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(1)

REMOTELY OPERATED ROBOTIC FIREFIGHTER

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AMETEK/OFFSHORE RESEARCH & ENGINEERING DIVISION (ORED) performed a conceptual design study of potential state-of-the-art robotic firefighting systems. To demonstrate the feasibility of major critical components, an Air Force P-4 Firetruck was provided and fitted with systems to allow remote operation. The converted vehicle was transported to Vandenberg Air Force base and a live fire test was performed at the fire training pit. The P-4 vehicle was returned to the original condition and to the Air Force, after the test exercises were completed.

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SUMMARY

In June 1985, AMETEK/ORED was tasked to develop a design for a robotic firefighting system to combat fires too dangerous for conventional equipment and personnel. The primary subject of concern is a circumstance when explosion of ordnance becomes a threat because of fire exposure on an aircraft. Many concepts were investigated to satisfy design criteria established early in the project. These conceptual studies indicated the need for a relatively small, six-wheeled vehicle equipped with multiwheel drive, self-righting features, boom-mounted nozzle, and a boom-mounted SPAAT® tool with halon storage tanks which could be supplied with firefighting fluid by relaying it from an existing type firetruck located a safe distance from the hazard. A special hose management trailer module would be employed to control deployment of hose both from the remote control station and to the remote vehicle. Radio frequency control signal transmission was selected to eliminate the possibilities of control umbilical entanglement.

Upon completion of the design studies, critical components were scheduled to undergo shop bench tests to verify feasibility for future applications on prototype or production systems.

Alternatively, it was decided to fit these and other critical components on a Government-Furnished Equipment (GFE) P-4 firetruck. The modified truck became a Feasibility Demonstration Model to verify concept validity as well as component performance. A radio frequency link for data and visual information was selected. The truck was self contained with respect to firefighting agents and a halon/SPAAT® system was not included.

Numerous subsystem and global system tests were completed at AMETEK/ORED facilities in preparation for an official demonstration to the Air Force.

In June 1987, the modified P-4 vehicle, with its specialized portable remote control console, was transported to Vandenberg Air Force base in California. In cooperation with the base firefighting crew, a series of firefighting training exercises was performed. These exercises at the aircraft fire training pit educated the AMETEK/ORED system operators in the details of aircraft firefighting. These exercises revealed performance of the remote system to be outstanding and in some ways superior to conventional methods.

On 18 June 1987, a team of selected Air Force evaluators was assembled at the Vandenberg AFB pit area and they witnessed a demonstration of the equipment and remote firefighting operations. The remotely operated system extinguished the 600-gallon. JP-4 fuel fire, engulfing the simulated medium bomber, efficiently and rapidly.

AMETEK/ORED completed those original contract requirements, which remained pertinent, as requested by the Air Force during the course of the program. AMETEK/ORED accommodated changes associated with the P-4 feasibility demonstration model and completed design, fabrication and testing as requested.

PREFACE

This technical report was prepared by AMETEK/Offshore Research and Engineering Division (ORED), Santa Barbara, California 93160-6447, under Contract Number F08635-85-C-107, for the Air Force Engineering and Services Center, Engineering and Services Laboratory (AFESC/RDCF), Tyndall Air Force Base, Florida 32403-6001. This work was co-sponsored by AFSC AD/PMR and AFSC AD/JAN Eglin AFB, Florida 32542-5000.

Mr. Joseph L. Walker and Mr. Richard N. Vickers, were the project officers for HQ AFESC/RDCF. This report summarizes work accomplished between June 1985 and July 1987.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

A. OBJECTIVES

1. Special-Purpose Remote Firefighter

Identify the most desirable conceptual design for development of a special-purpose remote firefighter.

2. Remote-Controlled P-4

Identify and implement a suitable design to allow wireless remote operation of an Air Force P-4 firetruck. This specially equipped P-4 is considered a Feasibility Demonstration Model (FDM) and will verify critical control components, as well as overall system proof-of-concept.

B. BACKGROUND

1. Recognized Need

Historic Air Force events indicate the need to be able to conduct firefighting activities near active weapons systems without endangering firefighters. Aircraft weapons and fuel systems require firefighters to be at least 2,000 feet away to be statistically "safe." This requires remote-controlled systems.

2. Concept Studies (Phase I)

Studies began on 27 May 1985 and continued until 3 October, 1985. These studies were accelerated from the planned 9 months to 4 months to conform to project funding requirements. Detailed subsystems analyses were performed to identify technologies suitable for mobility, firefighting, control/ feedback, power and man-machine interface. A baseline concept was developed and recommendations regarding technical direction were provided. The Concept Feasibility Review report for 3 October 1985 is included as Appendix "A" for further details of Phase I findings.

3. Feasibility Demonstration Model P-4 (Phase II)

It was decided that greater benefits would be provided by outfitting an existing P-4 for remote controlled operation. A no-cost Engineering Change Proposal (ECP) was submitted on 28 January 1986 (see Appendix "B") and later approved to allow the study of the P-4 firetruck and the design of a wireless remote control system. The Government-Furnished Equipment (GFE) P-4 firetruck was delivered to AMETEK/ORED from Edwards Air Force

Base (AFB) on 19 June 1986. Investigations revealed that it would be more cost-effective to substitute an electrically controlled unit for the manual turret. An ECP for the value of the replacement nozzle was issued on 25 August 1986, and approved on 4 December 1986 (see Appendix B). During the first interim Phase II review meeting, 3-4 September 1986, significant enhancements to the FDM systems were proposed. An ECP was issued on 14 November 1986 to provide funding for the enhanced features, but was not received and these features were not included in the final FDM. During the second interim Phase II on 20 February 1987 a Multiple Commercial Transmitter (MCT) data link was approved for FDM use and the official demonstration was scheduled for Vandenberg AFB in June 1987. Phase II was completed on 20 February 1987 with the finalization of the preliminary FDM design and critical component development.

4. FDM Design, Fabrication, Test and Demonstration (Phase III)

Remote control components were received, truck fixtures and the control console were fabricated and subsystem testing was performed at AMETEK/ORED facilities. Notification of reaching the 75 percent completion of project funding point was provided to the Air Force in April 1987. A Defense Contractor Auditor's audit was conducted on 20 May 1987 and results were satisfactory. An interim review was conducted on 28 May 1987 to review FDM design, fabrication, and testing. The major components of the remote-controlled P-4 were demonstrated to the Air Force project manager at AMETEK/ORED's facilities. Test plans for Vandenberg AFB demonstrations were also completed at this interim meeting.

The P-4 vehicle and support system were transported to Vandenberg AFB 10 June 1987. Numerous Training exercises were conducted at the firefighting training pit during the following week. The official demonstration was performed on 18 June 1987. The FDM successfully demonstrated that a remote-controlled firetruck could be effective and safely extinguish typical aircraft fires. Several Air Force observers felt that the FDM, equipped with a unique nozzle, was actually more effective at firefighting than current conventional equipment and teams.

Following the demonstration, the P-4 was transported to AMETEK/ORED facilities, refurbished to "as-received" condition, documented, and prepared for return to the Air Force on 8 July 1987.

The final report was developed in July-August 1987.

All phases of the contract were completed successfully within the proscribed budget by AMETEK/ORED.

C. SCOPE/APPROACH

1. Conceptual Studies

Phase I studies were performed based on literature search methods and the application of engineering experience. Illustrations were used to convey the concepts to the Air Force Program Manager(s).

2. Preliminary Design (P-4)

Potential components suppliers were queried regarding performance specifications and compcnent packaging. The results of these investigations yielded a system design which was presented to the Air Force Program Manager for approval to complete the detail design.

3. Detail Design (P-4)

Remote control components were selected and procured. "Detail" installation sketches were provided to senior technicians to create prototype fixtures, mounting and electrical wiring. Integration of the design components required that several specialized circuit boards be designed.

4. Shop Fabrication and Fit (P-4)

Based on the "detailed design sketches" and hardware provided, the technicians installed the remote systems. The components were then tested on a subsystem basis. Minor alterations and adjustments were then made.

5. System Testing and Demonstration (P-4)

The vehicle and control console were tested at the AMETEK/ORED facilities to confirm the complete system performance. Upon completion of in-house tests the system was transported to Vandenberg AFB, where, firefighting training was conducted at the fire training pit. Successful trial firefighting exercises confirmed readiness for the official demonstration.

6. FDM Documentation

System and subsystem drawings were completed. Photographs of critical system components were collected to document design details of "as-built" components.

SECTION II

DESIGN STUDIES OF STATE-OF-THE-ART ROBOTIC FIREFIGHTING SYSTEMS

A. DESIGN CRITERIA

The following criteria were established from a number of sources during the course of the study and the source is noted when applicable.

1. Firefighting Agent Supply

The contract Statement of Work (SOW) requires that the Robotic Firefighter system function without external support. Because of the high-flow requirements for water/Aqueous Firefighting Foam (AFFF) extinguishing agent, up to 250 gpm in the SOW and 500 gpm per technical direction, it is impractical to carry the supply of water/AFFF on the Robotic Firefighter. Provision of a new vehicle to act as a source of AFFF for the Robotic Firefighter is unwarranted, because existing vehicles can provide the requisite AFFF without modification. Therefore, the technical direction given during the Kickoff Meeting at Tyndall AFB, FL on 2-3 July 1985, included a provision that the water/AFFF would be supplied by suction/pumping from existing firefighting vehicles. Otherwise, the system was to be completely self-contained.

a. Existing Equipment Survey. Only equipment which is both currently used by Air Force (AF) Fire Protection Services field units, and relevant to support of the Robotic Firefighter system is described herein.

b. P-2 Crash Truck. P-2 Crash Truck specifications relating to supplying the Robotic Firefighter are discussed below:

The P-2 Crash Truck carries 3,000 gallons of water/AFFF (mixed during dispensing), and can be pumped from an external water source such as a water hydrant.

Pumping pressure and flow output are up to 1,500 gpm at 280 psi. This provides more flow than required for the Robotic Firefighter. However, depending upon the run distance and the diameter of hose used between the supply vehicle and the Robotic Firefighter, the pressure at the nozzle outlet on the Robotic Firefighter might be reduced below reasonable operational limits (150 psi).

The P-2 Crash Truck can travel in excess of 35 mi/hr on dry hard surfaces such as roads, ramps, runways, and taxiways. In rough terrain its speed may be reduced, to less than 5 mi/hr. These performance ratings are compatible with the P-2 firetruck's expected support role with the Robotic Firefighter system.

c. P-4 Crash Truck

P-4 Crash Truck specifications relating to supplying the Robotic Firefighter are discussed below:

- The P-4 Crash Truck carries 1,500 gallons of water/AFFF (mixed during dispensing), and can pump from an external water source such as a water hydrant.

-The pumping capabilities for the P-4 are identical to those for the P-2. All the comments about supplying the P-2 apply to the P-4.

Similarly, the hard surface and all-terrain performances for the P-4 are essentially identical to those of the P-2, except that the P-4 has slightly better rough terrain handling characteristics. Again, the performance ratings are compatible with its expected support role with the Robotic Firefighter system.

2. Aircraft

The aircraft in Table 1 must be effectively serviced by the robotic firefighting system.

TABLE 1. LIST OF AIRCRAFT TO BE SERVICED BY REMOTE FIREFIGHTER SYSTEM

AIRCRAFT		
Tactical:	Transport:	Strategic:
A-7	C-5	B-1
A-10	C-6	B-52F
A-37	C-7	B-52G/H
F-4	C-9	
F-5	KC-10	
F-15	C-23A	
F-16	C-47	
F-102	C-54	
F-104	KC-97L	
F-106	C-118	
F-111	C-119	
C-121	C-123	
	C-130	
	C-131	
	C/KC-135	
	VC-137	
	C-140	
	C-141	
	E-3A	
	E-4A	
	OV-102	

Table 1. LIST OF AIRCRAFT TO BE SERVICED BY REMOTE FIREFIGHTER SYSTEM(concluded)

MISCELLANEOUS

Helicopters:	Utility:	Army Helicopters:
UH-1	U-3	HU-16
CH-3	U-4	U-17
HH-1	U-6	QU-222
HH-53	U-10	

Observation/ Reconnaissance:	Trainer: (No Ordnance)
O-2	T-29
OV-10	T-33
WU-2	T-34
SR-71	T-37
	T-38
	T-39
	T-41
	T-43

3. Accessibility/Hazardous Zones

Table 2 indicates danger areas and how they apply to firefighting personnel and to a robotic firefighting system.

