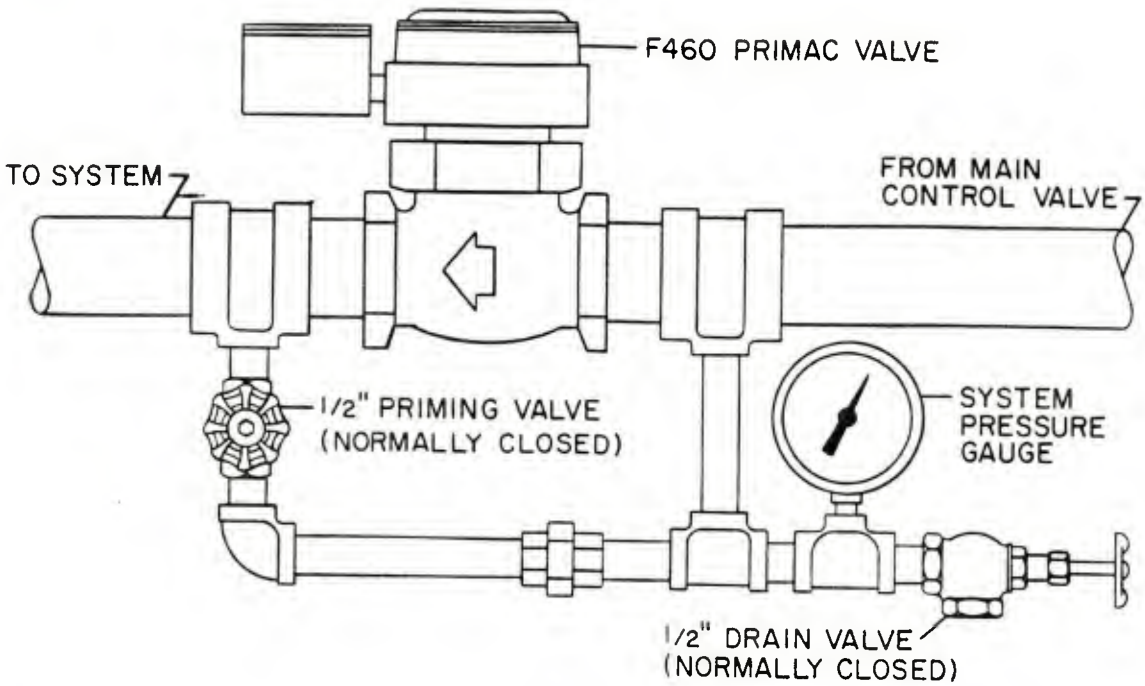
6. Obtain highest static pressure available. If available plant water supply static pressure is low, use a surge tank with the plant water supply as back up.

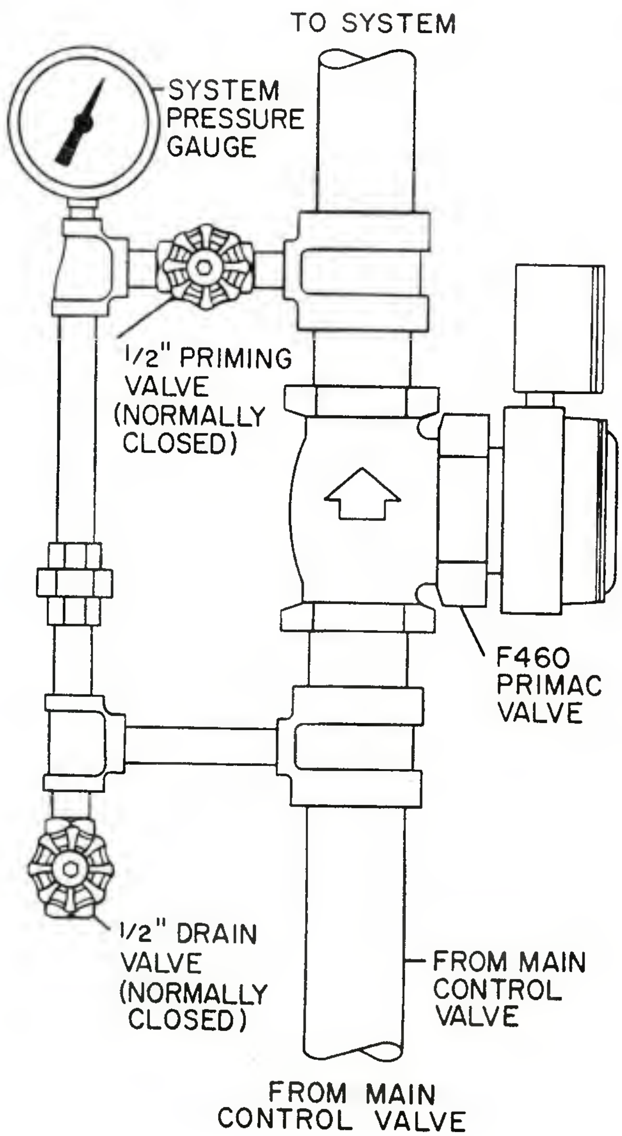
7. Calculate the system in the normal manner.

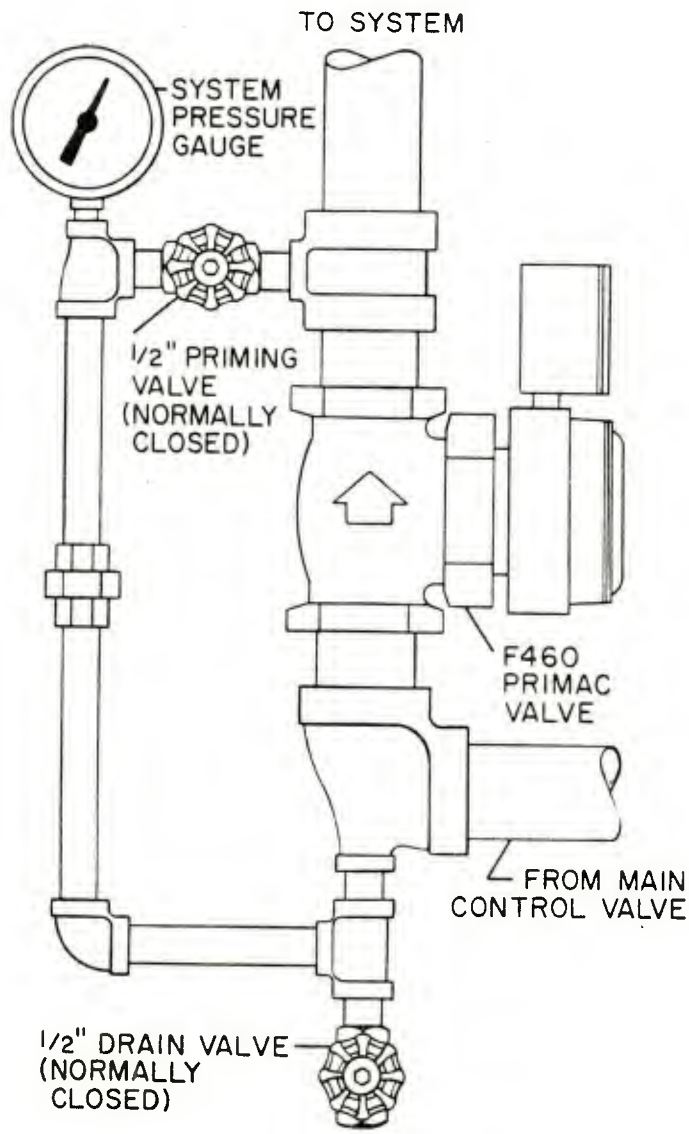


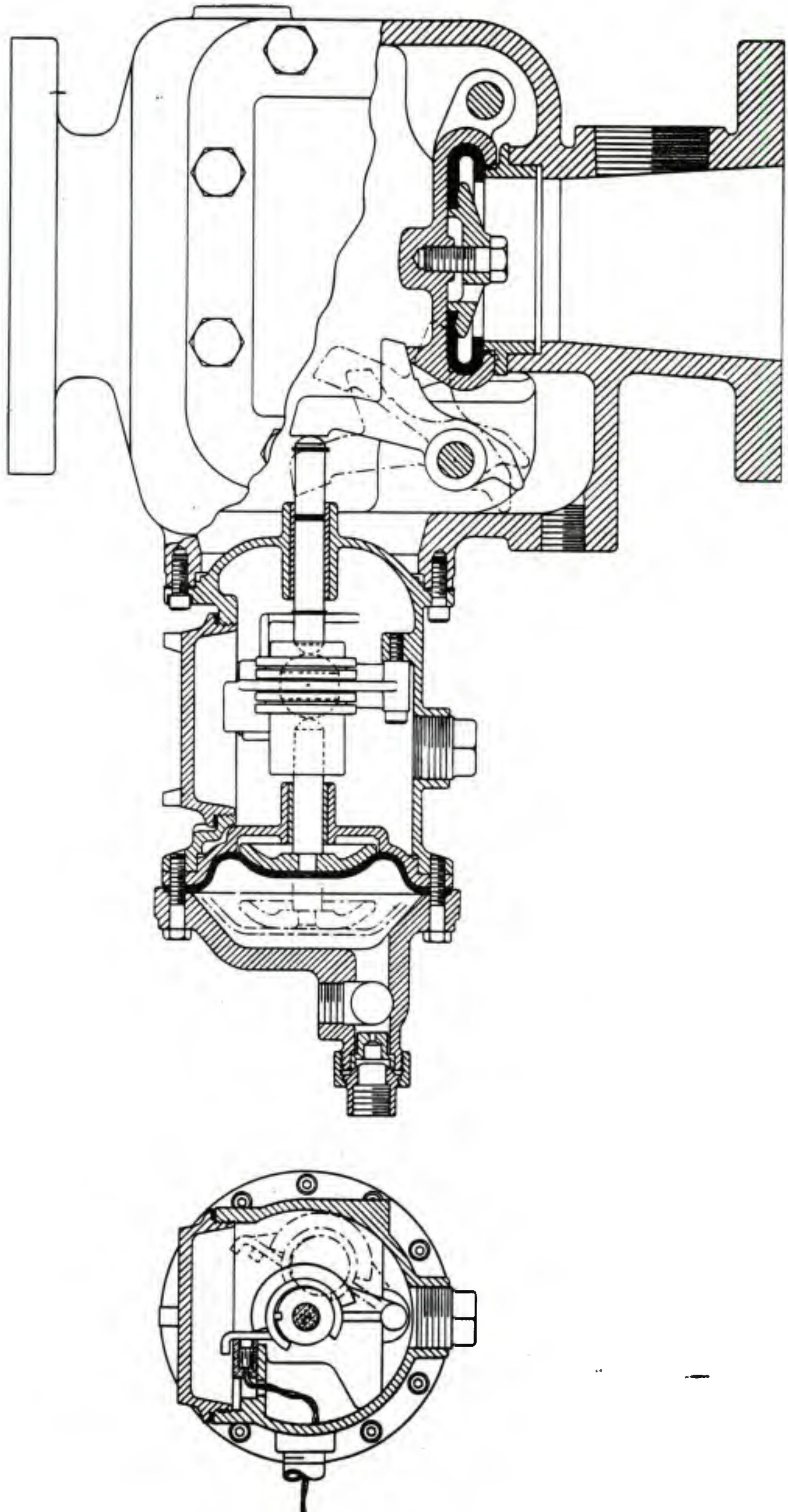
SET POSITION

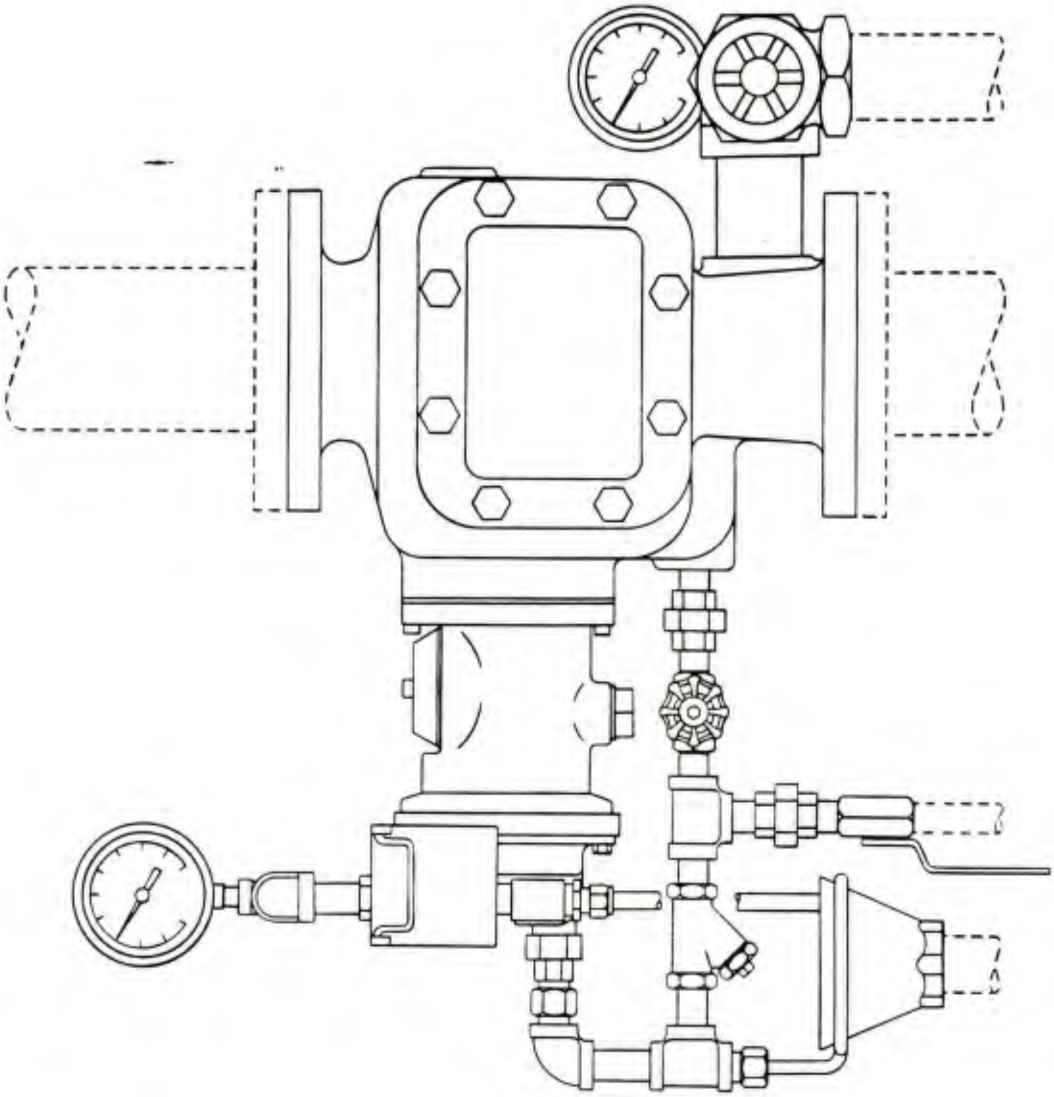
TRIPPED POSITION

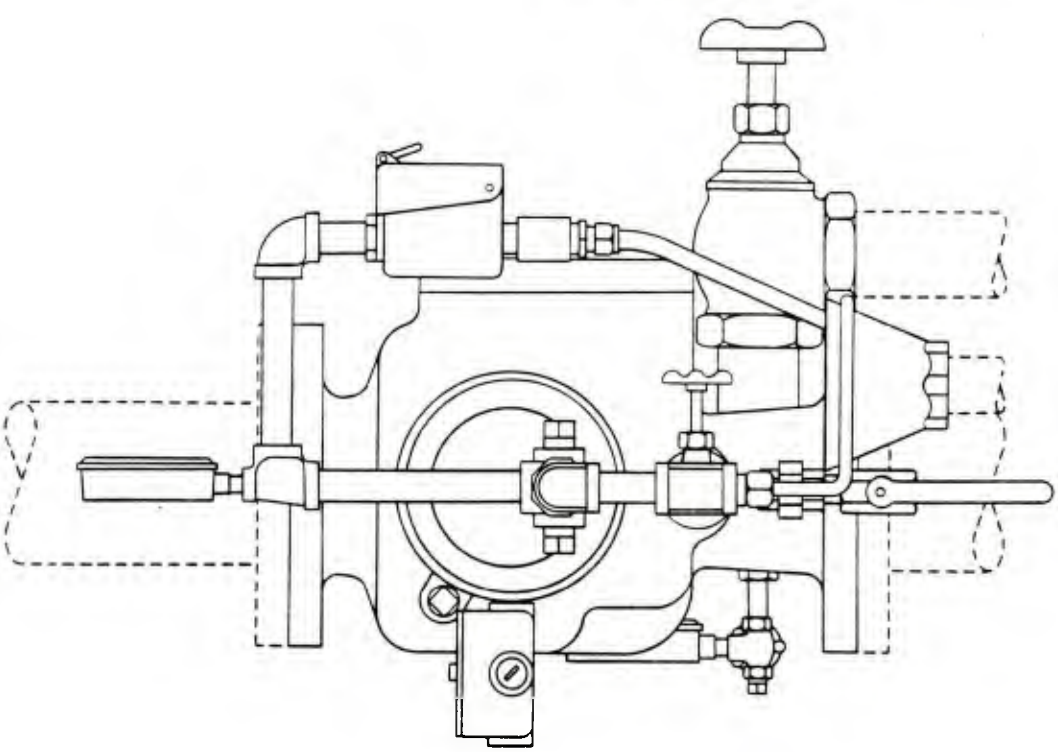

F460 PRIMAC VALVE
TO SYSTEM
FROM MAIN CONTROL VALVE
1/2" PRIMING VALVE (NORMALLY CLOSED)
SYSTEM PRESSURE GAUGE
1/2" DRAIN VALVE (NORMALLY CLOSED)

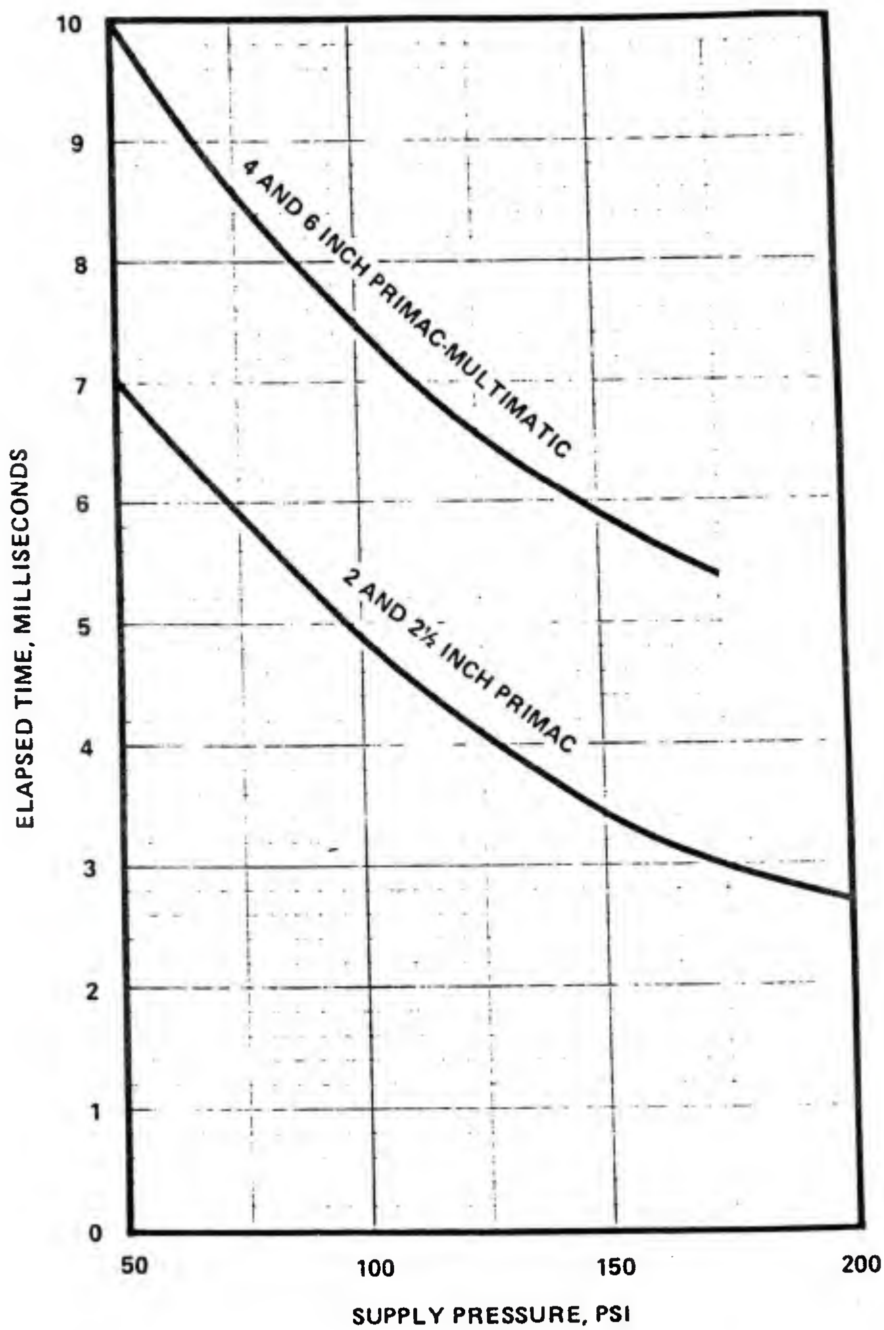

TO SYSTEM
SYSTEM PRESSURE GAUGE
1/2" PRIMING VALVE (NORMALLY CLOSED)
F460 PRIMAC VALVE
1/2" DRAIN VALVE (NORMALLY CLOSED)
FROM MAIN CONTROL VALVE
FROM MAIN CONTROL VALVE


TO SYSTEM
SYSTEM PRESSURE GAUGE
1/2" PRIMING VALVE (NORMALLY CLOSED)
F460 PRIMAC VALVE
FROM MAIN CONTROL VALVE
1/2" DRAIN VALVE (NORMALLY CLOSED)

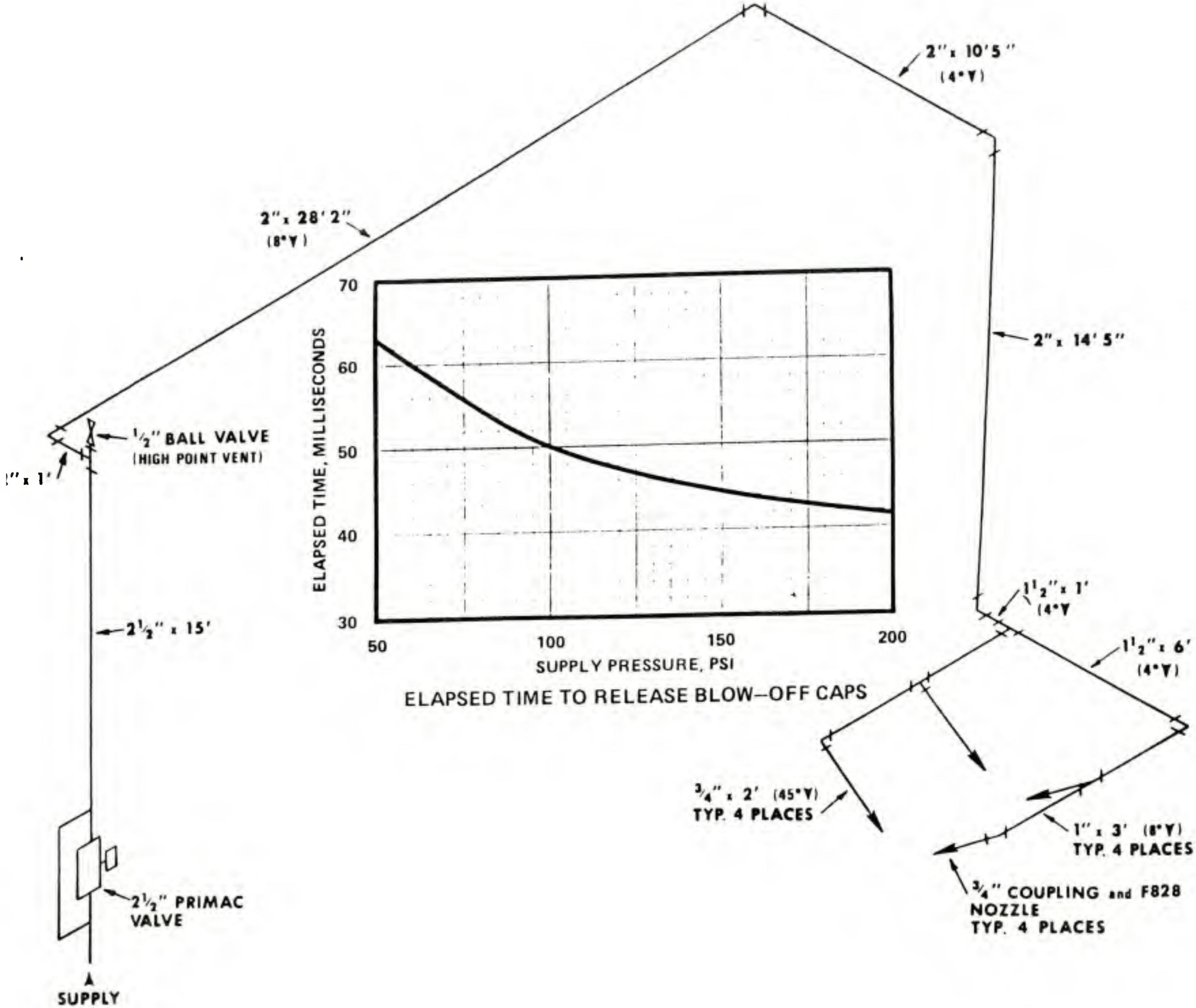








ELAPSED TIME FOR
PRIMAC AND PRIMAC-MULTIMATIC VALVES
TO UNLATCH


2" x 10'5"
(4°Y)
2" x 28'2"
(8°Y)
2" x 14'5"
1/2" BALL VALVE
(HIGH POINT VENT)
"x 1'
2 1/2" x 15'
2 1/2" PRIMAC
VALVE
SUPPLY
70
60
50
40
30
ELAPSED TIME, MILLISECONDS
50
100
150
200
SUPPLY PRESSURE, PSI
ELAPSED TIME TO RELEASE BLOW-OFF CAPS
1 1/2" x 1'
(4°Y
1 1/2" x 6'
(4°Y)
3/4" x 2' (45°Y)
TYP. 4 PLACES
1" x 3' (8°Y)
TYP. 4 PLACES
3/4" COUPLING and F828
NOZZLE
TYP. 4 PLACES

RAPID ACTION FIRE (DELUGE) PROTECTION SEMINAR

23 - 24 OCTOBER 1984

ROCK ISLAND, IL

PROBLEMS AND CHALLEGES OF DELUGE SYSTEMS

BY WILLIAM SCOTT SHIRLEY

SAFETY AND OCCUPATIONAL HEALTH SPECIALIST

LOUISIANA ARMY AMMUNITION PLANT

TITLE: PROBLEMS AND CHALLEGES OF DELUGE SYSTEMS

I. INTRODUCTION

A. I KNOW DELUGE SYSTEMS CAN AND WILL EXTINGUISH FIRES. AT LOUISIANA AAP THERE HAVE BEEN TWO COMP C-4 FIRES EXTINHUISHED BEFORE ALL INVOLVED C-4 BURNED. IN BOTH CASES IT IS UNCERTAIN IF THE UV DETECTORS WERE WHAT TRIPED THE SYSTEM. IN ONE CASE THERE WAS ALSO A RATE OF RISE DETECTOR, AND IN THE SECOND AN OPERATOR TRIPED A MANUAL PULL STATION.

B. EVEN WITH OUR SUCCESSES THERE REMAINS SOME PROBLEMS, THERE IS A LACK OF UNIFORMITY IN EXISTING SYSTEMS WHICH IS NOT COMPLETELY EXPLAINED BY DIFFERENCES IN BUILDING DESIGN OR OPERATIONS. VARIATIONS HAVE BEEN OBSERVED FROM LINE TO LINE AND PLANT TO PLANT.

C. DIFFERENCES INCLUDE

1. NUMBER OF DETECTORS
   A. FOR AREA
   B. ON SINGLE VALVE
2. DISTANCE OF DETECTORS FROM PROTECTED OPERATION
3. MANUAL ACTIVATION DEVICES, NUMBER AND LOCATION
4. NUMBER OF NOZZELS ON ANY GIVEN VALVE
5. NOZZELS FOR AREA COVERAGE AND/OR POINT OF OPERATION
6. OPERATING PRESSURE
7. ZONES AND CROSS ZONING
8. DESIGN AND MANUFACTURE OF COMPONENTS

II. Need For Standarization of R & D Testing

A. Lots of tests for specific projects

B. Tests done over the years have not followed uniform proceedures

C. Some types of equipment and operations not tested, for example no test done on capability to detect and extinguish molton HE fire such as found in melt kettle, grids, holding tanks and associated equipment.

D. No comparable indicator of termal hazard to TNT Equivalency.

III. DATA BASE UTILIZATION, (DATA FROM STANDARDIZED R AND D TEST)

A. FIRE "SIGNATURE" , MATHEMATICAL MODELS

1. FLAME HEIGHTS
2. TEMPERATURES
3. VELOCITIES
4. SMOKE, OR COMBUSTION PRODUCTS
5. BURNING RATES
6. UV/IR RADIATION

B. DEVELOPMENT OF DESIGN, INSTALLATION AND MAINTANCE MANUAL

— 1. NO CURRENT COE GUIDE SPECIFICATION

— 2. NO NFPA STANDARD ON HIGH AND ULTRA HIGH SPEED DELUGE

3. HARD TO QUALIFY OR DISQUALIFY CONTRACTORS

4. CONTRACTORS SHOP DRAWINGS ARE NOT REVIEWED AND ARE NOT LIKELY TO BE DONE BY FIRE PROTECTION ENGINEER. NO CONTROL ON SELECTION OF MATERIAL AND HANDLING. CAN CHANGE WITHIN CURRENT SCOPE OF CONTRACTS SUCH KEY VARIABLES AS LENGTH OF PIPE FROM VALVE TO FURTHEST HEAD.