TABLE 2. DANGER AREAS AND APPLICABILITY

Danger Areas	Applicable to Personnel	Rcb. Firefter.
Ordnance		
Forward-Firing Weapons	Yes	No
Aft-Firing Weapons	Yes	No
Bombs	Yes	No
Explosive Cargo	Yes	No
Engines		
Inlet	Yes	No
Exhaust	Yes	No
Turbine Blade	Yes	No
Tires	Yes	Yes
Canopy/Seat Ejection	Yes	No
Radiation - Nuc.Mat'ls.	Yes	No
Hazardous Materials	Yes	No
Chemical Weapons	Yes	No
Other HAZMAT Cargo	Yes	No
Oxygen, Liq. & Gas	Yes	No
Nitrogen, Liq.	Yes	No
Beryllium	Yes	No
Magnesium	Yes	No
Depleted Uranium	Yes	No
Graphite Composite Fibers (Corker)	Yes	No
Hydrazine	Yes	No
Ammonia, Liq. & Gas *	Yes	No
Hydrogen, Liq. *	Yes	No
Nitrogen Tetroxide *	Yes	No
Laser Test Bed HAZMATS	Yes	No

*These materials are only used on the Space Shuttle.

4. Required Personnel Clearances

The contract Statement of Work requires a 3,000 foot offset to control the Robotic Firefighter system. AFESC/RDCS has stated that the actual requirements are 2,000 feet for personnel in general and 1,200 feet for fire personnel.

5. Means for Determining Offset Distance During Approach

What AFESC wanted was a system to indicate horizontal closure distance (direct line) between the Robotic Firefighter system and the crash/fire site during approach, so that the control unit could be deployed at the minimum safe clearance distance from the crash/fire site. This system must have an all-weather, all-terrain, night-day capability.

6. System Packaging/Configuration

The SOW specifies that the system shall be designed for installation in a DOD Standard Family Mobile Tactical Structure, and be air-transportable in a C-130 aircraft in accordance with MIL-STD-8421 equipped with a A/A32H-4 dual-rail cargo-handling system without component removal.

During the 2-3 July 85 Kickoff Meeting, AFESC/RDCS clarified the technical requirements to specify a modular deployment and packaging concept, not necessarily tied to the DOD Standard Family Mobile Tactical Structure. Based on AFESC guidance, artist's concepts of two-system packaging configurations were prepared and forwarded to AFESC on 18 July 85. AFESC/RDCS expressed a preference for a particular concept as a conceptual baseline for the system packaging/configuration and deployment concept.

Ultimately, the system configuration will be determined by design studies. The operational requirements set basic constraints on the configuration.

7. Lift/Carry Capability and Speed

There are no SOW requirements, other than lift and carrying capability which specify any capabilities for lifting, carrying, or speed.

Any requirements for lifting and carrying must arise from the study of operational requirements, e.g., if operational personnel strongly identify a need to pick up and clear ordnance or debris which has become detached from the aircraft.

Speed requirements will be established by the operational timelines and perhaps existing or new directives. During the 2-3 July 85 Kickoff Meeting, AFESC/RDCS established a design goal deployment speed of 35 mi/hr to traverse the distance between the control site and the crash/fire site. This may be further clarified through visits to operational organizations.

It is assumed that the speed requirements during operation at the crash/fire site are generally much lower, than the stated upper limit.

8. Debris

The SOW requires that the Robot traverse crash debris up to 18 inches by 18 inches by 24 inches.

"Traverse" implies that the robot unit must climb over such debris. The definition of "traverse" is loosely interpreted to include concepts such as plowing lighter debris out of the way and moving around debris.

9. Bomblet Detonation Hardening

The SOW requires the tether and robot be protected against damage from bomblet detonation within 10 feet and 6 feet, respectively. Taking clarification from the 2-3 July 85 Kickoff Meeting at AFESC, the tether (control cable) and robot must be hardened to withstand a bomblet detonation at contact.

AFESC's guidance stated that the tether-hardening requirement applied only to a control/feedback signal cable, if used, i.e., if control/feedback are not wireless. AFESC/RDCS strongly favored a wireless link for control/feedback signals.

AFESC described the robotic hardening requirement as applying to the track/wheels/tires at bomblet detonation on contact. The undercarriage must withstand this detonation and isolate components of the robot from damage. It is assumed that the control unit does not require such hardening.

10. Operational Scenario

From SOW guidelines, AFESC/RDCS technical guidance, and survey of Field Air Force Fire Protection Service equipment, procedures, and recommendations, a matrix of aircraft/ordnance Operational Scenarios was developed. These are categorized by aircraft general type and the location of the incident.

Additional potential applications were also identified, some of which may involve compromise or extension of the basic capabilities of the system required for the "primary mission."

a. Guidelines and Assumptions

(1) Statement of Work (SOW)

The conditions mandating employment of the Robotic Firefighter system, as described in the contract involve the imminent threat of explosion of ordnance subjected to fire exposure on aircraft.

The SOW includes, more generally, any situations in which the human firefighters may be subjected to unusually hazardous environments, and involves not only direct firefighting but also salvage and overhaul.

The SOW also refers generally to replacing human firefighters in "extremely hazardous environments."

(2) Assumptions

The "primary mission" of the Robotic Firefighter system is to fight and control fires, and to cool ordnance to prevent cook-off, for aircraft carrying ordnance when firefighting personnel must be evacuated.

The range of employment for the primary mission extends to the flight line, runway and taxiways, and the terrain in the vicinity of the runways and taxiways.

(3) Primary Mission Operational Scenarios

The Operational Scenarios which satisfy the Primary Mission criteria are listed in Table 3. Elements in the Table represent combinations of aircraft and locations for incidents. The following paragraphs, numbered to reference elements in the table, describe the scenarios.

The first three columns in the table address the three basic categories of aircraft types in the Air Force, AF Reserve, and Air National Guard inventories, while the fourth column covers any other aircraft not included in the other categories, e.g., Helicopters.

TABLE 3. OPERATIONAL SCENARIOS

Incident Location	Tactical Fighter	Strategic Bomber	Transport Aircraft	Miscel. Aircraft
Flight Line	IA	IB	IC	ID
Runway or Taxiway	IIA	IIB	IIC	IID
Airfield Off Runway	IIIA	IIIB	IIIC	IIID
Off Airfield	NR	NR	NR	NR

NR Represents Not Required, i.e., the Robotic Firefighter system will not be required to respond to a crash outside the aircraft perimeter.

IA A Tactical Fighter with ordnance mounted catches fire on the Flight Line. Flames impinge on ordnance for 2 minutes and personnel must be evacuated.

IB A Strategic Bomber with weapons aboard catches fire on the Flight Line. Flames impinge on wing-mounted ordnance or an internal fire involves the bomb bay so that personnel must be evacuated.

IC A Transport Aircraft with weapons/explosive aboard catches fire on the Flight Line. An internal fire involves the explosive cargo so that personnel must be evacuated.

ID Another type of aircraft, e.g., a Helicopter, carrying ordnance catches fire on the Flight Line. Flames impinge on the ordnance for 2 minutes so personnel must be evacuated.

IIA A Tactical Fighter with ordnance aboard crashes on the Runway and catches fire. Personnel cannot approach because of flames impinging on ordnance. Debris may be scattered on the runway.

IIB A Strategic Bomber with weapons aboard crashes on the Runway and catches fire. Personnel cannot approach because of fire impinging on underwing ordnance or an internal fire involving weapons in the bomb bay. Debris may be scattered on the runway.

IIC A Transport Aircraft carrying weapons or explosives crashes on the Runway and catches fire. Personnel cannot approach because of an internal fire involving weapons or explosive cargo. Debris may be scattered on the Runway.

IID Another type of aircraft, e.g., a Helicopter, carrying ordnance crashes on the runway and catches fire. Personnel cannot approach because of the flames impinging on ordnance. Debris may be scattered on the runway.

IIIA A Tactical Fighter with ordnance aboard crashes on the Airfield but off the runway and catches fire. Personnel cannot approach because of flames impinging on ordnance. Terrain may be rough, sloping, soft, muddy, icy, and/or covered with snow. Potentially, there may be intervening brush and trees. Debris may litter the crash site.

IIIB A Strategic Bomber with weapons aboard crashes on the Airfield but off the runway and catches fire. Personnel cannot approach because of fire impinging on underwing ordnance or an internal fire involving weapons in the bomb bay. Terrain may be rough, sloping, soft, muddy, icy, and/or covered with snow. Potentially, there may be intervening brush and trees. Debris may litter the crash site.

IIIC A Transport Aircraft carrying weapons or explosives crashes on the Airfield but off the runway and catches fire. Personnel cannot approach because of an internal fire involving weapons or explosive cargo. Terrain may be rough, sloping, soft, muddy, icy, and/or covered with snow. Potentially, there may be intervening brush and trees. Debris may litter the crash site.

IIID Another type of aircraft, e.g., a Helicopter, carrying ordnance crashes on the Airfield but off the Runway and catches fire. Personnel cannot approach because of flames impinging on ordnance. Terrain may be rough, sloping, soft, muddy, icy, and/or covered with snow. Potentially, there may be intervening brush and trees. Debris may litter the crash site.

IVA Through IVD. Any aircraft carrying weapons, ordnance, or explosives crashes off the Airfield and catches fire. Personnel cannot approach because of fire involving the weapons/ordnance/explosives. It is assumed that the operational requirements for the Robotic Firefighter system do not include employment at crash sites off the airfield.

(4) Composite Primary Mission Operational Scenarios

The following composite scenarios are intended to illustrate the combination of worst-case conditions in specifics to serve as a foundation for development of the operational envelope. Other scenarios such as that described in the SOW contain elements of the composite scenarios, but are less complex; a system designed to operate in the composite scenarios should be able to handle any of the "primary mission" scenarios.

(a) A fighter aircraft (F-16) skids off the runway into rough terrain (sandy, brushy, undulating), with foul weather (ice and snow) at night, and catches fire. Pilot escapes. Conventional and special weapons are involved in the fire. Debris and bomblets are scattered about.

(b) A Bomber aircraft (B-52) similarly skids off the runway into rough terrain (muddy, swampy and brushy). Crew is evacuated. An internal fire involves nuclear weapons.

(c) A cargo aircraft (C-5) carrying munitions (conventional and special weapons) crashes and skids off the runway. Crew is evacuated. An internal fire engulfs the cargo, and the access to the fuselage is exposed to heat from an external wing fire. Debris is also present.

(5) Secondary Mission Operational Scenarios

Additional potential applications, or "secondary mission" operational scenarios, were also identified:

(a) involving employment of the system in areas other than in the vicinity of the airfield, either on remote areas of a large installation or off the installation;

(b) involving utilization of the system to augment conventional firefighting personnel, equipment, and procedures during scenarios not involving imminent threat of explosion of ordnance, i.e. not requiring evacuation of firefighting personnel from incident site;

(c) involving ordnance not mounted on aircraft, but carried in trucks on an installation -- here the purpose would be to prevent explosion of the truck in a fire where there could be extensive collateral damage; and;

(d) not involving ordnance, but hazardous materials either on an aircraft or elsewhere on the installation, where the Robotic Firefighter might be sent in to survey the situation, and potentially to take counter measures, prior to dispatching personnel to the site.

B. DESIGNS INVESTIGATED

A number of conceptual designs were developed before selecting the most desirable concept. This concept is presented in the Concept Feasibility Review included in Appendix "A." Conceptual design robotic firefighting systems are generally broken down into two separate portions, the operator's control station and the remote firefighting vehicle. Although they are generally separate portions, they must be carefully integrated to provide an efficient deployment package.

1. Operator's Control Station

a. Portable Operator's Booth

This control station is presented in Figure 1. The operator(s) control the remote vehicle from a portable "room."