IV. SYSTEM DESIGN PHILOSPHY

A. IT IS IN THE BOOK, BUT HAVE WE EXECUTED AND PROVIDED DEGREE OF PROTECTION CALLED FOR ?

B. THE BIG QUESTION

DO WE DESIGN FOR PREVENTION OF PROPAGATION TO OTHER AREAS OF THE LOAD LINE AND ONLY PROTECT PERSONNEL IN THOSE AREAS.

OR

DESIGN FOR POINT OF IGNITION SUPPRESSION AND PROTECT ALL PERSONNEL AT POINT OF OPERATION, WITH PROTECTION IN PLACE OR ADEQUATE ESCAPE TIME????

C. THE BOOK (DOD I 5154) SPELLS OUT WHAT IS ACCEPTABLE EXPOSURE, IT ALOWS (DOD I 5154, CHAPTER 13)

1. 2.3 PSI
2. 58 FT. LB.
3. 0.3 CALORIES PER SQ. CM PER SECOND

D. NEED TO DEVELOP PERFORMANCE STANDARD

1. STANARD BASED ON VALUES OF PROTECTION PROVIDED BY
   - A. MATERIAL BEING HANDLED
   - B. VOLUMN OF MATERIAL
   - C. DETECTION SYSTEM
   - D. SUPPRESSION SYSTEM
   - E. PROTECTIVE CLOTHING
   - F. EXIT DESIGN

V. Testing of New and Existing Systems

A. No current standard, don't know or don't follow uniform standard such as UL or FM

B. What is responce time ?

1. Ignition Time .... T_0
2. Ignition to sensing threshold time ... T_1
3. Sensor resopnce time .... T_a
4. Discrimination/ logic time .... T_b
5. Deluge valve open time .... T_c
6. Water exit nozzel time .... T_d
7. First water on target area time ...... T_e
8. Full flow water on target area time .. T_f
9. Ignition to water on target time ..... T_2
10. Extinguishment time .... T_3

C. How do wemeasure ?

1. what type UV/IR source
2. what type of timing equipment
   A. what values, T_1, T_2, T_3, other
   B. how is timing unit tied to systems ?
      UV/IR source, detector, controled, valve, nozzel, target.
   C. calibration
3. Which events are recorded ? Which events start and stop the clock ?
   A. UV/IR source
   B. controller
   C. first head
   D. closest head or most distant
   E. all hear

V. Testing of New and Existing Systems

D. Water Volumn

1. recognized method of testing needed
2. measurement over standard area(s)
3. standard kit to go with timing equipment
4. FM, UL possible source

E. Annual and subsequent preoperational tests

1. maitance of design and acceptance performance standard
2. tool to identify defects that simple flow tests don't show

VI. SYSYEM RELIABLITY

A. FAILURE MODE AND EFFECTS ANALYSIS

1. THERE IS AT LEAST ONE ELECTROMECHANICAL VALVE USED IN DELUGE SYSTEMS THAT WILL FAIL TO THE CLOSED POSITION.

2. NEED FOR SYSTEMS SAFETY ANALYSIS, FAULT TREE ANALYSIS

B. MAJOR PROBLEM FOR DETECTOR SELECTION

1. NO RELIABLITY SPECIFICATIONS

2. NO CONTROL ON QUALITY OF COMPONENTS

C. ROLE OF WATER PRESSURE

1. RELATIONSHIP TO SPEED

2. WATER SPRAY PATTERN

3. SUSTAINABILITY, WHAT VOLUMNS AVALIABLE AT WHAT PRESSURE, FOR HOW LONG ?

SOME SYSTEMS HAVE SMALL HIGH TANKS FOR INITIAL PRESSURE DEMAND, THEN RELY ON REGULAR SYSTEM IE, FIXED PUMPS FOR VOLUMN

VII. PROTECTIVE CLOTHING AS PART OF THE "SYSTEM"

A. VALUES OF PROPOSED TESTING IN EVALUATING PROTECTIVE CLOTHING CONCURRENT WITH OTHER TEST OBJECTIVES.

B. LACK OF PROTECTIVE CLOTHING TESTS IN FLAMMABLE SOLID SITUATIONS, ALL TESTS TO DATE HAVE BEEN DONE WITH JP-4 PIT FIRES.

C. IMPORTANCE IN DETERMINING ESCAPE TIME AND THUS DETECTION AND SUPPRESION RESPONCE TIME RELATIONSHIPS.

THAT CONCLUDES MY COMMENTS, ARE THERE ANY QUESTIONS ????

LSAAP
RAPID ACTION FIRE PROTECTION

- IN HOUSE DESIGN-INSTALLATION
- SPECIFICATION
- TIME/PERFORMANCE TESTING
- SPONTANEOUS ACTIVATIONS

PREPARED BY:
DAY & ZIMMERMANN INC.
LONE STAR DIVISION
OPERATOR OF
LONE STAR ARMY AMMUNITION PLANT

DAY & ZIMMERMANN, INC.
LONE STAR DIVISION
OPERATOR OF
LONE STAR ARMY AMMUNITION PLANT
TEXARKANA, TEXAS

EM-8500/EFP/GB
October 20, 1984

RAPID ACTION FIRE PROTECTION

SLIDE #1 - TITLE SLIDE

When Robert Loyd called and asked that Lone Star participate in a deluge seminar, we determined that it would not be possible to discuss the subjects requested in detail desired in 30-45 minutes. We will attempt to provide a brief overview and a little history, then make additional printed data and detail available to those interested in comparing the systems and techniques used at LSAAP to their own procedures. For those interested, we are receptive to discussing systems in detail after the formal presentations.

0 - Introductory Comments:

We will briefly discuss the following areas:

1.0 Day & Zimmermann's approach to in-house design and installation of high speed deluge systems.

2.0 Robert asked us to address our development of specifications to obtain installation through outside agencies.

3.0 We will look at test/performance procedures developed/used by Day & Zimmermann/LSAAP - Use of the Instar High Speed CCTV in performance testing.

4.0 We will look briefly at a history of problems associated with high speed deluge system technology, particularly the area of false or spontaneous system activations and techniques to minimize false system dumps.

1.0 D & Z - LSAAP In-house Design, Installation, Maintenance:

1.1 Day & Zimmermann, Inc. has been concerned and involved in high speed deluge systems technology for years as part of our corporate role as operating contractor of LSAAP. Our interest and involvement in research, development, and use of super high speed systems was accelerated in 1979 as a result of a production incident involving a fatality.

1.2 Market research/dialogue with vendor experts: We determined as many other agencies did, that increasing the speed and improving reliability of deluge systems was a very complex technology with more problems than solutions. The wide range of variables that were involved and the lack of a general set of definitions or criteria made it difficult to develop a design configuration and set a target for response time.

An evaluation of our in-house data base and historical records found our technology limited, so we set up dialogues with other agencies, the known experts. Since 1980, we have consulted with or visited Automatic Sprinkler Corporation, Detector Electronics of Minneapolis, Grinnel, Instar, Edison, Flame Sentry, Kidde and a number of other private as well as government agencies in an effort to determine the best technique and hardware available for high speed deluge systems. Out of these studies, we observed that in most cases the experts were faced with the same set of problems we were: a wide range of subjective variables to be studied and undefined targets or goals to set as design objectives.

Our assessment was that most organizations had heavy expertise in certain areas, but no particular agency had a complete insight into the overall spectrum of high speed deluge technology.

Faced with an immediate need and limited resources for research, we elected to take the most creditable data we had in plant, combined with our historical experiences and settle on a basic system configuration that we would concentrate on refining, rather than attempting to resolve all related deluge technology problems.

We took a systems engineering approach, that is, we selected the best hardware and techniques from a number of vendors and integrated this hardware into a functional concept to meet the needs at Lone Star.

Because so many variables or related elements can negatively affect the deluge systems sensitivity and speed of response we determined early that even a sound design would require close attention to installation. This reinforced our decision to concentrate on in-house design and installation of a standardized system.

Even in-house, to consistently achieve the control required to maintain design/installation/and maintenance standards, we determined that a team or organization of experts had to be trained and maintained. (Show slide of organization).

Slide 2: Slide 2 displays a diagram of the people system or team that supports the mechanical systems.

Currently all systems that are specified, designed, or installed goes through the approval team starting with the piping and electrical design personnel in Facilities Engineering.

With only one or two exceptions, all deluge design and installation have been accomplished in-house in the past few years.

We feel our deluge people team or system is as important as the mechanical systems. We will provide additional data on this organizational structure and functional responsibilities to those interested after this presentation.

Slide 3: Diagram of Typical Deluge System

On the screen, we are looking at a simplified block diagram of the basic elements or components in our deluge system configuration. Before we break the system components and design into detailed modules for study, lets briefly address some of the aspects or areas that influenced our development of this particular system.

1. First was the emphasis on increased speed and reliability that was a common denominator in this technology in general.

2. Second - A parallel objective outside the scope of this discussion but closely interrelated was our interest in developing improved and modernized production equipment and systems that would reduce operator exposure to mass quantities of explosives. That is minimize risk at the source. Improvements in equipment and operating procedures have influenced individual equipment configurations and earlier requirements for large scale time testing.

Regarding deluge system design specifically, our particular design parameters have been influenced by studies of high speed CCTV recordings made in actual dynamic production environments as well as additional follow up studies made with pre-determined and controlled conditions. A study was made in 1981 to resolve a number of anomalies or curious phenomenon observed in real production incidents as well as to obtain additional background on system response and in particular, flow patterns of specific nozzles.

We were interested in nozzle characteristics and flow patterns because in certain cases where predictable system response appeared to be adequate, we were still seeing facility damage when an incident occurred.

The second parallel objective has resulted in on-going improvements to production equipment in pyrotechnic operations, with a particular emphasis on installation of remote loading, drawoff, and conveyence systems to remove operators from the presence of large quantities of explosives to the extent that prior risks to personnel are being minimized.

As a result, the potential hazards are now assessed on an individual system basis and earlier requirements for overall time performance tests are now considered only for critical systems as determined by our management engineering and safety personnel.

With this history in mind, let's talk system design.

In the diagram displayed, we have for purposes of discussion, essentially divided our design into two modular subsystems with specific component functions in each.

Slide 4: Electronic Diagram/Deluge

Starting with the electronic section, system power is obtained from a 120 VAC source through a fire system disconnect that is connected to the line side of the building main disconnect. This allows the deluge system to function with building power cut off at the main disconnect.

We have, to date, not installed emergency power supplies to these systems because they are expensive and troublesome to maintain. The trade off being that historically we have not had a deluge system unable to perform at the required time because of no power availability.

Slide 5: Block Diagram of Controller

Looking at the system controller and enclosure: We procure an off shelf vendor enclosure, and modify it to our specifications by installing a lexan view port to allow observation without production personnel having to open the enclosure. Attention is directed to locating the controller outside the hazardous area. The standard UV controller currently used at LSAAP is the R-7303 unit manufactured by Detector Electronics Corporation of Minneapolis. However, this particular controller is purchased with a solid state relay replacing the electro mechanical version and without the time delay function. These options obviously related to minimizing controller time in the system. Further options are added at Lone Star. An auxilary relay with appropriate voltage and current rating is added in the enclosure to provide additional controller isolation from machines that are interlocked for shutdown in case the system detects an incident. This additional isolation contributes to minimizing spontaneous dumps caused by certain types of electrical interference. In other electrical aspects that might be peculiar to our configuration we jumper the fault reset circuit to minimize interruption of production operations that are caused by short intermittent faults that are not serious. In this configuration, the controller or system is automatically returned to an operative condition when the fault is no longer present.

Another modification we make is the installation of an external reset button adjacent to the controller enclosure to allow system reset by interruption of power. This configuration is useful for testing. We now provide an access port to the system or controller bypass switch so an operator can place the system in the bypass mode without opening the controller enclosure.

Although we do not have a formal data base to support this assessment we have indications that deluge systems in which we limit the design configuration to 6 detectors (the vendors maximum design limit on the R-7303 controller is 8) have fewer problems and the systems are less likely to spontaneously dump. We suggest 2 reasons for this: First, all hardware eventually degrades somewhat: By designing under the vendor's guidelines, system stability is maintained with some components at less than optimum efficiency. Second: We think the accumulative effect of multiple detectors is heightened in the presence of intense UV as such occurs in a thunderstorm.

Before we look at detection and actuation, lets talk briefly about wiring. You will note in the diagram on the screen that three conduits exit the controller enclosure. This is a standard practice and there is a reason: The conduit is reqired to separate electrical circuits to reduce spontaneous system activations. System power is accessed through one conduit. Circuits for equipment interface or machine interlocks, in our case usually (120 or 440 volts) exit through a second conduit. However, our configuration allows the solenoid wiring to be installed with detector circuits because the only time a voltage would be imposed on the solenoid is when an actuation is mandated or desirable. Close attention is also directed to vendor specifications in system wiring. Belden or other appropriate shielded cable is specified and used for detector to controller wiring. Generally, the detector cabling including D-leads is junctioned or terminated only at the detector or controller terminal board to further reduce the risk of spontaneous dumps.

Slide 6: Detection System Diagram

Looking now at Detection Systems: The area of detection includes a very broad spectrum for several reasons. Two of the most important are:

1. Detectors improperly installed may initiate spontaneous activations.
2. If improperly installed, they may not see an ignition source in time to interrupt an incident prior to it going high order.

Design of detection systems is an area that was influenced by out study of high speed film of real incidents in a production area. For example:

After an incident that resulted in facility damage, we upgraded the deluge system and installed an Instar CCTV System to observe operations. However, another incident occurred in the bay with facility damage, but we were able to disect this incident or break it into small (8 1/3 millisecond) time frames and analyze what happened with the Instar. Time precludes a detailed investigation into this filmed incident; it is a study within itself. However, to highlight: We determined that a number of very small flashes were occuring early in the incident sequence that the detection system was not seeing. This was the basis for relocating detectors such that we could see 360 Deg. around the perimeter of the mixer with detectors positioned not more than 36" from the bottom of the mixer or source of ignition. Through a series of events, we also determined that three detectors were required to sense an ignition source in time to preclude the incident from becoming high order. We assess two reasons for this: One is the Muellor wheel blocks part of the detectors line of vision as it rotates, and Two: We determined, and this was confirmed by Det Tronics that adding detectors makes the voltage signal sensed by the controller somewhat accumulative.

We also observed that a flash or ignition about the size of a large marble with a time duration in excess of 8 1/3 milliseconds (or one frame) was required to trigger the controller and dump the system. (In new installations, we place detectors in critical environments as close to the source of ignition as possible, but in no case further than 36".)

Other accumulated historical data, study of the Instar CCTV, recordings at G-11, and a study started in 1981, lead us to specifying other design parameters on the detection and extinguishing system.

We use the C7050 detector, the R-7303 controller with the OI feature and a 16 count sensitivity. In our layouts and design, attention is directed to installation of detectors away from a horizontal plane; this has minimized spontaneous activations from storm activity.

Slide 7: Diagram Agent Delivery System

This leads us to the activation device which is electro/mechanical: in our configuration, a solenoid. We will discuss this in context with the Hydraulic or Agent Delivery System.

For purposes of discussion, we will break the agent delivery system into 3 basic modules:

1. Water supply or source
2. Piping: with attention to the pilot lines
3. Nozzles

On the screen we have a diagram of the Agent Delivery System.

The system effectively interrupted the G-11 incident used existing building line pressure 65-70 PSI. We know this delivery can be improved from review of other agency data and our own research, but are reluctant to incorporate additional equipment to increase line pressure since the existing systems can interrupt an incident.

If the environmental hazard dictates higher pressure on future system designs, we would elect to use a simple system that would maintain say 125 PSI for only a very brief duration, perhaps four seconds. Our CCTV investigations indicate that an incident that reaches a "high order state" terminates very rapidly.

Again, study of our CCTV data and subsequent research resulted in observation of very peculiar phenomenon of water flow and patterns at certain pressures and with selected nozzles.

Particularly in several instances, we observed an initial heavy burst of water, a secondary effect when the water pattern diminished into a less effective small cone, then a third fluid stage several milliseconds later when the final heavy water blanket occurred.

The third stage was the fluid delivery that effectively contained the incidents.

To improve water pattern and delivery, we separated the deluge system electrically into two individual systems and reduced the number of nozles per system. Nozzles were relocated. We now have a nozzle directly protecting the operator and a nozzle aimed at critical sites or points of ignition, as part of our standard design configuration. In addition, on new systems, a solenoid is adjacent to each critical nozzle to further reduce response time. Results from the initial 1981 research also provided guidelines to selection and placement of specific types of nozzles in our configuration.

For example, we now specify a 28 MA Auto Sprinkler Nozzle for locations requiring optimum response and maximum density. A 29 WA Nozzle is used for secondary coverage of the facility such as ceilings or walls. At this point, I don't know whether this guideline is in line with or contradictory to Automatic Sprinkler tests or research.

We have a reasonably creditable data base to substantiate nozzle selection, but this area definitely needs additional research and evaluation.

We also determined there were definite relationships between the restrictive orifice kit used in the pilot line, size of the pilot line, and type and size of the solenoid orifice.

In one case, I'm fairly certain that our data is divergent to that of other agencies. We have determined that a 3/8" copper pilot line provides a faster response than a 1/2" line in our system configuration.

A pecularity about this is that our particular overall system response is approximately the same as other systems observed. This is an area that needs additional discussion, research, and understanding of the relationship of the specific variables.

To summarize then: Our current system employs a restriction orifice kit, pilot valve, and nozzles from Auto Sprinkler. We however, specify a 3/8" pilot line with a 120 VAC activated solenoid located adjacent to the pilot valve on critical nozzles. In case of the nozzles, they are threaded by D & Z to allow water to be piped out of equipment areas for testing. Attention is also directed to location of valves at high points in the piping system to blead air, for we determined, as other agencies have, that a very small percent of air in the agent distribution system significantly increases the time required for agent delivery to the source of ignition.

There are a number of other aspects related to designing, installing, and maintaining systems at Lone Star we have not addressed. We have a more detailed drawings of our composite design for review and discussion after the formal presentation for those interested. We also have data from the 1981 research conducted at Lone Star and a chronological history of an incident recorded on high speed CCTV.

2.0 Specifications

The second area that Mr. Loyd asked us to address developed into a problem of sorts.

We looked at our track record and determined that we should not get into detailed discussion in this area. Except in a very few cases where systems were designed and installed under management of the Corps of Engineers, we have been responsible for design and installation in-plant. For this reason, even though we have developed a composite specification, anticipating contracts through the make or buy process, we would be reluctant to present our spec as a final guide to obtaining design and installation services.

This particular specification is suitable primarily for situations where design would be accomplished in-house and installation by a private vendor or other organization. (We have an outline of this specification available for informal discussion or review after the presentations if you are interested.)

3.0 Slide System Time and Performance Testing

Slide 8: Deluge System Testing

Deluge system timing and test performance procedures used by LSAAP have undergone several years of changes from early techniques in which we used digital or electronic instrumentation to measure response from ignition to water or agent at the nozzle. Currently a high speed Instar CCTV configuration is used. This system was developed to perform a series of tests at LSAAP for Amman & Whitney, New York, as part of a study conducted for the U. S. Armament Research & Development Command in 1981. The data on timing systems employed, techniques, and test results can possibly be obtained by requesting Contractor Report ARLCD-CR-80049, Engineering Guide for Fire Protection and Detection Systems at Army Ammunition Plants, Volume II, Testing and Inspection, December 1982, from DRDAR-ISS, Dover, New Jersey, 07801.

The logic and data base used by Day & Zimmermann, Inc. to standardize its total performance testing system is extensive; however, for purpose of this discussion, we will qualify our decision with the following rational:

Slide 9: G-11 Timing System

The typical early timing system displayed measured only system response from initiation to nozzle or source, not other parameters. We also determined that a significant number of duplicate tests had to be performed to obtain verifiable or statistical credibility in test results. Faced with unexplained incidents in which predicted system response was adequate, but we were still not interrupting high order incidents we considered other instrumentation, particularly hardware which would graphically display system water patterns or delivery.

Second generation tests by D & Z involved use of electronic timing with the addition of high speed filming (FASTAX). Although the data bases we were developing were significantly more descriptive, informative, and accurate than electronic timing, excessive quantities of film were required for extensive testing.

Logically, as D & Z assessed vendor sources for state of the art research hardware, we saw a significant value in the high speed CCTV systems being marketed by Instar.

An Instar system was installed in Area G, Building 11, and we were able to record a number of incidents on high speed film that occurred in an actual dynamic production environment.

By breaking an explosives incident life span of say four to five seconds into eight milliseconds still frames we were able to get inside the real architecture of a blow and study its nature from start to loss of facility or termination of the incident which we are now able to do.

Using a system engineering approach again, D & Z acquired other vendor available hardware, and again modified the hardware to meet our requirements, to achieve a total performance testing system.

Primary rational for D & Z's decision to standardize on Instar and recommend CCTV testing was ease of storing and retreiving data and the fact that we were able to evaluate flow patterns as well as perform system time tests.

Slide 10: Instar CCTV Time Test Configuration

This slide depicts the typical basic system configuration used in the series of tests with Amman & Whitney at LSAAP, and is essentially the standard configuration the writer would recommend in future system testing and research.

We had hoped to have time and resources to bring enlarged still shot slides of an incident which was terminated without damage to the facility or equipment; however, time constraints precluded this. We feel, however, that it would be prudent to obtain funds for additional study of these tapes and other specific related studies. A number of anomalies or curious phenomenon were observed that need additional explanation. For example, a sequence from the CCTV tapes as well as other studies since demonstrated that at average line pressure, say 65-70 PSI, we observed the 3 distinct stages in the water discharge pattern mentioned earlier. We have limited data to indicate that increasing the line pressure will eliminate this phenomenon as well as increase system response. However, in discussions with Engineers at Auto Sprinkler at a Deluge Seminar conducted March 29, 1984, in Cleveland, we were told that they did not observe this phenomenon in their tests.

Additional, more elaborate tests were conducted by D & Z at LSAAP in which decisions were made about selecting specific nozzle types for specific applications.

In some cases, our observations of nozzle characteristics, pilot lines, and other parameters are somewhat contradictory to other agencies. This is another study area which influenced our design concepts, but a number of areas definitely need additional research and evaluation before a universal design criteria is developed.

Due to the complexity and detail required to address the setup of the CCTV time test procedure used at Lone Star we will not get into the actual mechanics now. For those that are interested, we have available detailed drawings, photographs, and written procedures that we will be glad to review after the presentations with those who are interested.

4.0 Problems and False Activations

We have covered a number of items related to minimizing spontaneous system dumps in our design and installation discussion. We have elected to provide copies of other typical situations and D & Z solutions for review for those interested after this presentation.

5.0 Summary

D & Z prefers in-house design/installation to maintain a tight control over final hardware configurations. Even in-house we determined attention had to be directed to n ot reinventing the wheel. For this reason, the people system or team designing, approving, and maintaining deluge systems is more important than the mechanical systems. We set up a deluge system team and maintain it. System changes are made slowly after trial on a limited scale.

An in-plant test program is conducted: Systems are wet tested on a monthly basis. System problems and spontaneous dumps increased when the test cycle was increased.

In future cases where make or buy decisions require outside contracts, the philosophy of in-house design and control will be maintained and a standardized modular structure will be used on specification formats for outside system installation.

Large scale time and performance tests have not been conducted due to cost and unavailability fo equipment in past years. We feel we have developed a reliable and effective performance testing system in conjunction with the 1981 Amman & Whitney survey; however, as a result of parallel advances and improvements in pyrotechnic equipment and procedures in loading, draw off and conveyance systems which are reducing operator exposure to mass quantities of explosives, risk assessments are being revised. Testing that is being considered will be accomplished on a limited basis only on critical systems or nozzles. On systems targeted for evaluation time tests, they will be accomplished at time of installation and yearly thereafter.

Slide #11

An area we think we are all weak in is record keeping. We recently set up a specific format for establishing a useful data base on start up of several systems in Area E at Lone Star.

Though still on a trial basis at our plant, we would recommend some similar format be maintained at all plants; then submitted annually to a central agency for compilation and analysis to assist in isolating common problem areas, perhaps as a guideline to developing an overall or standard deluge system design.

Last but not least, we still see subjective and unanswered questions that need to be resolved. Additional research is needed prior to developing an overall sound system design criteria.

Day & Zimmermann would propose research to be conducted jointly with the Army and participating private agencies.

Slide #12: Close

Copies of our typical system design, specifications, time performance systems, history of solutions can be obtained by requests through Bob Loyd. Additional assistance on areas discussed can be obtained through Army channels or consultation and assistance on design, trouble shooting, and testing direct from Day & Zimmermann on a third party contract basis.

We are receptive to detailed nuts and bolts shop talk after the formal program.