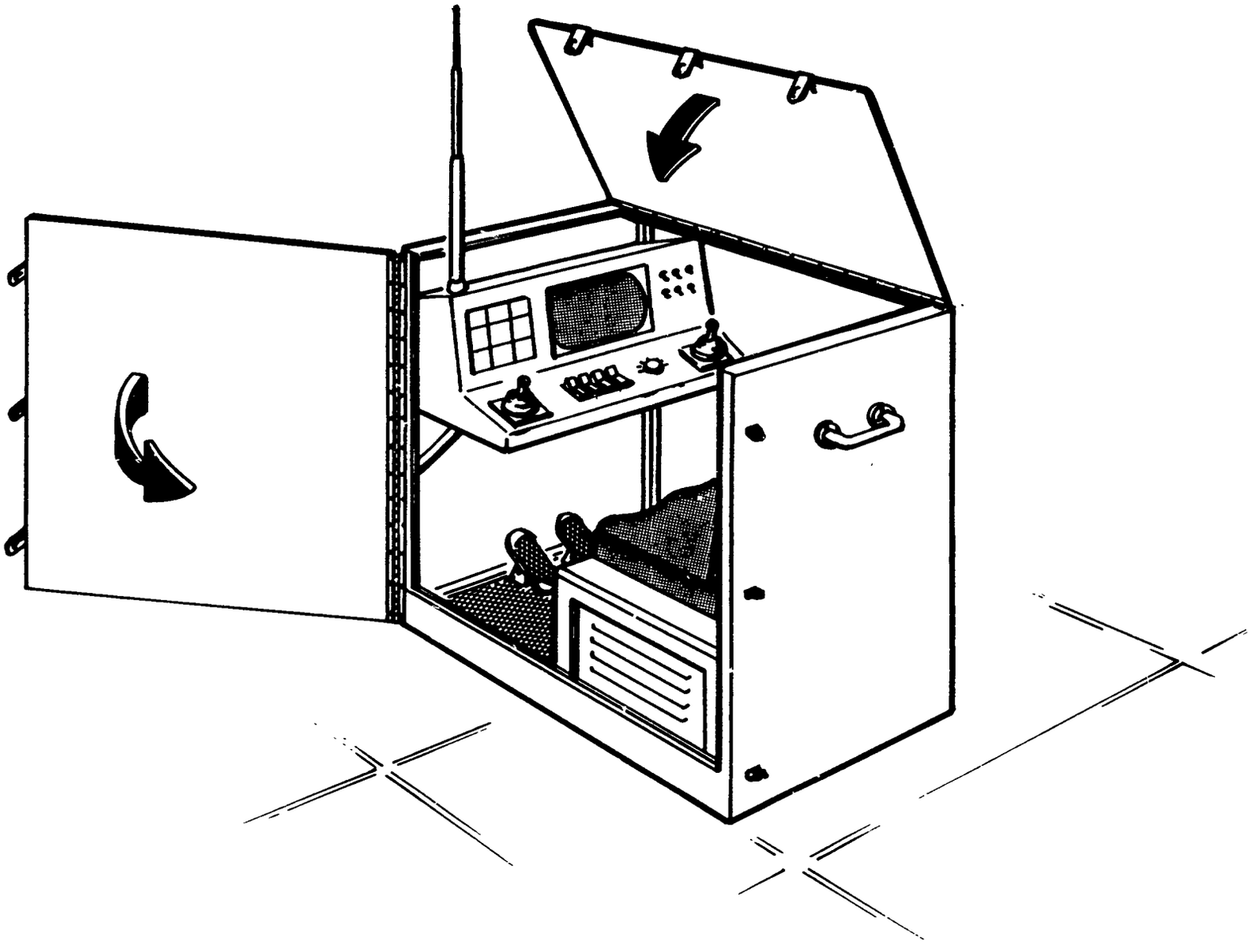

Figure 1. Portable Operator's Booth.

b. Portable Operator's Bench

This station shown in Figure 2 is operated by straddling the "bench" facing the monitor. This design offers good stability and light weight for a self-contained unit.

c. Portable Table Top Console

This concept is depicted in Figure 3. Multiple operators can use this portable system after placement on an available table top surface and deployment of the foot controllers. This unit would be the lightest and more versatile.

d. Portable Freestanding Two-Operator Station

Figure 4 shows a two-place unit which is freestanding with collapsible legs. A conventional diver's steering wheel and foot pedals are employed.

e. Towable Advanced Operator's Unit

This concept is displayed in Figure 5. Advance telepresence technology is employed for a maximization of state-of-the-art feed Insert Figure 1 back and control. Multiple monitors, stereoscopic vision, slave manipulation control for hand (firefighter nozzle) and head (firefighter camera(s)) are a number of the subsystems to be incorporated in this unit.

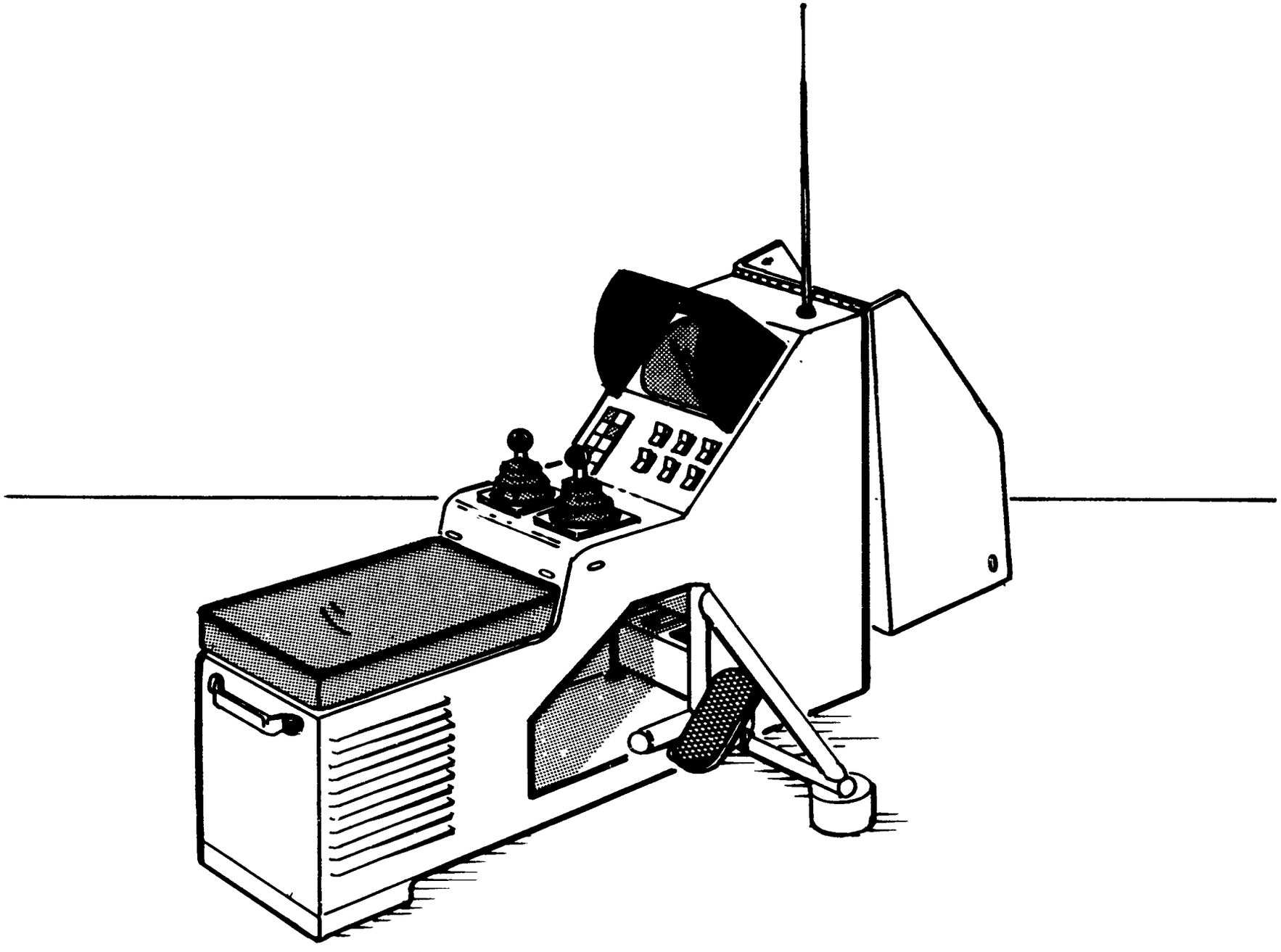

Figure 2. Portable Operator's Bench.

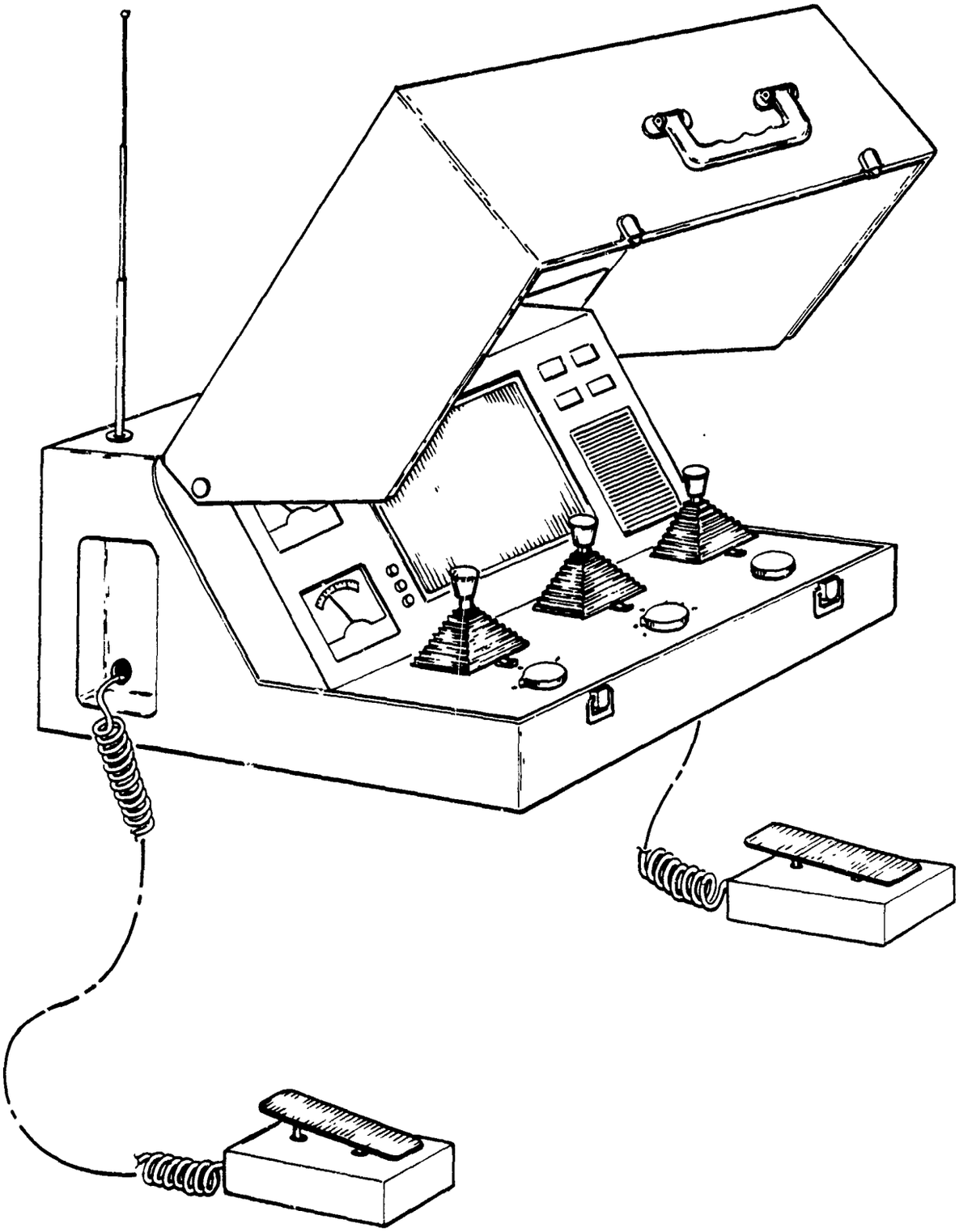

Figure 3. Portable Table Top Console.