GB/bp

SLIDES 1-12

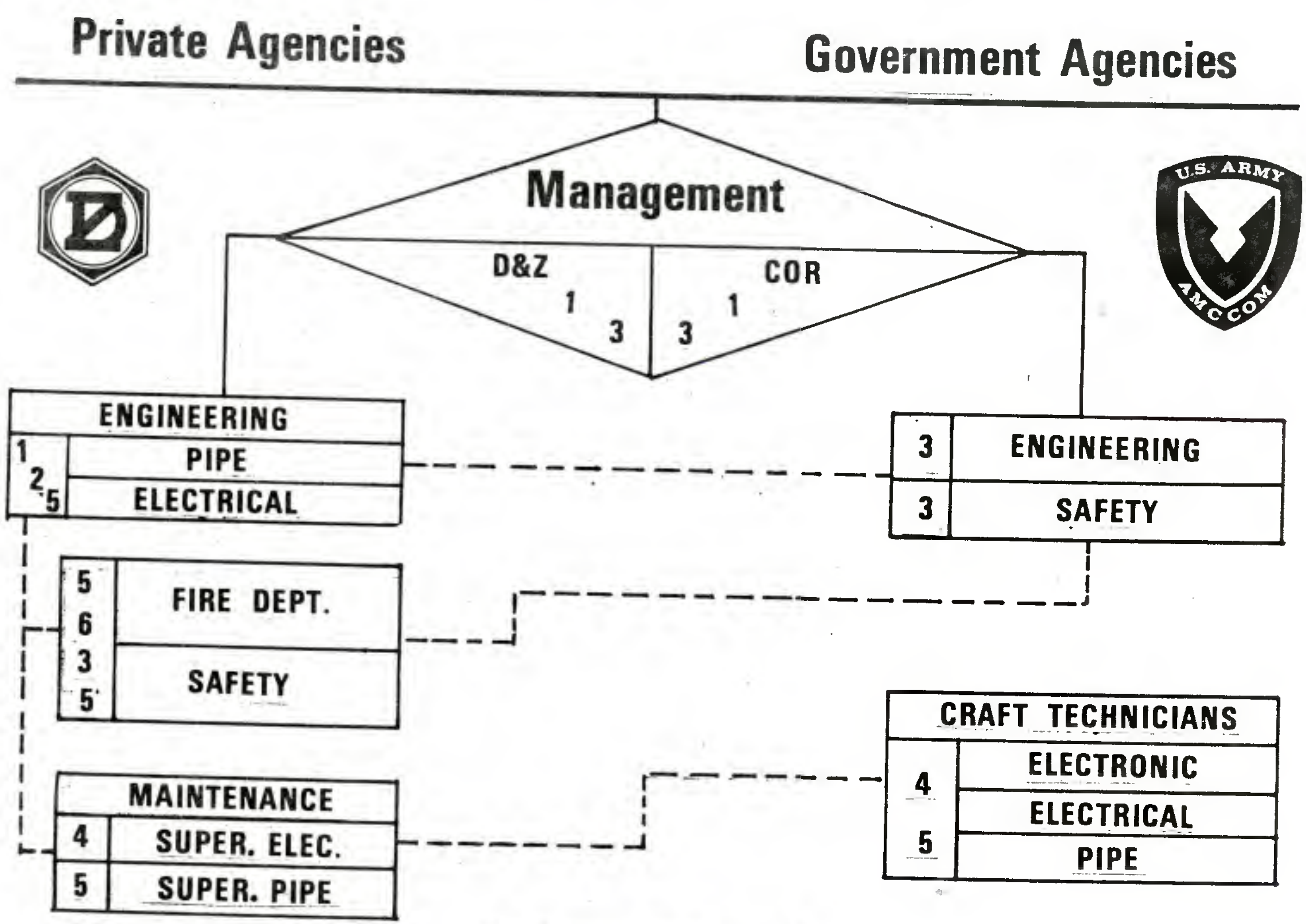
LSAAP
RAPID ACTION FIRE PROTECTION

- IN HOUSE DESIGN-INSTALLATION
- SPECIFICATION
- TIME/PERFORMANCE TESTING
- SPONTANEOUS ACTIVATIONS

PREPARED BY:
DAY & ZIMMERMANN INC.
LONE STAR DIVISION
OPERATOR OF
LONE STAR ARMY AMMUNITION PLANT

D&Z/LSAAP DELUGE SYSTEM TEAM

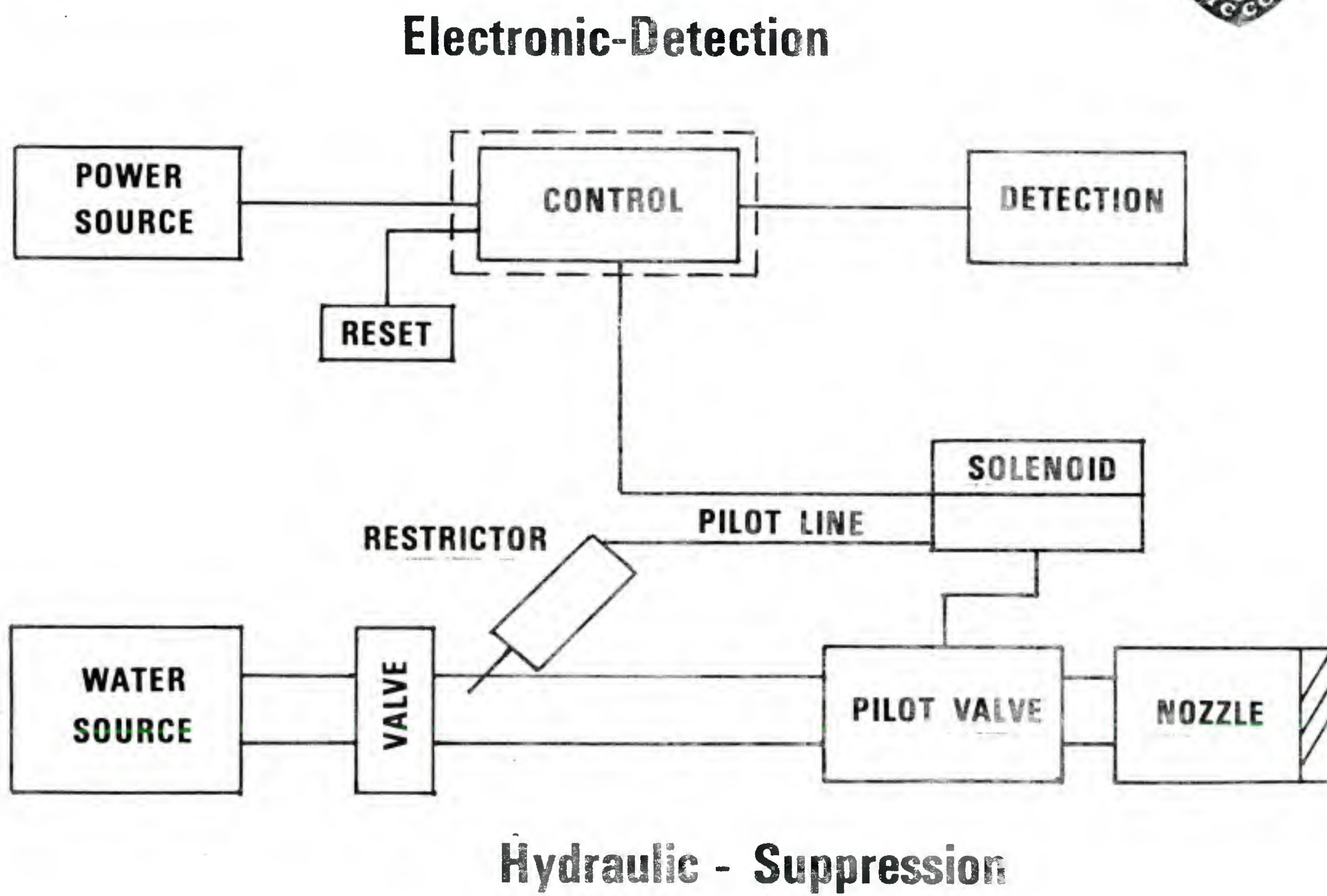
Slides 2



FUNCTIONS

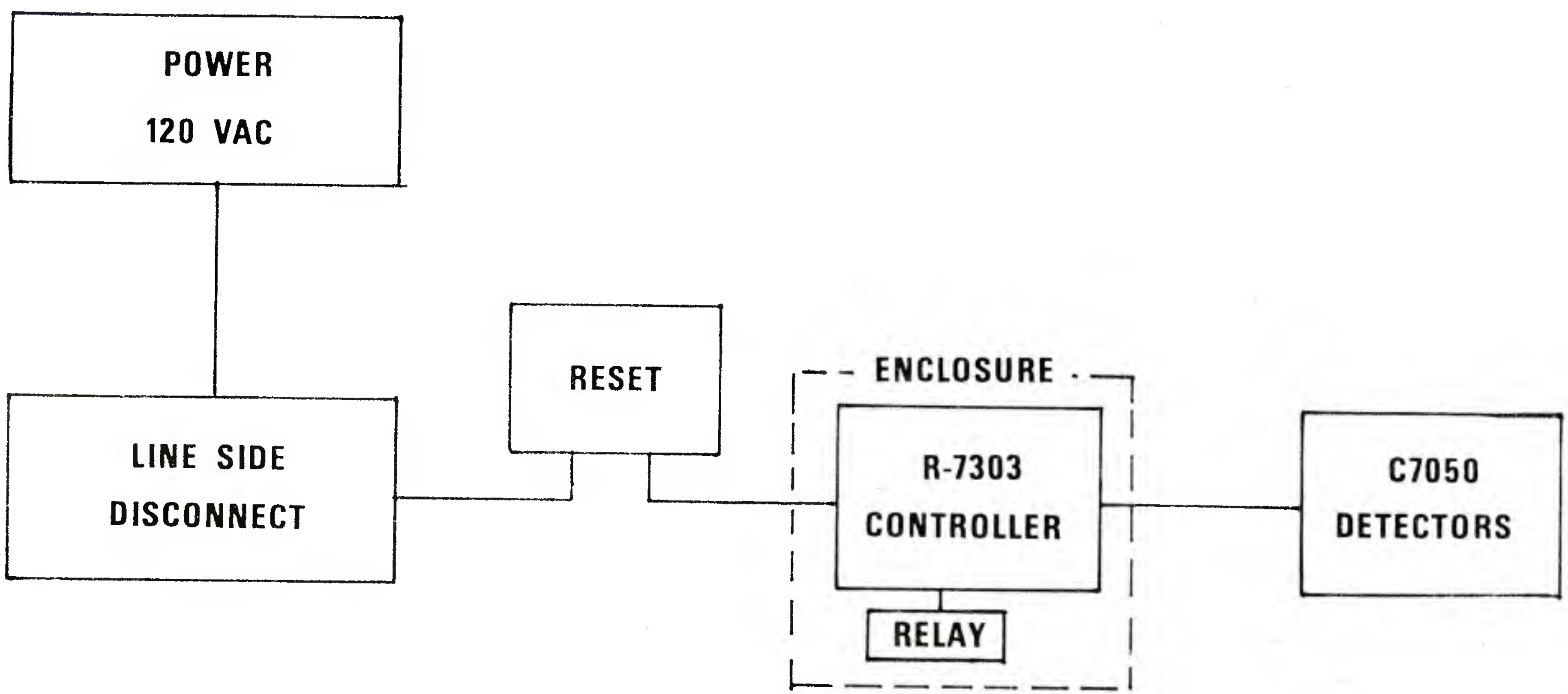
1	DATA TRANSFER	4	MAINT./REPAIR/INST.
2	RESEARCH/DESIGN	5	TEST INSPECTION
3	APPROVAL/INSPECTION	6	RECORDS FIELD DATA

TYPICAL LSAAP DELUGE SYSTEM DIAGRAM

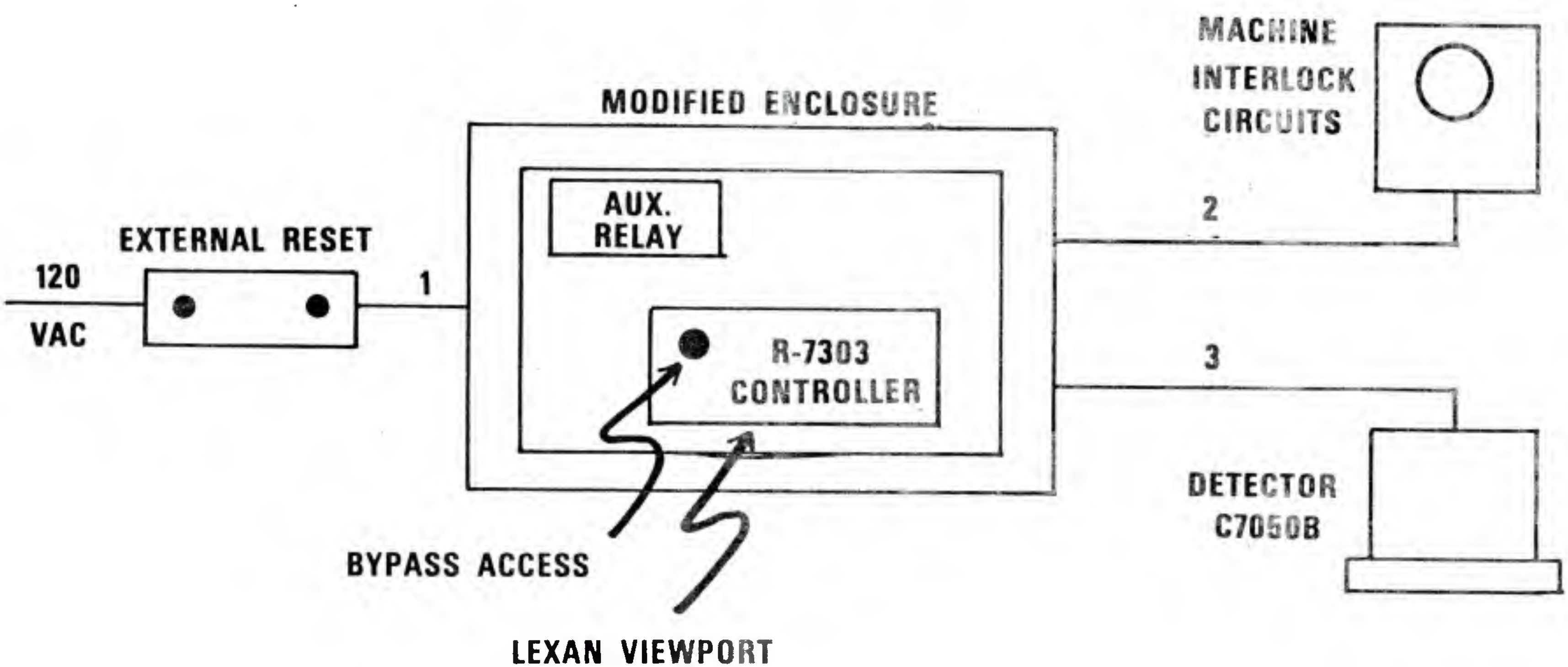


4

LSAAP
ELECTRONIC DIAGRAM - DETECTION

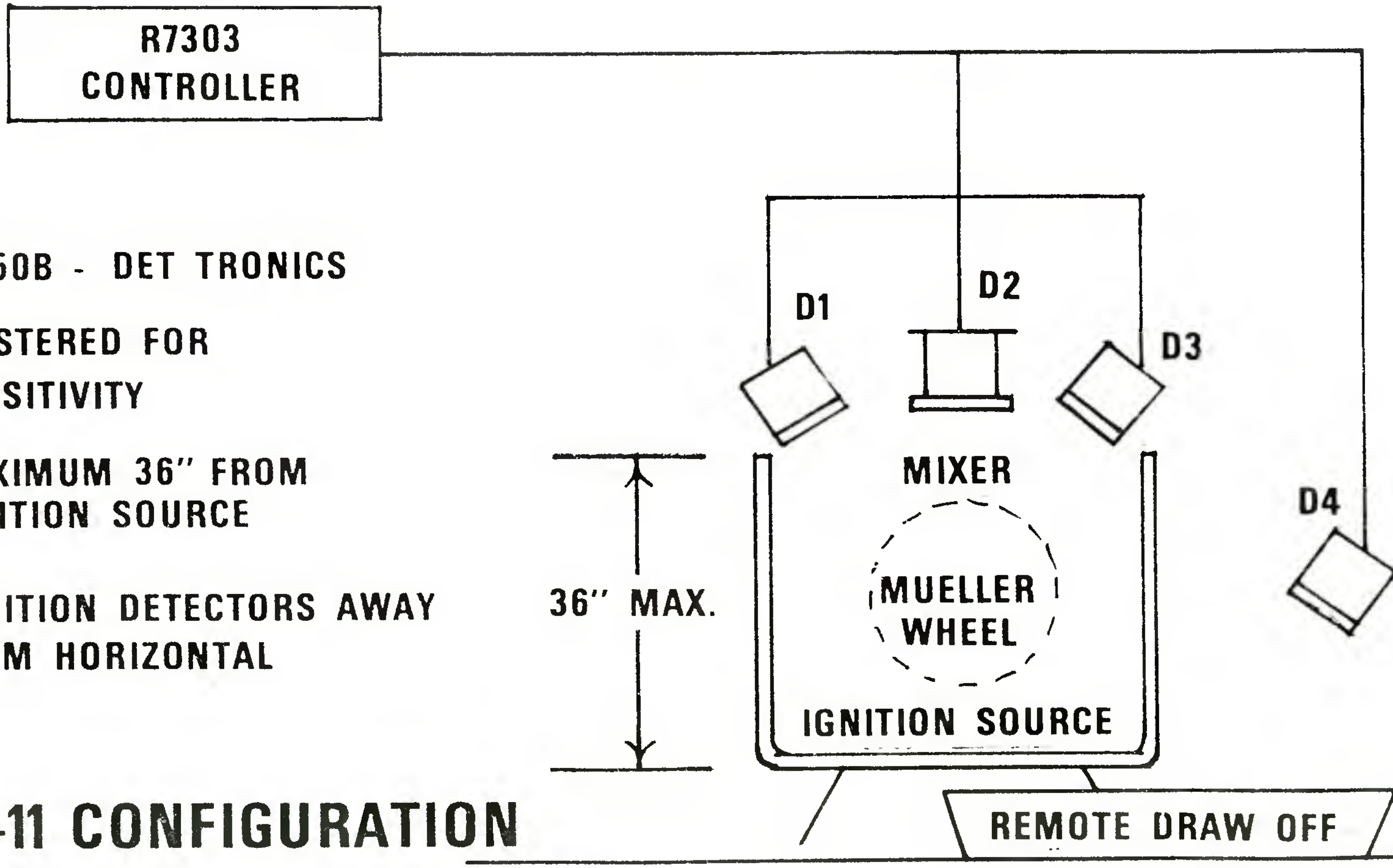


LSAAP
TYPICAL CONTROLLER SYSTEM



R-7303 CONTROLLER
W/ ● SOLID STATE RELAY
● NO TIME DELAY
● 16 COUNT SENSITIVITY

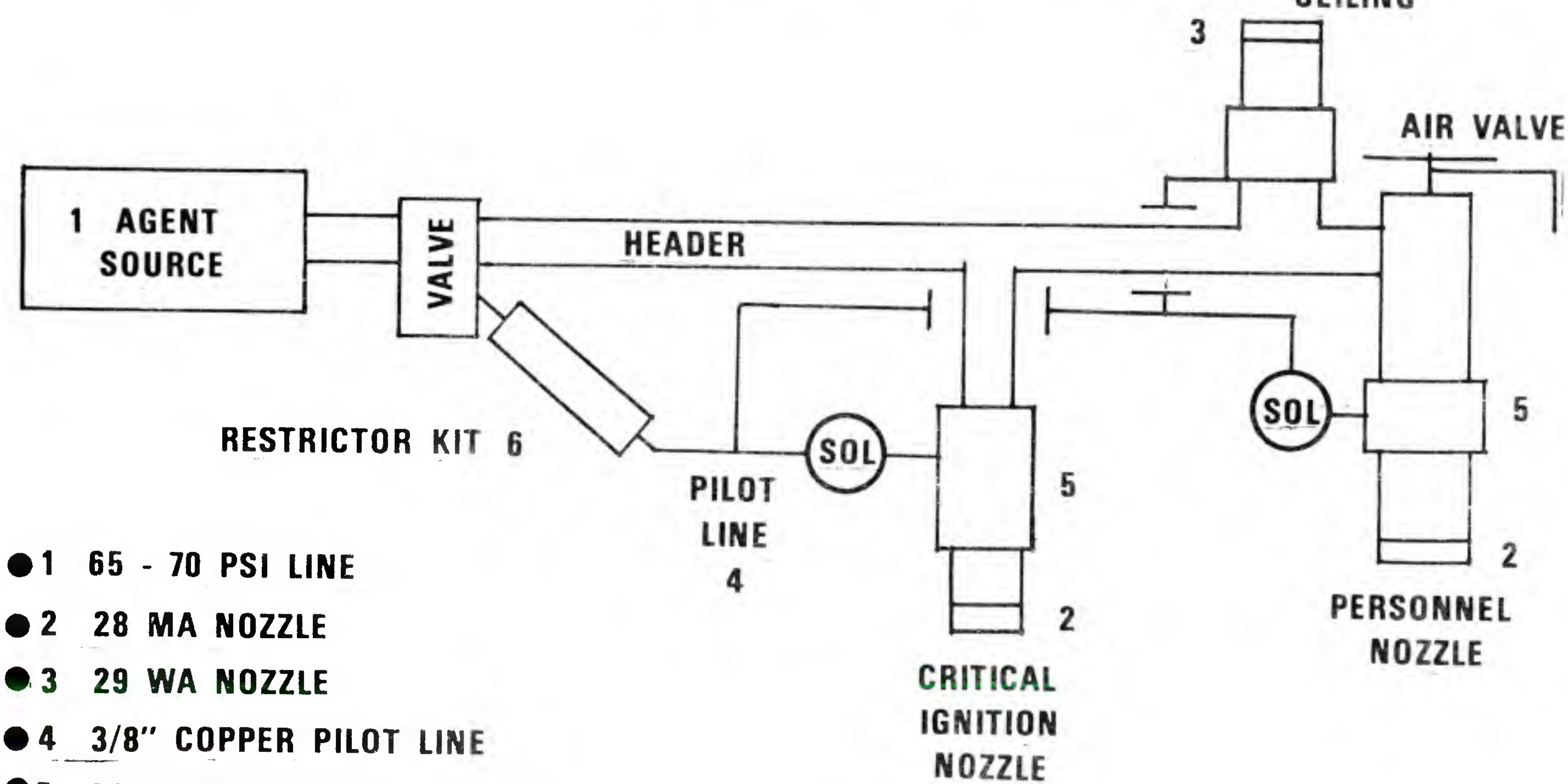
LSAAP
DELUGE DETECTION SYSTEM



- C7050B - DET TRONICS
- CLUSTERED FOR SENSITIVITY
- MAXIMUM 36" FROM IGNITION SOURCE
- POSITION DETECTORS AWAY FROM HORIZONTAL

G-11 CONFIGURATION

LSAAP
DIAGRAM AGENT DELIVERY
F/ SUPPRESSION



- 1 65 - 70 PSI LINE
- 2 28 MA NOZZLE
- 3 29 WA NOZZLE
- 4 3/8" COPPER PILOT LINE
- 5 ACTUATOR #165-5125-PILOTEX
- 6 SEE TYPICAL UV SYSTEM DRAWING

LSAAP
DELUGE SYSTEM TESTING

DIGITAL-ELECTRONIC TESTING

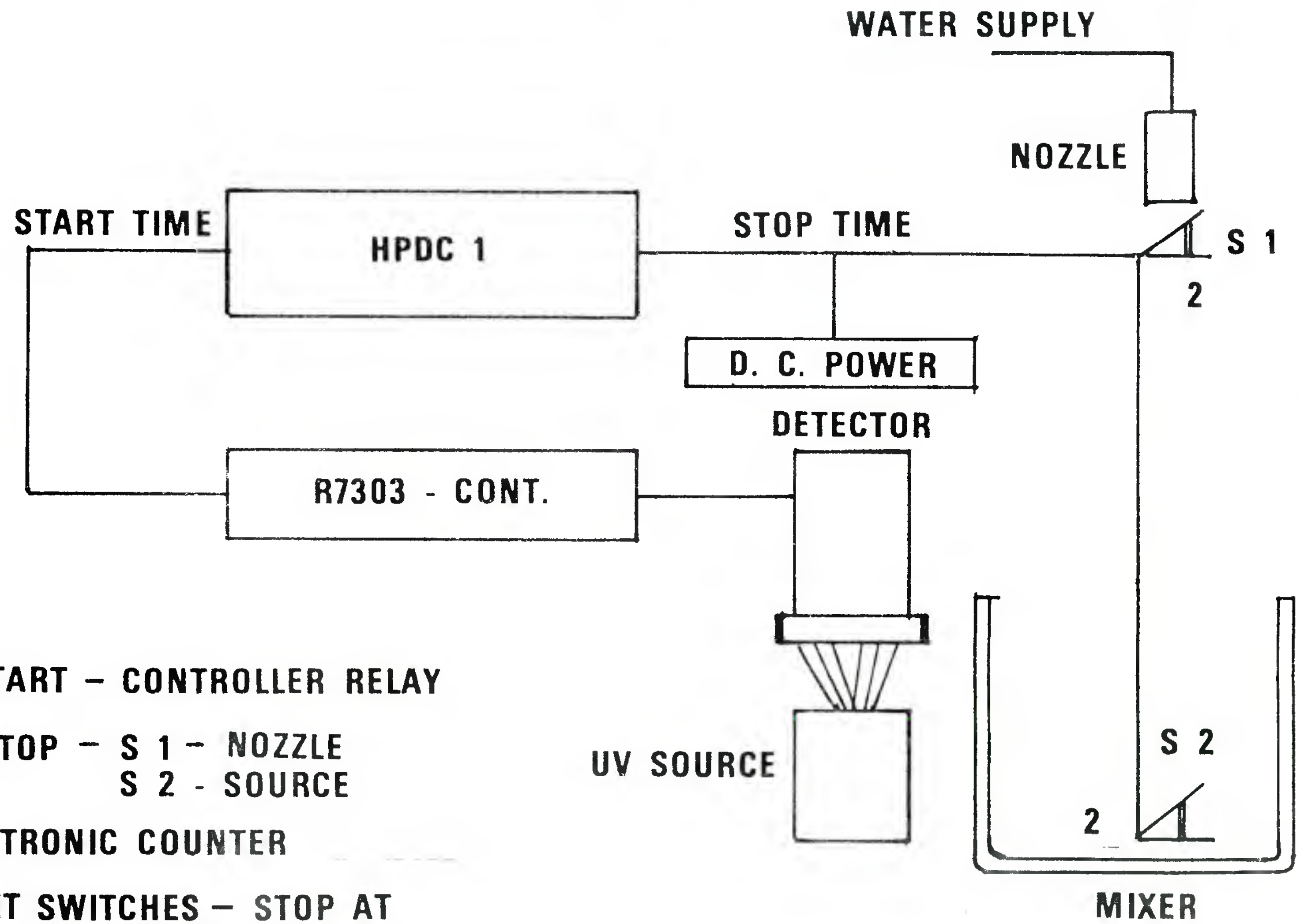
- IGNITION TO NOZZLE OR SOURCE/IGNITION

TOTAL PERFORMANCE TESTING

- TIMING
- FLOW PATTERNS
- FASTAX FILM
- CCTV - INSTAR

8

LSAAP
DIGITAL - ELECTRONIC TESTING DIAGRAM



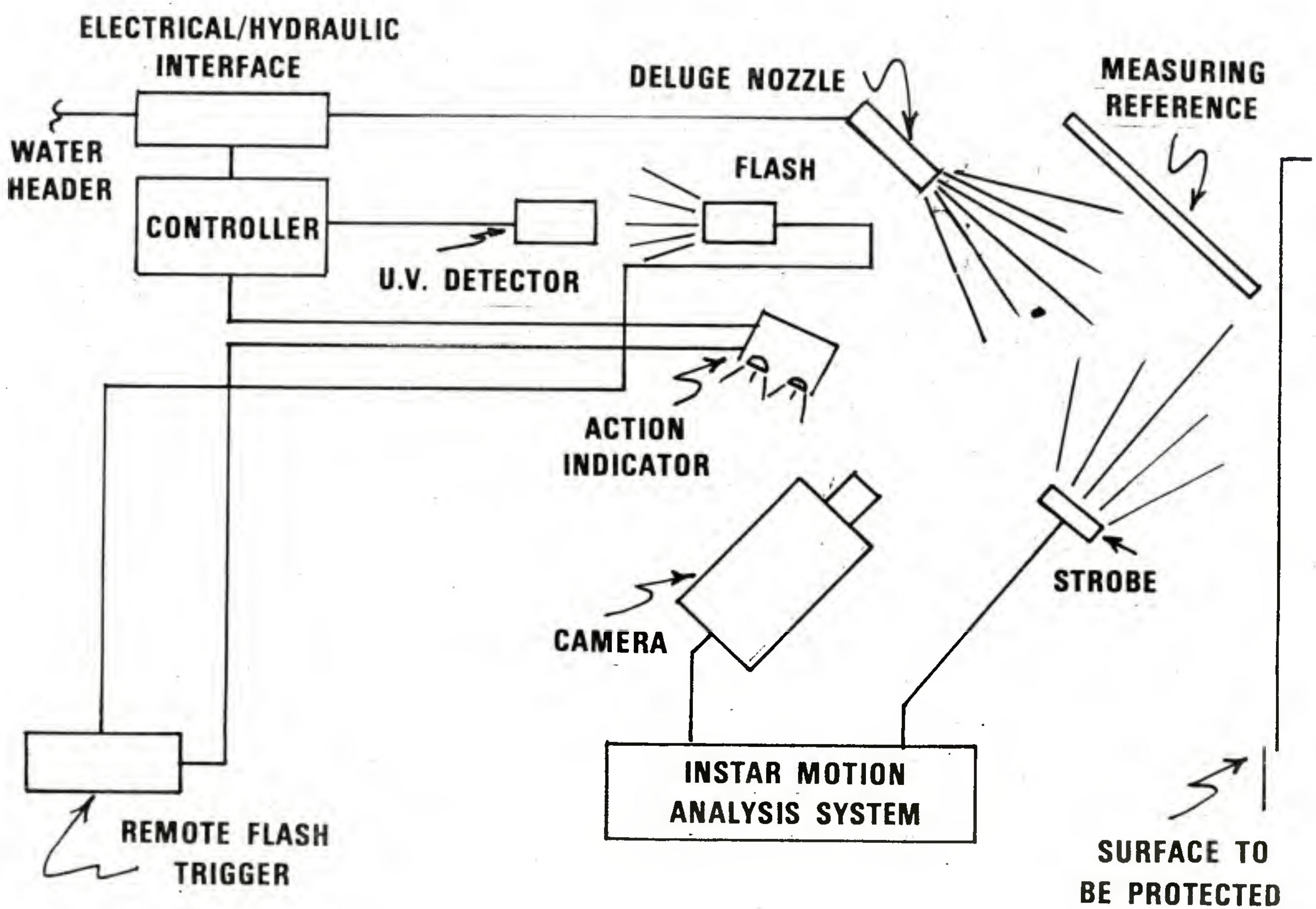
TIME START – CONTROLLER RELAY

TIME STOP – S 1 – NOZZLE
S 2 - SOURCE

1 ELECTRONIC COUNTER

2 LIMIT SWITCHES – STOP AT WATER PRESENCE

LSAAP
TIME/PERFORMANCE TEST SYSTEM DIAGRAM WITH INSTAR CCTV



LSAAP
DELUGE SYSTEM RECORDS
TYPICAL FORMAT

- TIME OF INCIDENT OR FAULT
- WEATHER CONDITIONS
- FAULT ANALYSIS (CAUSE)
- SYSTEM IDENTIFICATION - NUMBER - LOCATION
- SERICE REPAIR PERFORMED
- TEST/INSPECTION DATES
- ON SYSTEMS DISABLED: INCLUDE
  PERSON GIVING AUTHORITY
  TIME FIRE DEPT. NOTIFICATION
  REASON FOR DISABLING

RAPID ACTION FIRE PROTECTION PRESENTATION

ICI Americas Inc.

Indiana Army Ammunition Plant

Charlestown, Indiana 47111

J. R. Brazell
S. M. Straker

I. System Design and Installation

A. Designed by Shiremer Engineering - 1978

B. Installed by Bently, an Electrical Fire Detection Contractor, Louisville - 1979

- Grinnel Company - Piping and Fire Protection Systems Installer

II. Sensor Location - Slide Presentation

A. Review of Load Line Production Operation and Equipment

B. Review of Fire Protection Equipment: Type, Location and Purpose

III. Detronics Fast Acting Deluge System Control and Operation

A. Controller Console

B. Back-up Electrical

C. Detonator System

D. Primac and Multimatic Water Actuation Valves

E. Sensors Systems

IV. <u>System Trouble-shooting and Problem Solving</u>

A. System Contamination - Moisture, Powder, etc.

B. Sensor Problems

C. Electrostatic Forces

D. System Modifications

V. <u>Current and Proposed Test Equipment</u>

VI. Preventive Maintenance Program

VII. Interaction with Detronics

Gen. Outline - R.I. UV Talk

I. Determination of Locations of U.V. Systems

A. First Priority - Personnel Protection

1. Propellant - Motor Body Assembly Areas
2. Black Powder Areas
3. Powder Screening & Inspection Areas
4. Dusty Powder Areas
5. Drill Bays
6. Future Expansion to Melt Kettle Areas

B. Second Priority - Facility Protection. Remote Operations such as RDX & Demo Block Pressing

II. Determination of Detector Head Locations around a Process

A. Most Importantly - Detector Heads are aimed properly to cover the desired area using as many heads as necessary for complete coverage.