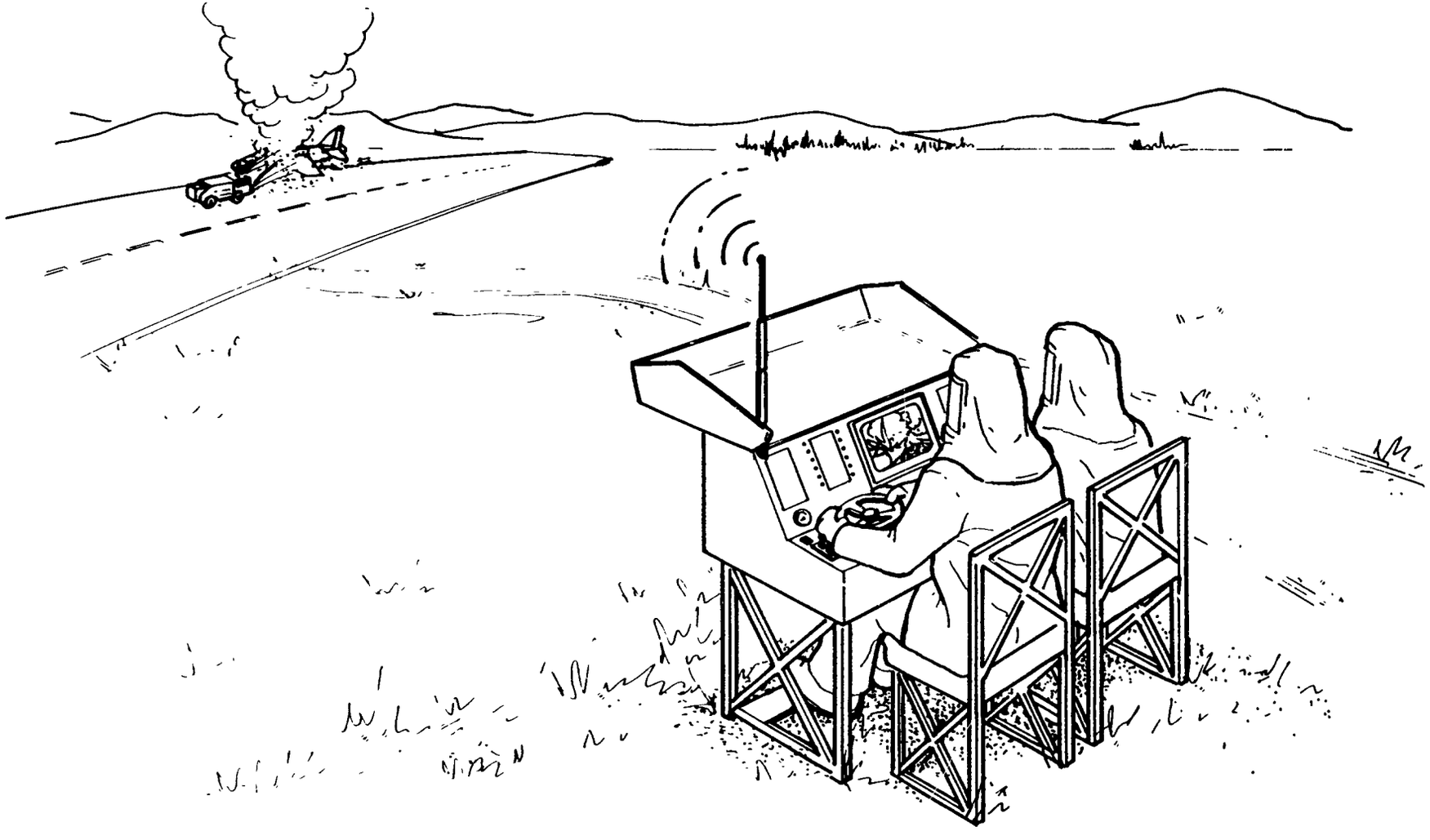

Figure 4. Portable Freestanding Two Operator Station.

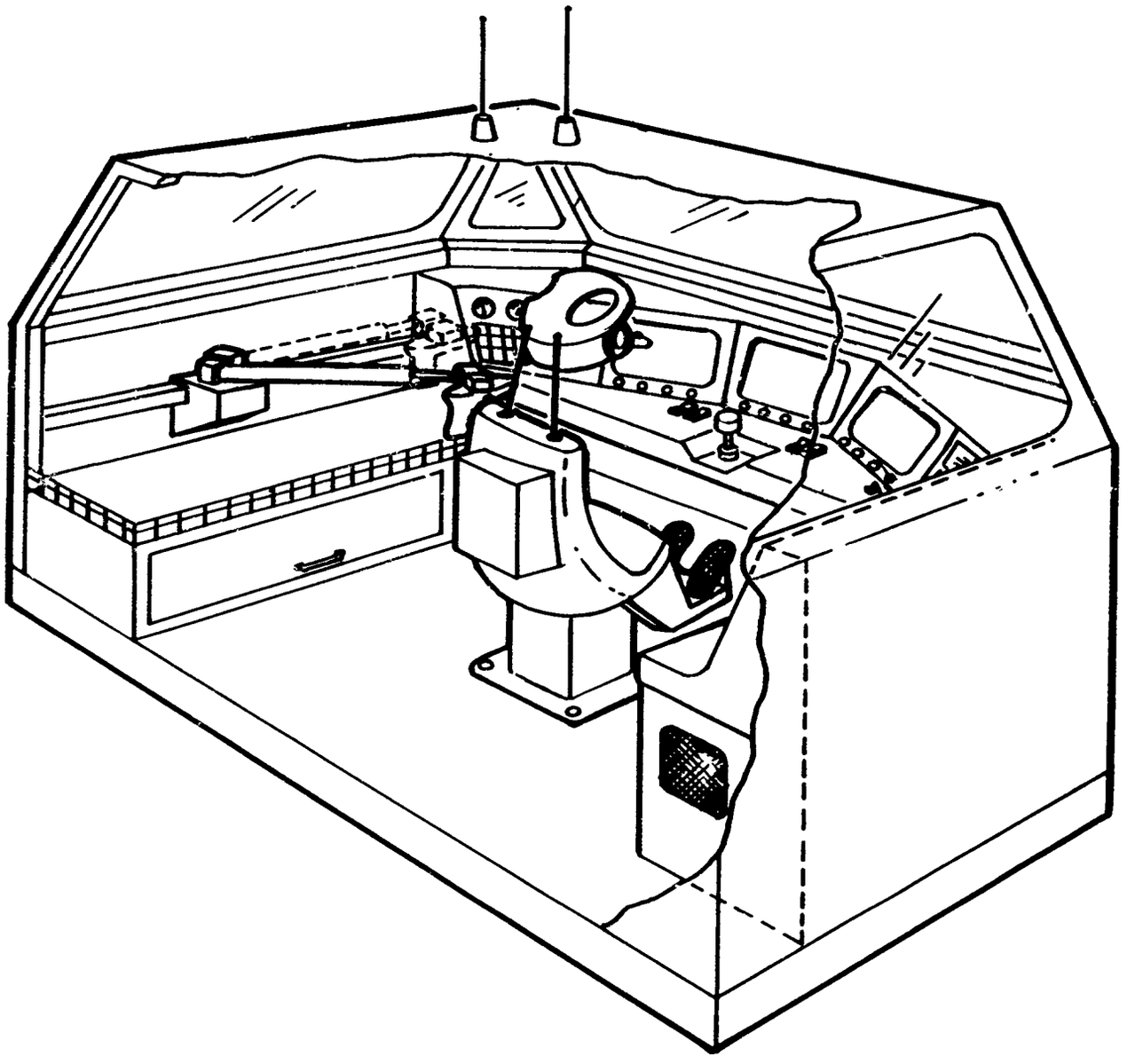

Figure 5. Towable Advanced Operators Unit.

2. Remote Firefighting Vehicle

a. Anthropomorphic Type Robotic Firefighter

An advanced tethered robotic firefighter supplied with firefighting agents and control signals, as shown in Figure 6, was studied. Motion platform, manipulator and optics are all current technology. Tether management for this type of system with an integral fluid hose was judged difficult. Development and production of such a special purpose seldom used system would be expensive.

b. Remotely Operated Firetruck with Auxiliary Agent Supply

Figure 7 depicts a P-19 (or P-4) fire truck remotely operated from a console as presented in Figure 2. The firetruck is nursed from a larger supply such as a P-2 tanker truck. For these conceptual studies, nursing was considered a requirement to provide the volume and rate of firefighting agent proscribed by the Air Force. The "safe" distance of remote operation was dictated by Insert Figure 6 the Air Force to be 2,000 feet to reduce risk to operators to the lowest practical. Figure 8 depicts the remotely operated firetruck close to a live weapons hazardous area. Figure 9 represents the same concept with the addition of a remote-controlled boom with a SPAAT® penetrator tool fixed at the end.

c. Special-Purpose Robot Units

Several variations of this theme were considered. Figure 10 indicates a six-wheeled unit transported to the deployment site in a towed-van unit which contains the operator's station. The robot unit pulls the hose trailer unit to an area near the fire. Upon disconnection, the base trailer unit deploys hard hose as required by vehicle movement.

Figure 11 shows a slightly different version where the robot unit tows the hose trailer unit to a safe location, drops off the control unit and proceeds into the hazardous area in the same manner as described for Figure 10.

Figure 12 indicates the general arrangement of the deployment pattern for equipment in Figures 10 and 11.

A radio-controlled unit without a nursing hose was investigated and is represented in Figure 13. The robot unit tows a self contained halon supply tank into proximity of the fire, proceeds to the aircraft, then installs the SPAAT® tool with an articulated boom and injects halon gas.

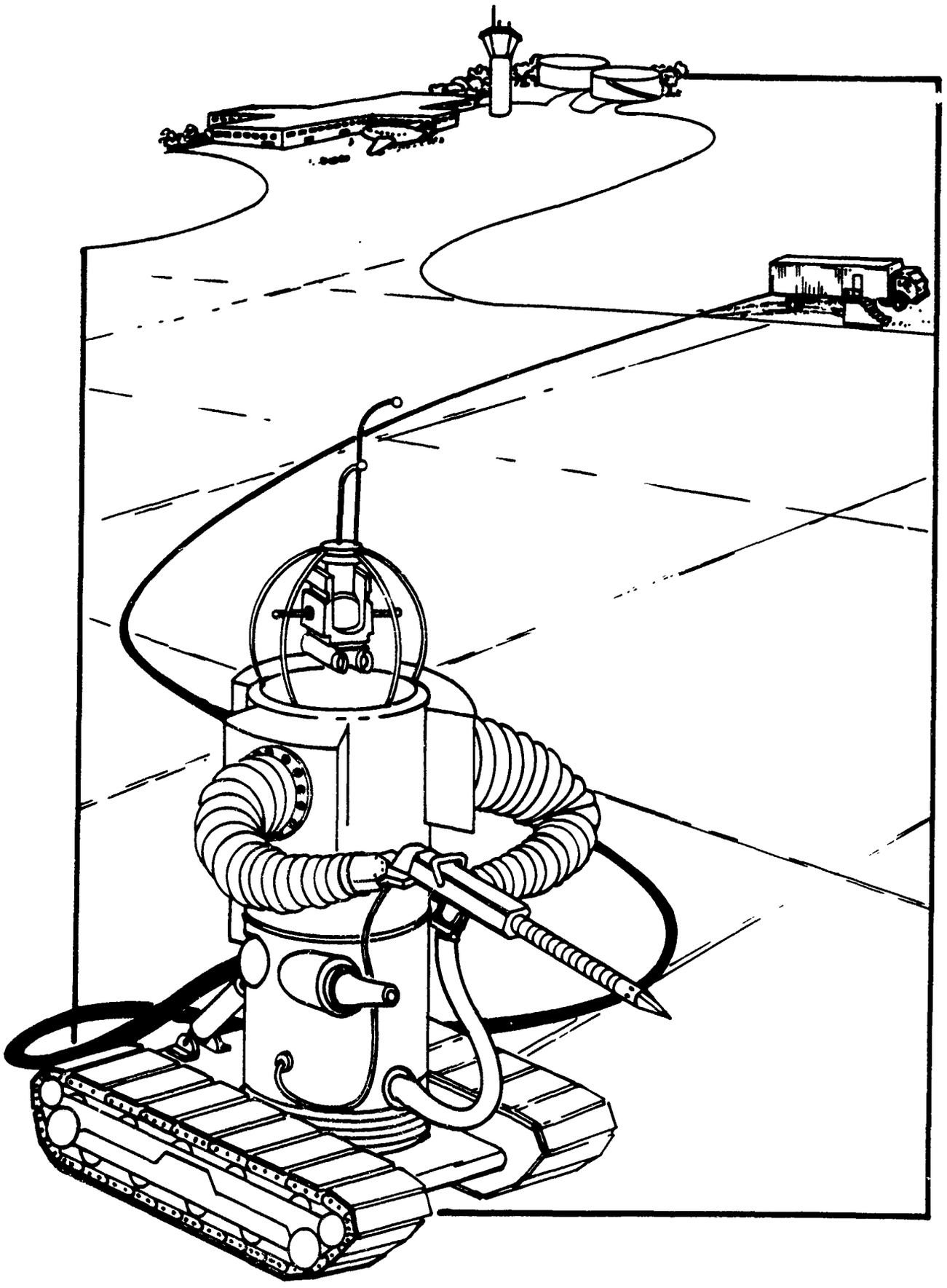

Figure 6. Anthropomorphic Robotic Firefighter.