B. Heads should be as close to a process as possible; however, this is not as critical as proper aiming.

1. It may be desirable to increase detector head distance in cases where process is dusty (or use self cleaning lense).

2. Or the head(s) would be in the way of personnel or equipment (avoid shock & aiming misalignment).

III. Reaction Time Testing

A. Had several tests made by area distributor at initial installation. Time averaged 250 ms.

B. Built our own instrument for testing - UV Source, Timer, & Detect Switch.

IV. UV System We Use

A. Detronics Model R7303 Controller with automatic optical integrity feature and C7050B Detector Heads.

B. Pressurized to nozzel water deluge system with detonator initiated release value.

C. Manual pull rings at bay exits to manually initiate fire system response.

D. Audible Alarm

E. Automatic equipment shutdown in case of alarm.

F. Remote alarm & fault monitoring system at Guard HQ.

Also Included in Talk -

Breakdown of causes of False Alarms over a six month period.

3 Firings - Faulty Detector Heads
4 Firings - Improper System Installation
2 Firings - Probable Cause was Lightning
1 Firing - Welding Nearby

SITE WATER SUPPLY

FOR

ULTRA-HIGH-SPEED DELUGE SYSTEMS

AT

ARMY AMMUNITION PLANTS

Manuel S. Avelar, P.E.

Associate-in-Charge of Fire Protection

AMMANN & WHITNEY

Consulting Engineers

Two World Trade Center

New York, New York 10048

Presented at the Rapid Action Fire Protection System Seminar, sponsored by the U. S. Army AMCCOM Safety Office Rock Island, Illinois 23-24 October 1984.

Site Water Supply

for

Ultra-High-Speed Deluge Systems

My primary intent, at this seminar, is to heighten the awareness of the engineering design professionals, fire chiefs, risk and loss control engineers, facility fire protection engineers and maintenance personnel to the fact that ultra-high-speed deluge systems require full design water flow and pressure instantaneously when tripped.

As General Bowen mentioned yesterday morning hundreds, if not thousands, of munition plant operators perform their jobs knowing that the difference between life and death is the ultra-high-speed deluge system - Furthermore, these systems uphold our modernization program by preventing critical disruption in the production facilities.

So that you can appreciate the fast operating time frame involved in an ultra-high-speed deluge system, I would like each and everyone of you to blink your eyes as fast as you can.

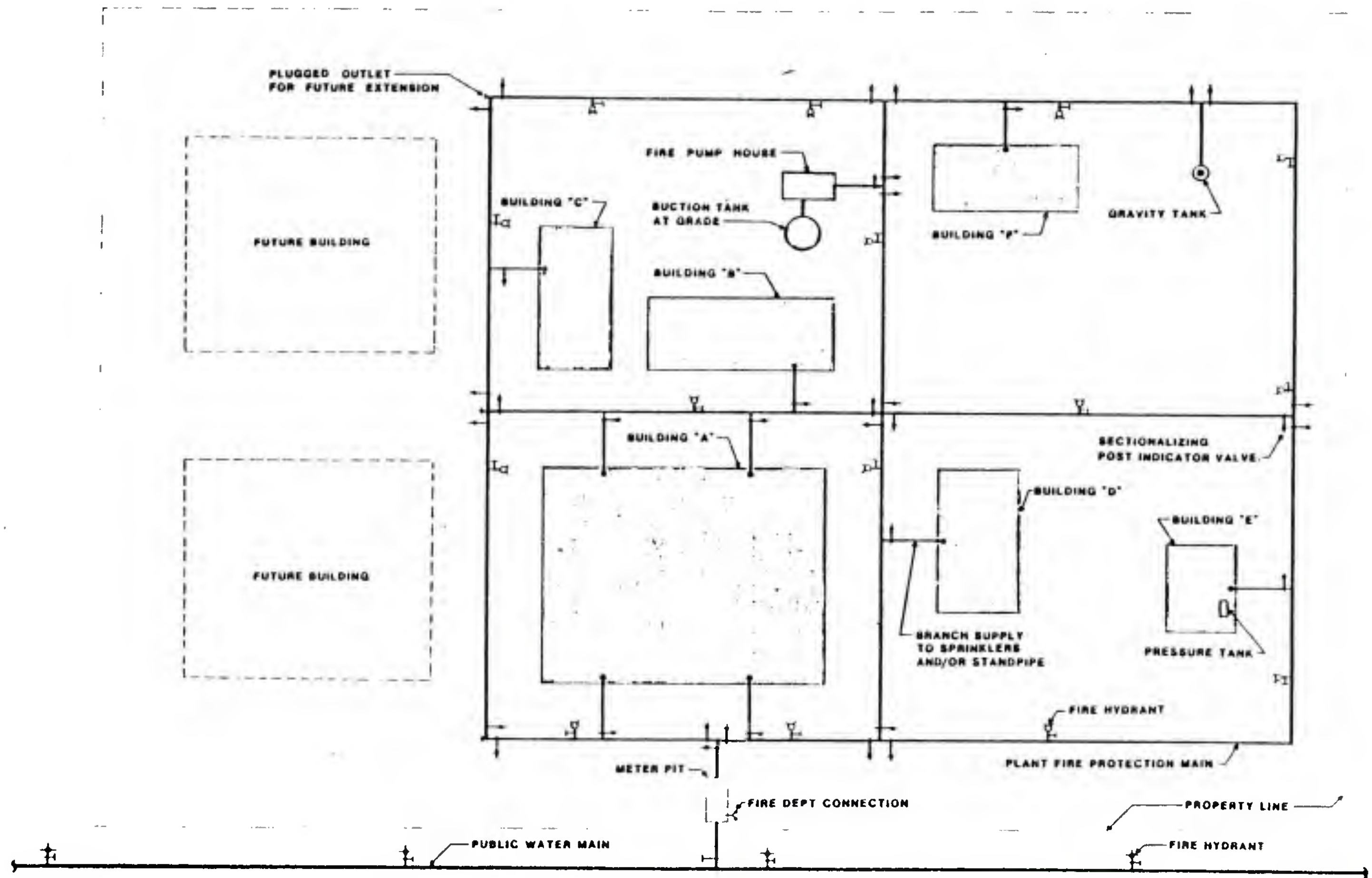
When properly designed and installed by competent contractors, an ultra-high-speed deluge system can detect an ignition/flame and extinguish or control it within a time frame of 50 to 150 milliseconds, that is, faster than you can blink your eyes.

This paper will present the various methods that can be used to provide a reliable, instantaneous, supply of water at the flow rate and pressure required for fire extinguishing purposes. Decision as to the type of supply will affect, and should involve, siting of elevated water storage tank, pressure tank, and/or pumping facilities, if required. In addition, those responsible for the design of the fire extinguishing system should consider alternative designs available and the effect they would have on the water supply requirement, pipeline routing, space allocation, and costs.

The comparative advantages and limitations of direct connection to public and/or private water source, elevated gravity storage tank, pressure tank, and fire pumps will be addressed. Basic considerations applicable to the layout of site water distribution systems will be given.

An ultra-high-speed deluge system must have an integrated system of underground and overhead piping with reliable and instantaneous water supply, both flow and pressure, all designed in accordance with engineering hydraulic standards and good piping practice.

When calculating the water supply requirement for the elevated storage tank or the pressure tank, inside and outside hose demands should not be added to the flow assigned to the ultra-high-speed deluge system(s) because in high hazardous operations fire department procedure is to respond to fires on a standby basis, hand off, until clearance to approach is given.



TYPICAL PLANT SITE WATER DISTRIBUTION SYSTEM

FOR FIRE PROTECTION SUPPLY

The view-graph shows a representative layout of a site water distribution system for fire protection where we have incorporated most of the water supply sources we will discuss:

1. Direct connection of the facility site water distribution system to a public or private water source.
2. Connection to the facility site water distribution system with a fire booster pump installation.
3. Connection to the facility site water distribution system with an elevated gravity water storage tank.
4. Connection to the facility site water distribution system with a pressure tank installation.

1. <u>Direct connection of the facility site water distribution system to a public or private water source</u>:

The most desirable type of water supply based on considerations of economy and reliability is undoubtedly direct connection to a public or private water source fed from two directions that can at any time of day, meet the instantaneous flow requirement of the system, both pressure and gpm.

Where certification of such capability is not available from the water utility company/agency or from the facility engineering department, extensive flow testing of the mains should be carried out in a manner described in NFPA Standard 291, Fire Flow Testing and Marking of Hydrants.

During survey of existing site water distribution systems we have encountered some of the following problems:

a. Isolation valve in a partially closed position.

b. Lines loaded with sediment.

c. Severely tuberculated pipe interior surfaces. Tests indicated "C" value of 60.

d. Pressure relief valve on a diesel fire pump had been reduced to 50% of design pressure to minimize blowouts in the old deteriorated piping grid.

e. Ultra-high-speed systems incorrectly connected to a system supplied by a diesel fire pump.

Should the test results indicate that the flow and pressure is not available to satisfy the system requirements due to pipe friction and static losses, we would recommend that alternative designs be investigated such as new pipeline routing, parallel and looped configuration, and the relative costs involved compared.

Public water supply systems generally operate at somewhere in the range of 60 to 80 psi; therefore even where the losses are low, the pressures will probably be inadequate for most ultra-high-speed deluge systems in a building much more than one story high, because nozzle pressures of approximately 30 psi minimum are normally required - and higher pressures will provide faster response times.

To assure that the specified density is reasonably uniform throughout the area of demand and the response time criteria is achieved NFPA Standard No. 13 Sprinkler Systems, No. 15 Water Spray Systems and No. 24 Water Distribution Systems, should be followed.

2. Connection to the facility site water distribution system with a fire booster pump installation:

Due to the response time requirement of the ultra-high-speed deluge system, fire pumps (electric or diesel) are not acceptable as primary water source. Their application comes in as back-up supply for the elevated gravity storage tank and/or the pressure tank.

If the public or private water source can supply the required flow but the pressure is inadequate, the installation of an automatic fire pump taking its suction from the main source should be considered. In case the available source cannot meet the required flow, and/or would have its pressure lowered to an unacceptable level by the fire pump suction, a stored supply of water should be used as the suction source for the fire pump(s). This stored supply must be of adequate volume to satisfy the maximum design demand and flow duration for the system or systems it supplies, and should have a dependable arrangement for maintaining the required stored quantity of water.

Fire pumps are generally driven by either electric motors or internal combustion engines. Internal combustion engine drives have the advantage of being independent of an outside power source but will generally have a considerably higher installed cost, and require more maintenance and service than an electric pump. The advisability of providing a standby pump or pumps should be considered, especially where the fire pump installation is the sole supply for the fire protection system. For a higher degree of reliability, the use of a combination of motor driven and engine driven pumps may be warranted.

In a large facility where the site water distribution system is combined, potable and fire protection, and the design requires constant on-line pump operation, it may be possible to utilize this arrangement to satisfy the reliable instantaneous flows required for the ultra-high-speed deluge systems. Of course, the on-line pump must be able at all times to satisfy the maximum ultra-high-speed deluge system design flow and pressure simultaneously with the maximum potable/process water demand, if such a system is to assure proper deluge system operation.

Fire pumps, controllers, and accessories to be provided should be approved for the intended service by the Underwriters' Laboratories. The design of the fire pump installation should be in accordance with NFPA Standard No. 20, Fire Pumps.

3. <u>Connection to the facility site water distribution system with an elevated gravity water storage tank:</u>

When the public or private water source is inadequate as to flow and pressure for the system, an elevated gravity water storage tank will provide a reliable water supply for fire protection purposes. Such a gravity tank should preferably be erected on an independent structure with its own foundation, but if space is not available (usually the case where the hazardous station is in a built-up area), the tank may be located on top of the building, provided the structure is designed to accept the tank loads.

The bottom of the tank should be at an elevation sufficient to provide the required residual pressure at the system flow rate. The tank should be sized to provide the ultra-high-speed deluge system demand for two minutes or more until the automatic fire pumps can come up to speed, as well as the total storage required for all other fire protection.

Adequate provisions must be made for automatic maintenance of water level and the necessary freeze protection for the tank and all associated piping system where required.

The design of the tank installation should be accomplished in accordance with NFPA Standard 22, Water Storage Tanks.

4. Connection to the facility site water distribution system with a pressure tank installation:

Storage tanks pressurized with air or inert gas may be used as the primary source of the initial water flow to the ultra-high-speed system at the required pressure until the automatic fire pump(s) can come up to speed. In a similar fashion to the elevated gravity storage tank, the pressure tank should be sized for slightly more than two minutes of water flow.

Pressure tanks may be of the stored pressure type (where the pressure decreases progressively once the water discharge begins) or the type where constant pressure is maintained during the water discharge by flow into the tank of pressurized air, carbon dioxide, or nitrogen.

The use of a pressure tank installation for ultra-high-speed systems is practical only if it serves a distribution system dedicated to fire protection exclusively.

Pressure tank installation should comply with the requirements of NFPA Standard 22, Water Storage Tanks.

In conclusion, I must emphasize that the examples of water supply systems I have discussed are not meant to be definitive for any particular case, but were presented to illustrate the range of possible alternative methods that could be considered. The selection of a basic water supply scheme for a plant or building may require input from the civil, architectural, structural, and electrical disciplines and an early decision as to the water supply system to be used will facilitate the entire design process.

Additionally, the early planning of the fire protection requirements and its associated water supply system will permit analysis of the interrelated sizing of interior and exterior portions of the system for optimization of cost considerations and space allocation, and assure proper operation of the ultra-high-speed deluge system to protect life and minimize interruptions in plant operation.

We heard yesterday from equipment manufacturers that tests have indicated reduction in response time with an increase in system pressure. I would like to caution that an increase in system pressure might not be matched by the existing site water distribution system. We must not lose sight of the fact that an ultra-high-speed deluge system must have adequate water supply back-up for proper operation.

I hope I have been helpful in furthering the aim we all have of improving fire safety conditions at ammunition plants. Now I would be happy to hear any discussion and try to answer any questions you may have.

OBTAINING PROPERLY DESIGNED AND INSTALLED ULTRA-HIGH-SPEED DELUGE SYSTEMS AT ARMY AMMUNITION PLANTS

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Obtaining Properly Designed and Installed Ultra-High-Speed Deluge Systems at Army Ammunition Plants

Introduction

A good deal of time has been spent during this seminar discussing the present state-of-the-art in the technology of systems capable of the very rapid detection and extinguishment of fires in ammunition plants. As a practical matter, and especially with the constraints involved in the systems for governmental procurement of engineering and construction services, obtaining a properly designed, installed and tested system that will function when needed often proves to be very difficult.

We are going to attempt to provide guidance that might be helpful in avoiding some of the problems that occur between initial concept and successfully completed installation.

Prmary Factors

In our estimation, the most important factors in obtaining the desired final product are:

1. Definition of the extent of the ultra-high-speed (UHS) deluge systems needed, and establishing the necessary criteria for these systems at an early stage in project concept development.

2. Having the Contract Documents produced by personnel or firms experienced in the field of ultra-high-speed (UHS) deluge systems.

3. Requiring that all contractors certify that they have successfully completed detailed design, installation and testing of systems similar in type, size and complexity.