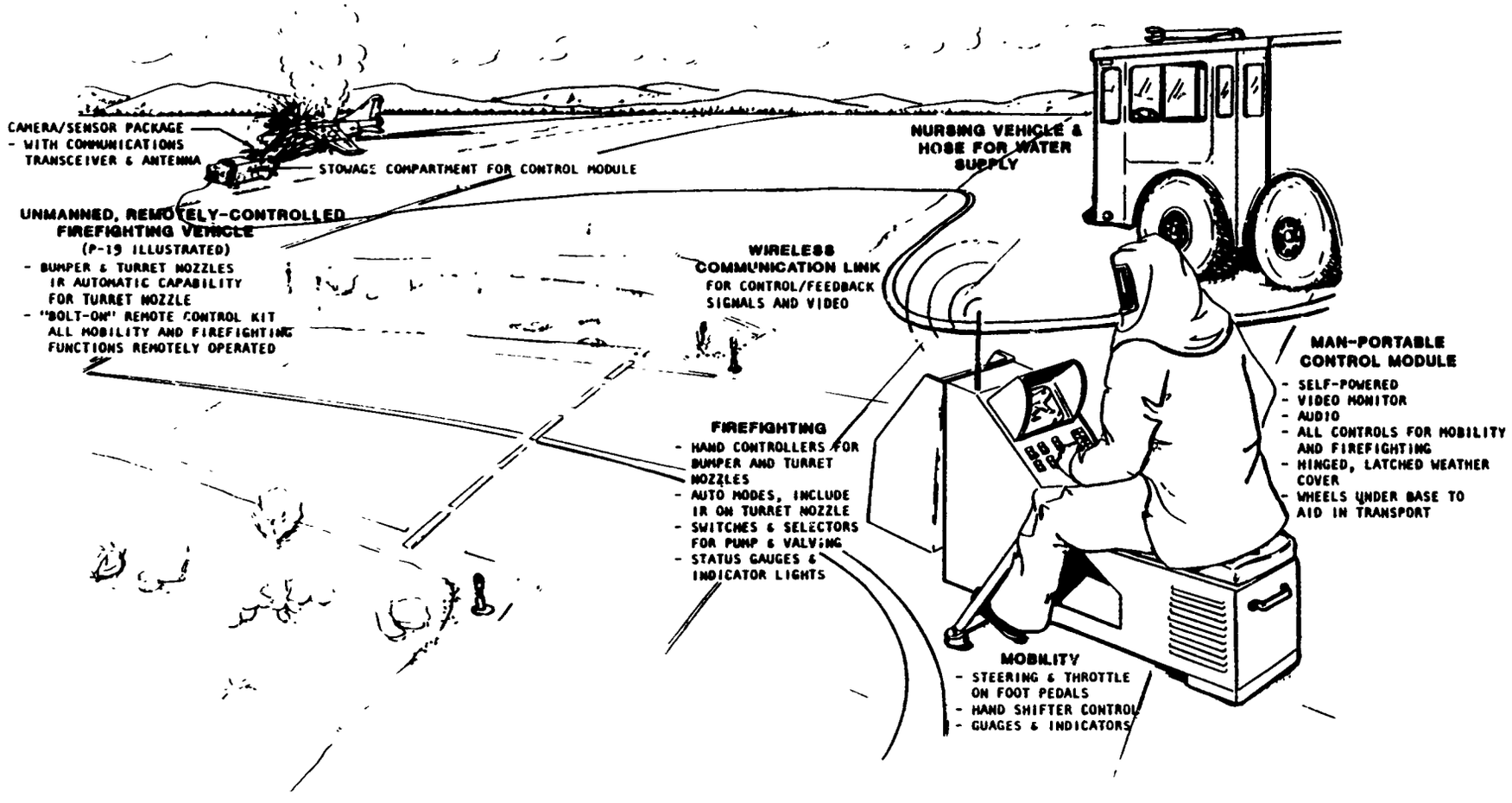

Figure 7. Firetruck (P-19) with Remote Agent Supply.

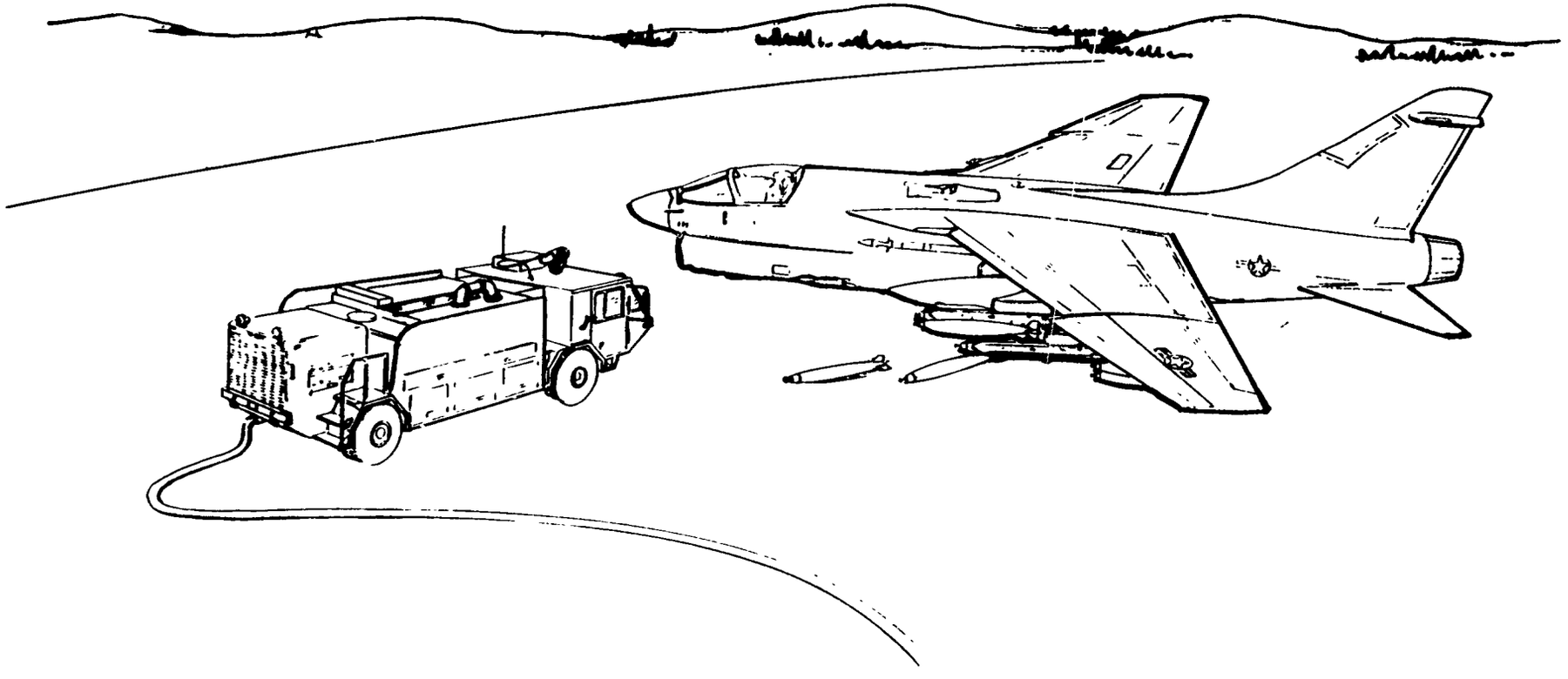

Figure 8. Nursed P-19 in Hazardous Area.

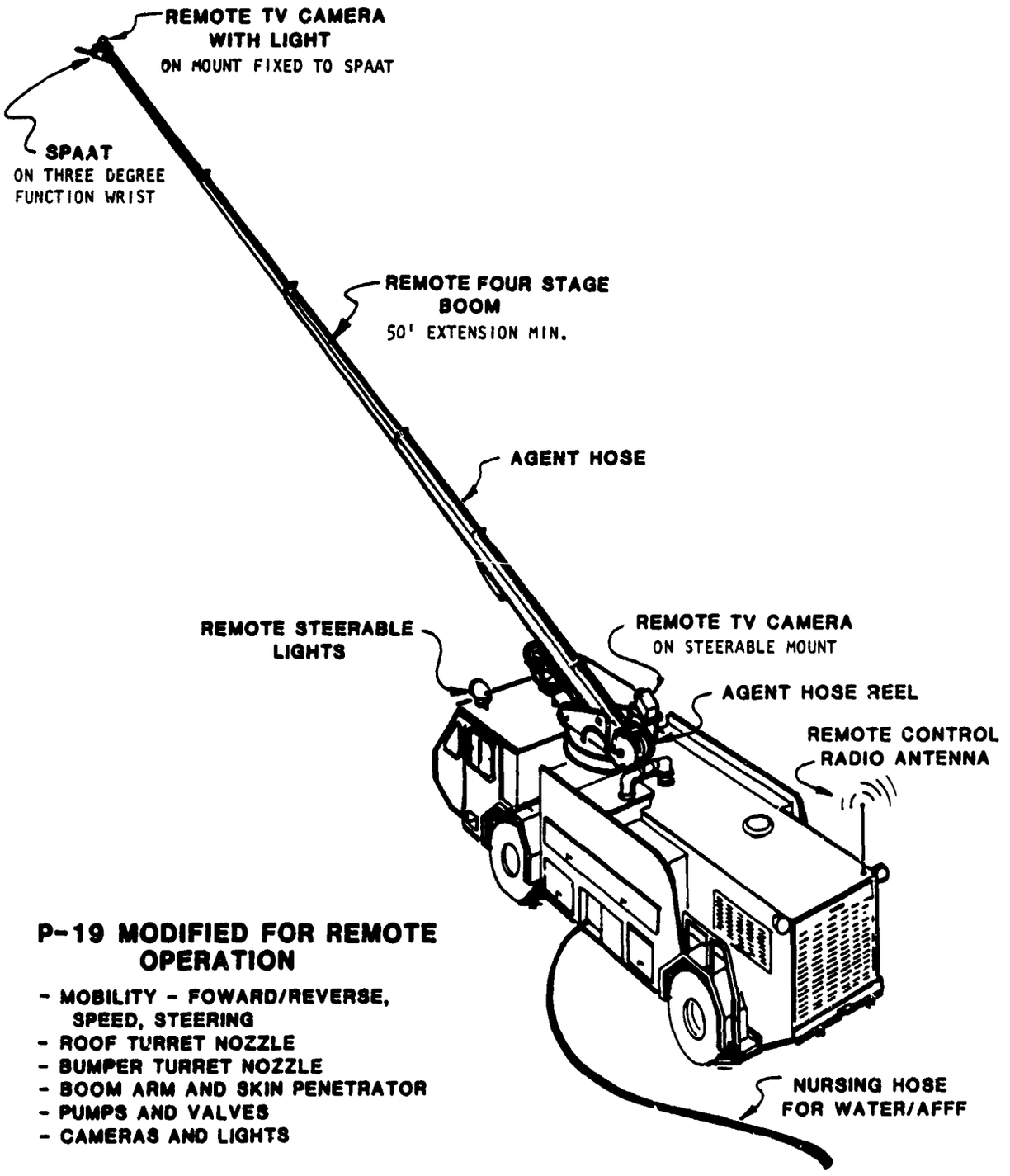

Figure 9. SPAAT Boom Option.

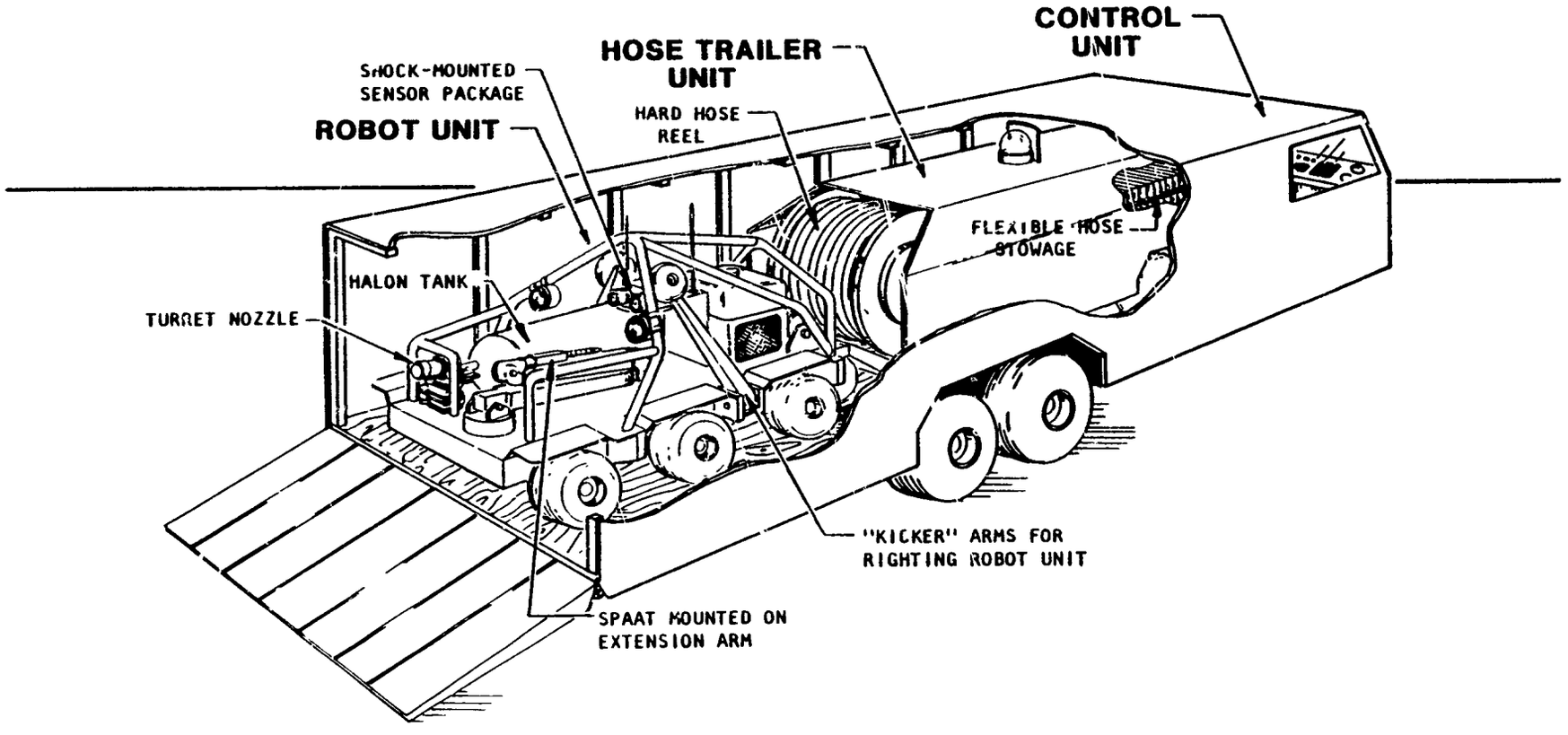

Figure 10. Towed Robotic Firefighter System.

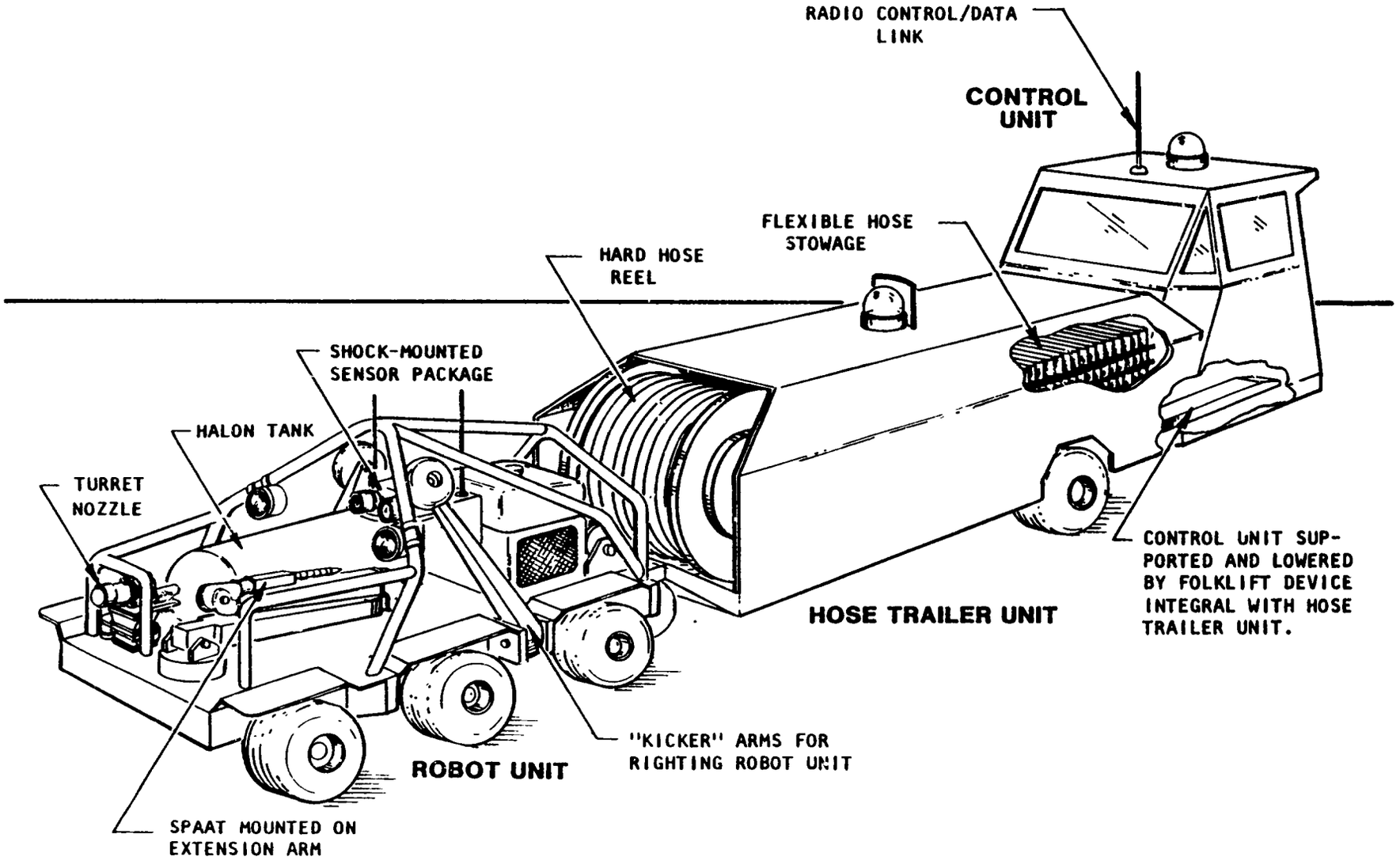

Figure 11. First Generation ROV Tractor System.

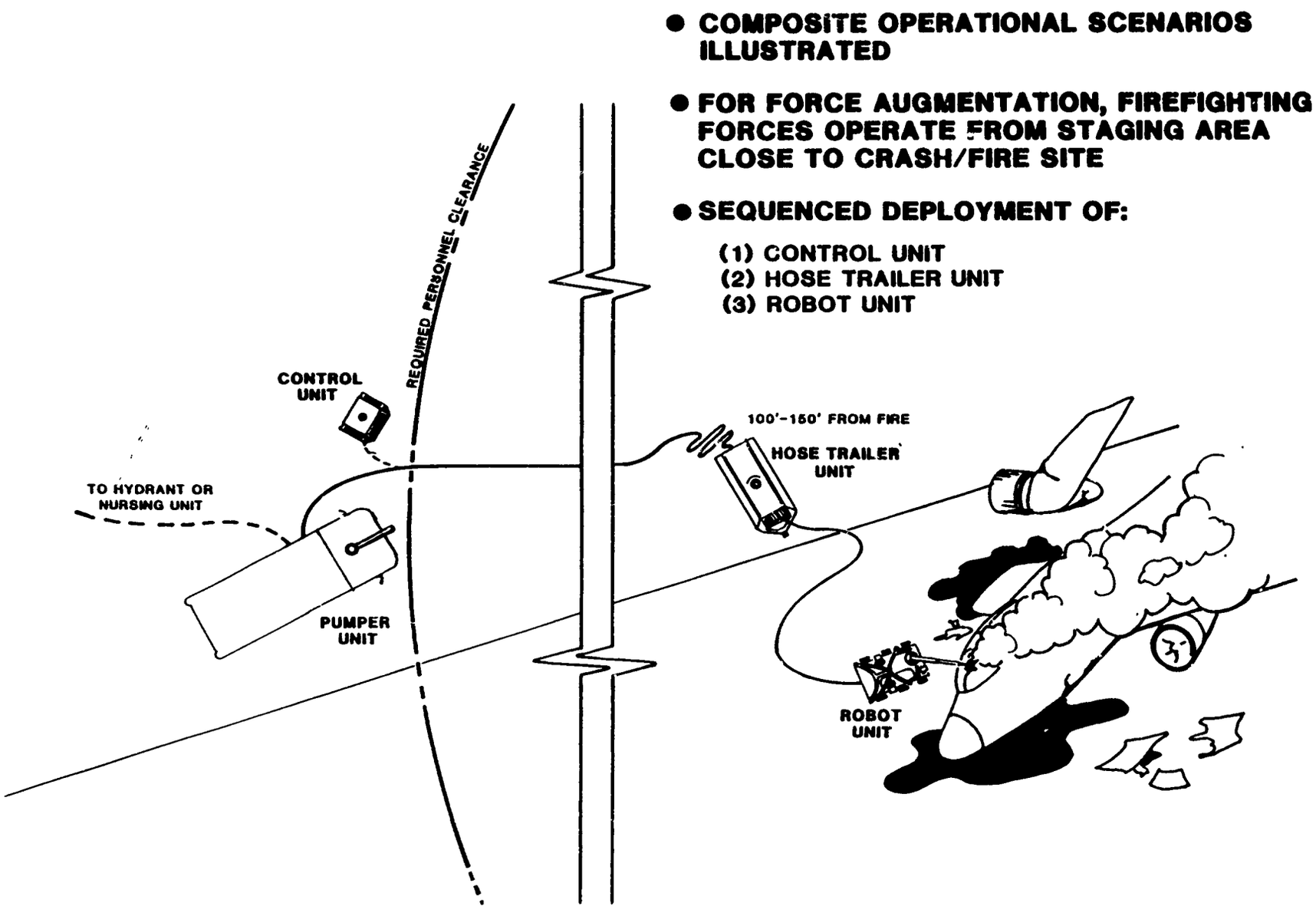

Figure 12. ROV Tractor System Deployment Pattern.

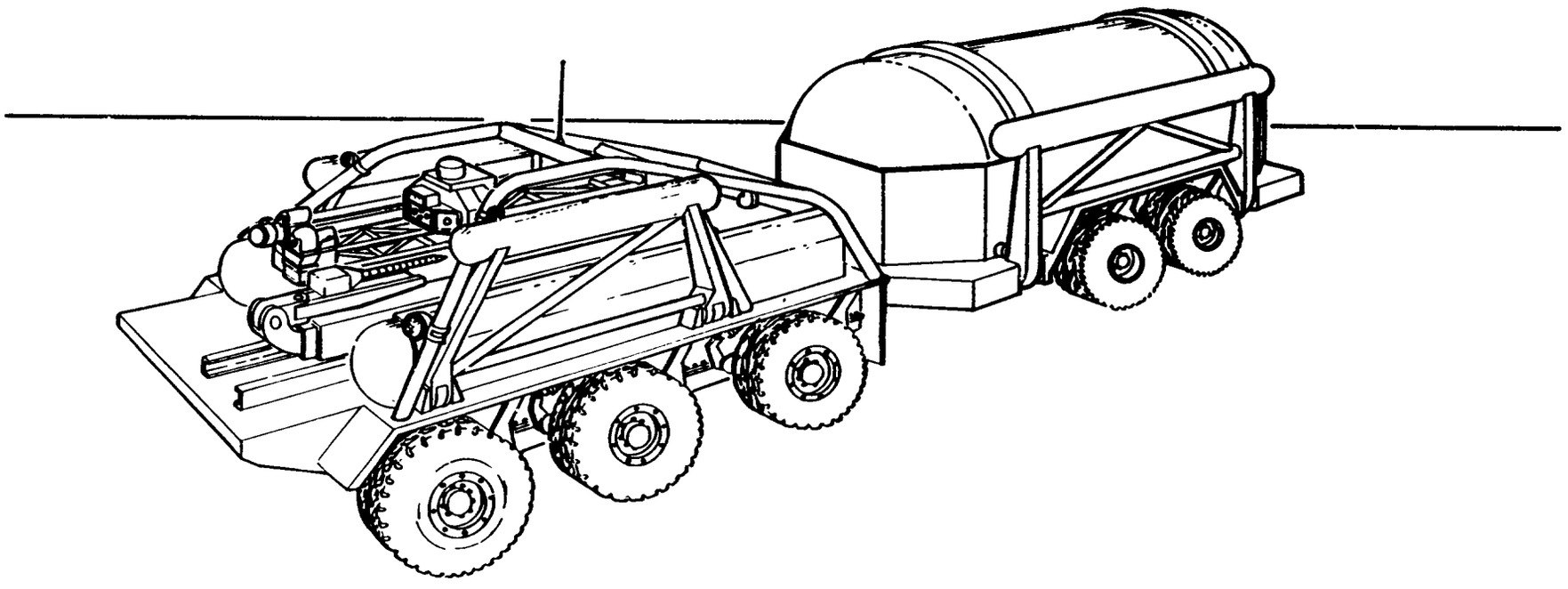

Figure 13. Self-Contained ROV Tractor/Halon Trailer System Option.

C. SELECTED CONCEPTUAL DESIGN

Figure 14 depicts the favored concept to deliver the fire extinguishing rates and volumes required. The robot unit is enhanced over previously presented concepts with "picker" bar arms and a more efficient arrangement of components. The nozzle is fitted on to an articulated boom which was added to improve nozzle location control. The deployment scheme is the same as described previously for Figure 11 and represented in Figure 12. The Concept Feasibility Review (CFR) included in the appendix provides further details about the favored concept and reasons for its selection.