4. Arranging to have the fire detection and extinguishing systems installed by one contractor who accepts full responsibility for testing and performance of the complete detection-extinguishing system.

Establishing Criteria

Determine Where UHS Systems Are Required

The plant process and safety people should analyze the operations and materials involved at the facility to be protected, in order to make determinations of the extent of fire protection required, and to select the particular types of systems that should be provided for specific buildings, areas or work stations.

Army Technical Manual TM 5-812-1 ("Fire Prevention Manual") provides recommendations that should be followed for "conventional" systems; Volume I of Contractor Report ARLCD-CR-80049, "Engineering Guide for Fire Protection and Detection Systems at Army Ammunition Plants," contains some recommendations with regard to more specialized systems; DARCOM-R 385-100 ("Safety Manual") sets forth mandatory requirements and advisory provisions for the entire range of fire extinguishing systems applicable to ammunition facilities - unfortunately, with regard to UHS deluge systems some of the requirements and advisories may be misleading or inaccurate; but more about this later.

Practical economic limitations may force reduction in the amount of fire protection that can be provided - in such cases, a hazard analysis of the various structures, systems and operations may be required in order to establish priorities for fire protection installations. With such a priority listing, and cost estimates of the various fire protection systems involved, it will be possible to provide the optimum fire protection for the available funds. The effect of escalation of construction costs should be carefully considered in establishing these priorities.

In determining where UHS systems are to be used, it is important to avoid overkill. If total response times (between ignition and water delivery) on the order of one or two minutes or longer can be tolerated, the sophistication and costs involved in providing UHS response systems is probably not warranted. Bear in mind that the overall costs for an

UHS system will probably run approximately five times more than a standard deluge system, and may be eight or ten times as much as for a standard wet sprinkler system - and this does not include the costly changes that may be needed in the water supply system.

When the need for UHS systems for particular locations or operating stations has been decided upon, criteria for response time and density of water application should be established.

Response Time

Response time criteria should be set realistically, and defined in a manner that will permit meaningful testing of the completed installation in order to confirm that the criteria has been met. In general, it should be recognized that even with perfect design and installation, the larger the piping system, the longer the response time. As a practical matter, we feel that the minimum response time that can be guaranteed for even the smallest system is about 50 milliseconds from detector system signal to water delivery from the nozzle - for larger systems, 100 or 150 milliseconds is probably a reasonable time. (I'm sure the representatives from Grinnell and Automatic will have some comments to make in this regard.)

I think it appropriate at this time to point out that the Safety Manual, in paragraph 12-33g, defines "...a 50 millisecond response...as the time from the sensing of a detectable event until water hits the location of the event." Perhaps the Grinnell or Automatic representatives would be prepared to guarantee, in advance, 50-millisecond performance for a very small system, if the time period ends with water discharge at the nozzle - but when the time period includes water travel to the protected surface, I feel that 50 milliseconds would be realistic only where extremely short travel distances are involved. In addition, the suggested possibility of using rate-of-rise for control of UHS deluge systems (in paragraph 12-33a of the Safety Manual) is, in our opinion, not correct for the applications discussed.

Testing

While on the subject of response time, it is important to touch on the subject of testing of the completed system. The procedure commonly used for testing response time utilizes a millisecond digital timer that is started by the "discharge" signal from the detection system, and stopped by actuation of a paddle switch at a nozzle outlet. This method does not measure the time lag from actual ignition to detector system output; assuming the use of solid state relays in the detector circuitry, and depending upon the ignition source, this time period will usually fall in the range of 10 to 40 milliseconds. In 1981, Ammann & Whitney, in cooperation with Day and Zimmermann, ran some tests of UHS deluge systems at Lone Star AAP utilizing Videologic high-speed closed circuit TV equipment (very similar to that shown yesterday) that permitted measurement of "ignition to detector signal times," as well as observation of the water flow from the nozzle to the protected surface.

The TV system as described yesterday had a maximum speed of 120 frames/second, which permits timing events recorded to an accuracy of approximately ± 4 milliseconds, or 1/2 the time interval between frames. The complete system, with all needed accessories would probably cost about $75,000 today - a considerable sum. Where a facility has a project involving many UHS systems to be installed, the expenditure may be justifiable for initial and periodic testing, as well as for other possible experimental and research tasks for which it could be useful. As an even more practical approach, I would suggest an appropriate central agency (perhaps the Corps of Engineers or AMCCOM Safety) acquire one or more such systems. These systems could then be used, as needed, at any Army Ammunition Plant for acceptance testing of newly installed UHS systems to verify that the contract criteria have been met.

Density

The required water application rate, or density, usually expressed in gallons per minute per square foot of area to be covered, should be established for each UHS system. The necessary density will depend on the type of hazardous material involved, whether the aim is extinguishment, preventing propagation of a fire beyond the original site, preventing serious injury to personnel, protection of the structure, or a combination of several of these. Where no applicable data can be found for a particular hazard or material, experimental extinguishment tests should be conducted if possible. A commonly used density for preventing propagation and structural damage is 0.5

gpm/square foot. For extinguishment in a localized area, or for direct protection of personnel, significantly higher density rates may be necessary. Under some conditions, placement of a nozzle to knock a worker out of harm's way may save a life at the cost of some bruises. At Lone Star, Day and Zimmermann provided such a nozzle as part of each high-speed deluge system installed several years ago at a number of mixer stations. The mixing operation did not require an operator to be present, but in order to clean the kettle and mixer, it was necessary for a man to stand on a low platform next to the kettle. The nozzles on these systems were arranged to drench the interior of the kettle and the operator's position, but an additional nozzle was placed to direct a strong jet at the operator's chest in order to push him away from the kettle in the event of an incident and system discharge.

Water Supply

At this stage it should be possible to make reasonable estimates of the maximum water flow rates and pressures that would be required by the systems to be installed. The capability of the existing water supply and distribution system to meet these requirements at the locations involved should be checked. If there is any doubt as to the adequacy of the existing water system, flow tests should be performed, preferably in the immediate area where the new suppression systems are to be installed, to determine whether modifications to the water system will be required.

This subject was covered earlier by Manny Avelar in much greater detail, but even at the risk of being repetitious, one point should be emphasized. The water pressure necessary for proper functioning of a UHS deluge system must be available instantaneously - and therefore can not be produced by starting a fire pump on pressure signal (or even on signal from the detection system).

Detection System Criteria

For UHS systems having the response times we are talking about, the choice of detection systems will generally be limited to either infra-red (IR) or ultra violet (UV) types. Except in very special cases where IR detectors can be completely isolated from all possible extraneous IR sources that might cause false alarms, UV detection will be the system of choice.

Manufacturers of UV detectors should be consulted at this stage to verify the suitability and sensitivity to ignition of the particular hazardous materials that will be involved. If such information is not available, arrangements should be made for tests by UV manufacturers to develop the needed data.

Another possible approach to this problem, as suggested by Stan Straker, would involve developing a standardized required detector system response to ignition of a quantity of a particular material at some standard distance from the detector. Then, for each proposed installation, the required detector system response to ignition of the specific material involved could be expressed in terms of the standardized response - this determination could probably best be made by the user.

Criteria should also be spelled out at this time for any special provisions that may be necessary to avoid false detection signals caused by extraneous UV or gamma radiation.

Additional detection system criteria that should be established as guidelines for design are:

1. Should a time delay feature be incorporated?
   Adjustable time delays are available for a range of approximately 0.2 to 12 seconds between alarm signal and release signal. This feature can provide an abort capability, but obviously should be omitted if maximum response speed is required.

2. Should response by more than one detector be required for system operation?
   Arrangement of circuitry and logic can be provided that requires a response by two (or more) detectors to actuate the system. This arrangement is frequently provided to reduce the possibility of system discharge due to faulty signal. In such cases, every part of the protected area must be visible by at least the number of detectors required for system operation.

The Design-Construction Phase

Once the conceptual phase has been completed, and the basic system requirements established, all that remains is to have the work designed, installed and satisfactorily tested - and there's the rub.

The major problem areas in this regard are:

1. Inadequate construction Contract Documents.

2. Unqualified installing contractors.

3. Installation of equipment or devices that can not meet system requirements.

It is my understanding that according to Governmental regulations and procedures, if the dollar value of a planned project at a facility is below a given figure, and certain other guidelines are met, the engineering, or the engineering and construction can be performed in-house. If this is the case for any proposed UHS deluge installation at an ammunition plant, the responsible person or department, with input by Safety and other concerned parties should decide whether the facility has the people sufficiently experienced and qualified to do this work - or whether outside firms should be contracted with to perform the work.

In initiating the actual design-construction phase of a project that includes UHS deluge systems, selection should be carefully made to assure that the firm chosen has engineered similar systems that have been successfully completed and tested, and is aware of current developments in the field. The Engineer should have sufficient background to be able to analyze the conceptual criteria that had been previously developed, and, with sufficient information provided by the facility, detect the shortcomings or inconsistencies in the conceptual systems and in how they fit into the overall fire protection capabilities at the facility.

In most cases, we recommend that the construction Contract Documents produced by the A/E should not get into the actual detailed design of the detection and extinguishing system, but rather should very clearly spell out the performance criteria for each system and each area involved, to include, as a minimum:

I. <u>For the detection system</u>

a. Area to be viewed.

b. Source of flash or flame to be detected.

c. System logic required.

d. Supervisory requirements.

e. Testing requirements.

II. <u>For the extinguishing system</u>

a. Area to be protected.

b. Water applicati rate or density.

c. Testing requirements.

Additionally, the Contract Documents should designate the approximate locations of: system water supply connections; main piping runs and valves; and fire detection, alarm and supervisory panels. The available static and residual water pressures (at the estimated minimum required flow rate) should be defined at each supply connection, and preferably verified by testing.

The type and extent of supervision desired for the detection and extinguishing systems, the standby battery or emergency power requirements for supervisory and alarm modes, and the remote signal requirements should be clearly established.

Guaranteed response times that the various UHS systems must meet should be given, along with a complete description of the testing procedure that will be used to verify the performance of the completed installations.

If at all possible, the contract should be written so that the detailed design, installation and testing of the UHS systems, complete with all components of extinguishing, detection, supervisory and alarm systems, is the ultimate responsibility of one contractor or subcontractor. This will minimize problems caused by divided responsibility.

The contract should also require that qualified representatives of the manufacturers of the major components of the detection and extinguishing installation should be made available for on-site check out, final adjustment and testing of the completed UHS systems, and training of facility operating and maintenance personnel. In addition, a submission of complete operation and maintenance manuals should be called for.

The Contract Documents should require submission of complete detailed shop drawings of the entire installation coordinated with the work of all disciplines, and all pertinent hydraulic calculations, as well as catalog cuts and data sufficient to completely define the devices, materials and equipment proposed for the installation, and recommended spare parts lists. Wherever feasible, conformance with applicable recognized standards, codes, regulations and equipment listings should be required in order to set minimum levels of quality for the project.

This brings us to another problem area that ammunition plants are confronted with in obtaining UHS installations. Leaving aside the detection end of the systems, there are two basic types of UHS deluge systems, each of which was described to you yesterday by its most ardent proponents. Having representatives of both Grinnell and Automatic here, you have had a golden opportunity to learn the advantages, (from the Manufacturer), and the disadvantages, (from the Competition), of each type. As an unbiased party, - I will not offer an opinion. Actually, for most applications, either type of system, with properly detailed design and installation, would be suitable. Therefore, except for cases where there is some overriding consideration that would rule out one type or the other, we would recommend that Contract Documents be prepared to permit installation of either - a little healthy competition is good for all us taxpayers.

While we can all agree that competition is a good thing, the government requirements for open bidding and restrictions on proprietary specifications, particularly for very specialized types of installations like UHS systems, can lead to disastrous consequences when it results in awards on a low-bid basis to Contractors who do not have the required expertise. This problem is compounded where a General Contractor, after receiving such an award, is left free to shop around for any subcontractor who will offer to do the work for a lower price.

We would suggest two lines of attack on this problem. First: a clause should be included in the Contract Documents that would require submission, with the bid, of the name of the contractor and his subcontractor who will be responsible for the entire UHS deluge systems installation, along with certification that such firm has successfully completed detailed design, installation and acceptance testing of at least three named projects having UHS deluge systems of comparable size and complexity to those specified in the Contract Documents. Second: every attempt should be made to obtain government waivers of the non-proprietary requirements for specific systems or system components. Because of the criticality of these systems from a standpoint of life safety, we feel a good case can be made for such waivers.

Inspection during Construction

Under ideal conditions, a competent contractor, with expert supervisors, skilled mechanics, and a full set of approved shop drawings should be able to provide the perfectly installed fully operational system. In the real world, competent field inspection during the construction period will discover shortcomings, mistakes, interdisciplinary conflicts and all sorts of unforeseen problems before they become major disasters.

Obviously, it would be best if at least one of the team members responsible for overseeing the day-to-day operations during the construction period is very familiar with all aspects of UHS deluge systems. We recognize that the Corps of Engineers normally handles this phase of the work, but perhaps the Rock Island Safety people (and the Corps people who are here today) can impress on the Corps the importance, from the standpoint of life safety, of having qualified people assigned, even if only on a periodic basis, to oversee this phase of the fire protection work and testing on such projects. In any case, we feel that provisions should be included in the original design contract for some level of involvement by the engineering people during the construction and testing work - at a minimum, they should be made responsible for shop drawing review, and should be available for "on-call" construction visits on an as-needed basis.

I want to thank you for your attention, and express my thanks to General Bowen, Mr. Smith, Mr. Loyd, and all the other people responsible for arranging for and organizing this seminar, and for the opportunity to give you some of my thoughts and suggestions on this subject. I hope they will be helpful in reaching our common goal of improving fire safety at ammunition plants. Now I would be happy to hear any discussion and try to answer any questions you may have.

INFORMATION PAPER

AMSMC-ISE

17 OCT 1984

SUBJECT: Rapid Action Fire Protection System - Hazardous Waste Generation

ISSUE: To provide information concerning environmental requirements associated with the operation of rapid action fire protection system.

FACTS:

1. The Resource Conservation Recovery Act (RCRA), Public Law 94-580:

    a. Regulates hazardous waste management.

    b. Defines waste which is hazardous by specific criteria (reactivity, ignitability, corrosivity, and EP toxicity) or is listed by specific source or compound in Subpart D of 40 CFR 261.

    c. Requires the implementation of a contingency plan and emergency procedures when there is a fire, explosion, or release of hazardous waste or hazardous waste constituents.

2. The rapid action fire protection system operates in response to the reaction of reactive/ignitable material(s), thereby generating waste water.

    a. The waste water generated has a potential for meeting the hazardous waste criteria.

    b. The waste water must be contained*and treated/disposed of in an appropriate manner, i.e., the waste water should be tested to determine if in fact it is a hazardous waste.

*This HQ recommends that the waste water be collected in a tank and disposed of within 90 days, thereby eliminating the necessity for a RCRA Permit.

CF:
AMSMC-ISF-O

Mr. Shinbori/ AV 793-4793