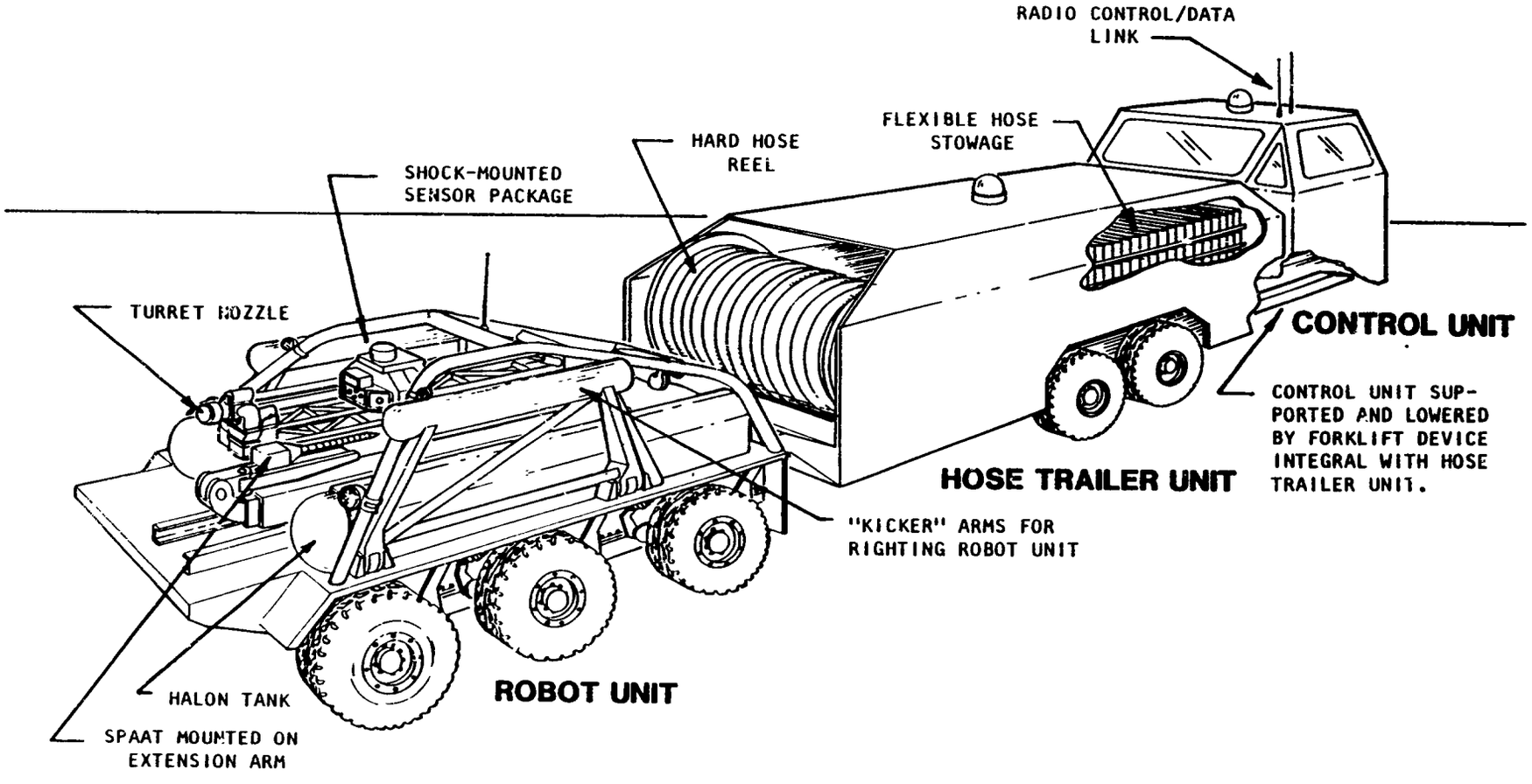

Figure 14. Second Generation ROV Tractor System.

SECTION III

DESIGN AND FABRICATION OF REMOTE CONTROLLED P-4 FDM

A. DESIGN

Common design practices were employed to size and select components. Schematics diagrams and installation sketches were created to guide FDM fabrication efforts. Figure 15 depicts an overall representation of the FDM remote firefighting system final design.

1. Selection Guidelines

Special considerations governed the selection of some of the major components and are noted in this section.

a. Steering Actuator

An actuator was selected with sufficient speed, torque and the capability to be back-driven. The back-driven feature allows the steering to be manually operated, and remotely controlled. An electric rotary actuator was chosen for ease of installation and control interfacing.

b. Brake, Throttle, Gear Shift Actuator

Electric linear actuators were selected for ease of installation, ease of control interfacing, and suitability to actuation motion required. The linear actuator with pull cable action of brake allows emergency local manual override. All three actuators were identical to minimize parts and spares. The brake pedal speed and force, as well as the gear shift stroke length, guided the selection of the actuator unit model. Position control driver cards were desired for feedback control purposes.

c. Remote Firefighting Nozzle

The FEECON remote control nozzle was selected to conform with original manual nozzle flange. Price and other features were attractive and approved by Air Force project management.

d. Video Cameras and Pan and Tilt unit

Video cameras, lenses and the pan and tilt unit were selected to provide acceptable viewing and performance. Strong consideration was given to those components which were available rental equipment and had reasonable costs for a short demonstration period.

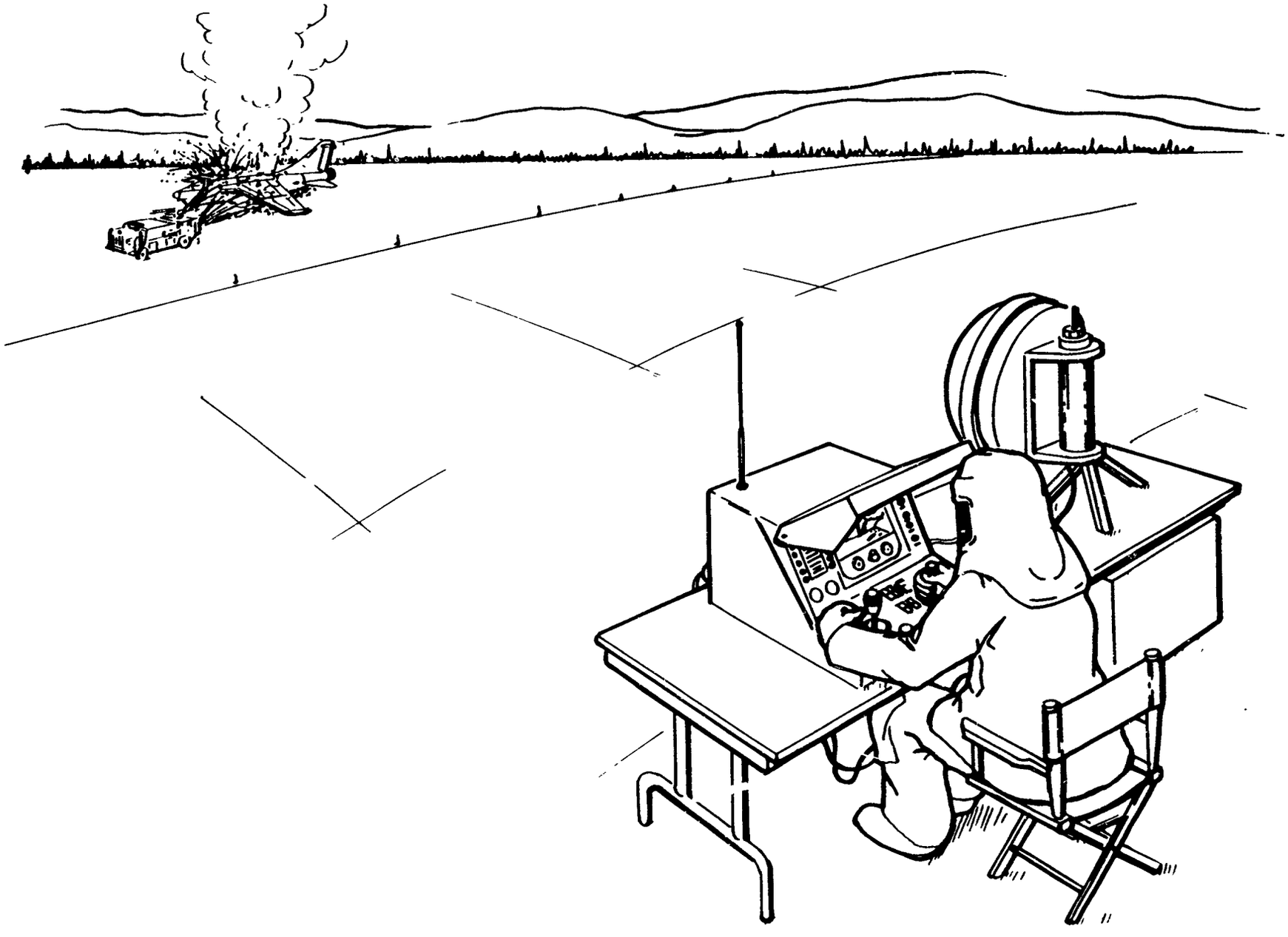

Figure 15. Remotely Operated Firetruck FDM.

e. Video Transmission System

A system was selected that was available for rentals at reasonable costs with a satisfactory range and frequency.

f. Data Transmission System

The Futaba radio transmitters were selected for suitable range, frequency, signal security, programmable signal loss shutdown sequence, reasonable cost and ease of adaptability to the AMETEK/ORED control console and vehicle control circuits.

g. Vehicle Status Indicator Display

The use of individual or a series of indicator lights viewed by the primary fixed video camera was employed to provide critical truck feedback.

B. FABRICATION

Brackets and mounts were fabricated in-house by AMETEK/ORED technicians. Component installations and electrical connections were performed, based on design sketches and schematic diagrams. Significant modifications were made to the data system units and cameras by the AMETEK/ORED technicians to adapt the commercial units to specific fire truck needs. Custom electrical circuits were also fabricated by AMETEK/ORED technicians.

C. DRAWINGS

Drawings were created to document the FDM design and to allow records of sufficient detail to re-create the FDM at some future date.

The following drawings are included for reference:

1. "Remotely-Operated Robotic Firefighter Vehicle CAB System Installation" D 01080-09011 Figure 16

2. "Remotely-Operated Firefighter Control Console Layout" D 01086-89002 Figure 17

3. "Remotely-Operated Robotic Firefighter RC System Functional Block Diagram Vehicle System" D 0180-09001 Figure 18

4. "Remotely-Operated Robotic Firefighter RC System Functional Block Diagram Control Console" D 01000-09002 Figure 19

5. "Remotely Operated Robotic Firefighter Vehicle Pneumatic Modifications" D 01080-09012 Figure 20

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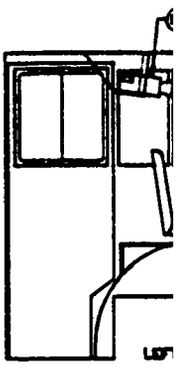
ITEM NO.	DESCRIPTION	MANUFACTURER PART NO.
1	PARKING BRAKE ELECT/PNEU. VALVE	KIP NO. 651134
2	PARKING BRAKE ELECT/PNEU. VALVE	KIP NO. 651164
3	WINDSHIELD SPRAY ELECT/PNEU. VALVE	KIP NO. 651116
4	WINDSHIELD WIPER ELECT/PNEU. VALVE	KIP NO. 651116
5	AGENT SELECT,WATER ELECT/PNEU. VALVE	KIP NO. 651134
6	AGENT SELECT,FOAM ELECT/PNEU. VALVE	KIP NO. 651134
7	GEARSHIFT ACTUATOR-BALLSCREW	INDUSTRIAL DEVICES NO. 15D-06050-06-MP2-FC2-LP0-6"
8	STEERING GEARMOTOR	PMI NO. U12FG-82.731
9	THROTTLE ACTUATOR-BALLSCREW	INDUSTRIAL DEVICES NO. 15D-06050-06-MP2-FC2-LP0-6"
10	BRAKE ACTUATOR-BALLSCREW	INDUSTRIAL DEVICES NO. 15D-06050-06-MP2-FC2-LP0-6"
11	CAMERA PAN&TILT MECHANISM	QUICKSET NO. QPT30-24
12	SYSTEM AIR PRESS.-SWITCH	DELAVAL/BARKSDALE NO. D1H-A150 (120 PSD
13	ENGINE OIL PRESS.-SWITCH	STANDARD MOTOR PROD. NO. PS-149X(4.5-7.5 PSD
14	ENGINE WATER TEMP.-SWITCH	STANDARD MOTOR PROD. NO. TS-50(273-293 F)
15	WATER PUMP PRESS.-SWITCH	DELAVAL/BARKSDALE NO. B1S-H12 (250 PSD
16	FOAM TANK LEVEL-PRESS. SWITCH	DELAVAL/BARKSDALE NO.
17	WATER TANK LEVEL-PRESS. TRANSDUCER	MICROSWITCH NO. 242PC05G (0-1.45 PSD
18	HYDRAULIC PRESSURE-SWITCH	DELAVAL/BARKSDALE NO. R1S-H12 (500 PSD
19	PAN & TILT VIDEO CAMERA	RCA NO. CLC025
20	FIXED VIDEO CAMERA	JVC NO. GR-C1U
21	VIDEO TRANSMITTER	R.F. TECHNOLOGY NO. RF200 RECEIVER R.F. TECHNOLOGY NO. RF203 TRANSMITTER
22	ROOF TURRET NOZZLE	FEECON NO. 01460040
23	PAN & TILT CAMERA CONVERTER	RECOTON NO. V 800 A
24	SHIFT ACTUATOR DRIVER CARD	INDUSTRIAL DEVICES NO. AC2002B
25	THROTTLE ACTUATOR DRIVER CARD	INDUSTRIAL DEVICES NO. AC2002B
26	BRAKE ACTUATOR DRIVER CARD	INDUSTRIAL DEVICES NO AC2002B
27	STEERING ACTUATOR DRIVER CARD	PMI NO. VXA-24 VDC-8 AMP
28	MOTOR START RELAY	POTTER & BRUMFIELD NO. KRPA11VG,24 VDC
29	MOTOR STOP RELAY	POTTER & BRUMFIELD NO. KRPA11VG,24 VDC
30	VIDEO SWITCH RELAY	ALLIED CONTROL NO. 244W
31	DATA/CONTROL SYSTEM RECEIVERS	FUTABA NO. 8SGA/PCM (REF)

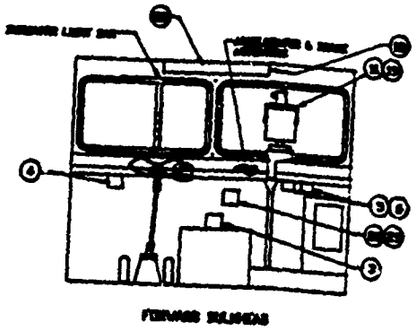
NOTES:

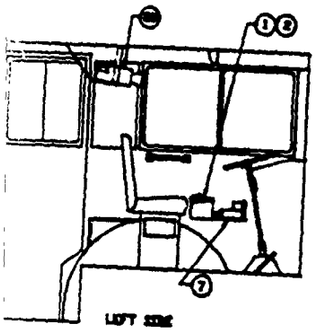
1) ITEM 12 MOUNTED AT MAIN AIR TANK
2) ITEM 13,14 MOUNTED ON ENGINE
3) ITEM 31 MOUNTED AT BASE OF ANTENNA ON ROOF OF CAB

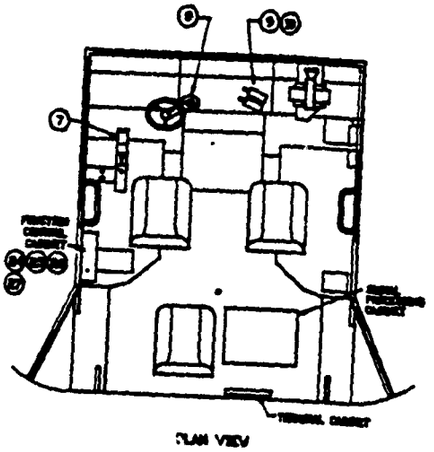


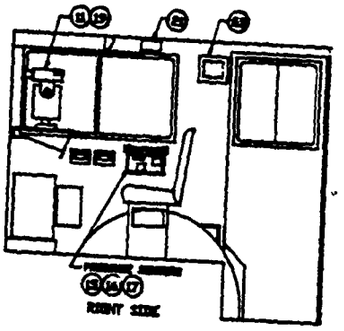
NEXT ASSEMBLY		AME
DWG NO. / TITLE		
DRAWN JARRETT	DATE	TITLE REMOTELY-OPERATED VEHICLE CAB SYS
CHECK		
DESIGN		
ENGR APPR		SIZE D / PROJECT NO. 108 / DRAWING NO. D-
APPROVED		SCALE NONE / FIRETRUK

MAIN AIR TANK
ON ENGINE
BASE OF
F CAB









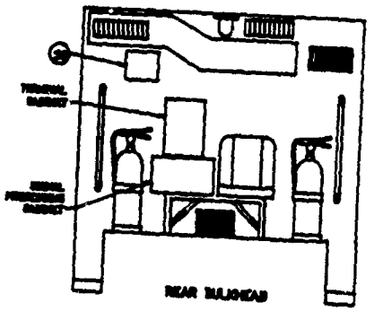


FIGURE 16.

AMETEK	
OPERATED ROBOTIC FIREFIGHTER CAB SYSTEM INSTALLATION	
DRAWING NO. D-01080-09011	REV
FIRETRUK FT-8	SHEET 1 OF 1

ROBOTIC FIREFIGHTER
CAB INSTALLATION

PAGE 35

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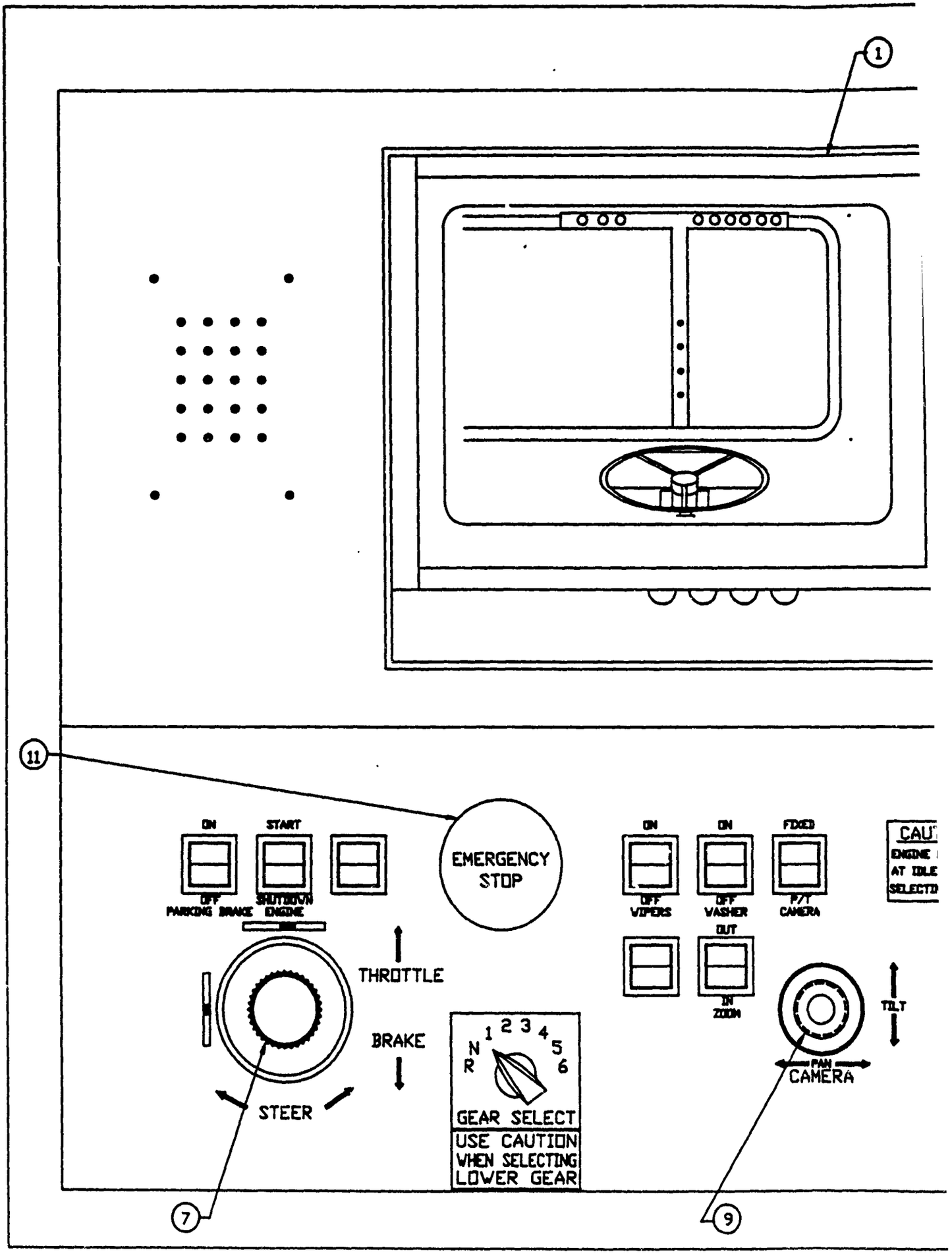
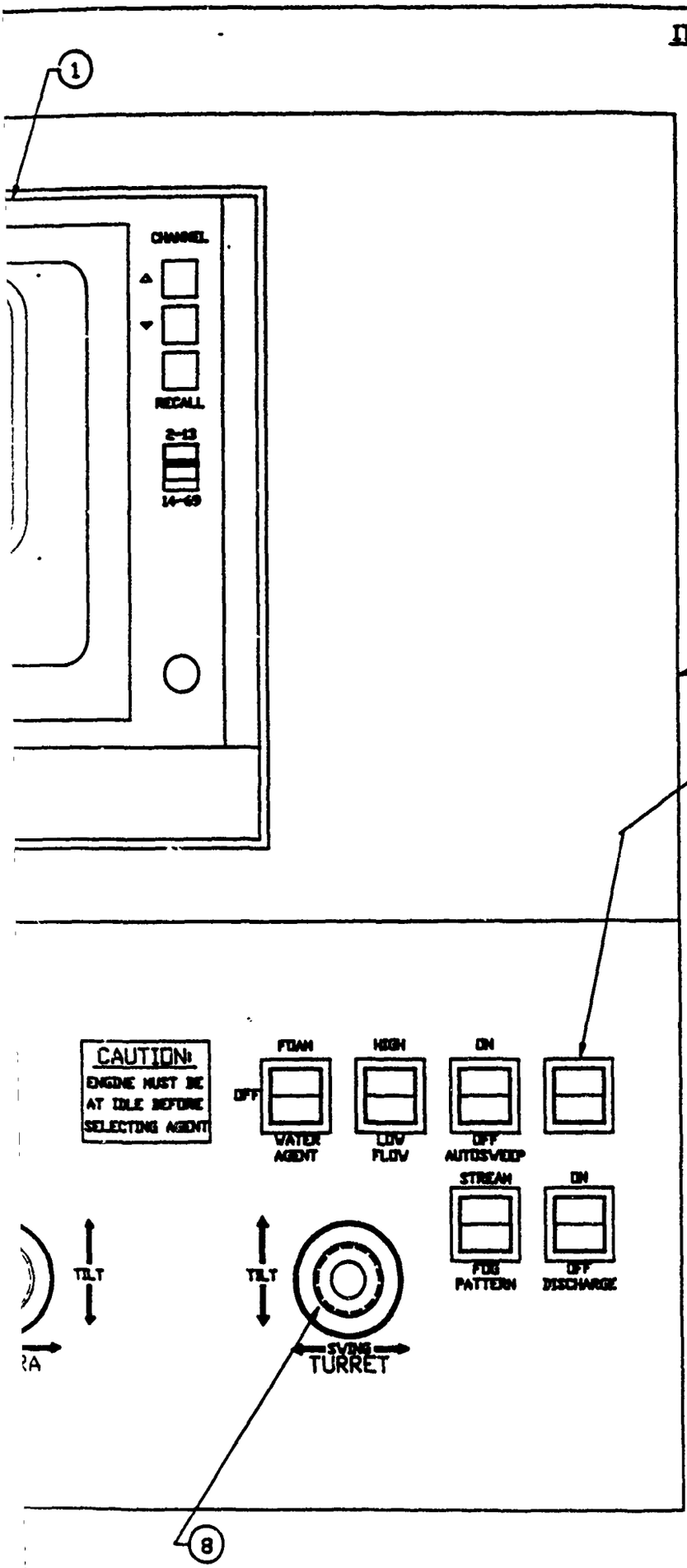

1
11
ON
START
OFF
PARKING BRAKE
SHUTDOWN
ENGINE
EMERGENCY
STOP
ON
ON
FIXED
OFF
WIPERS
OFF
WASHER
P/T
CAMERA
CAU
ENGINE
AT IDLE
SELECTO
OUT
IN
ZOOM
THROTTLE
BRAKE
STEER
TILT
PAN
CAMERA
N
R
1
2
3
4
5
6
GEAR SELECT
USE CAUTION
WHEN SELECTING
LOWER GEAR
7
9



ITEM NO.	DESCRIPTION	MANUFACTURER	PART NO.
1	TV RECEIVER	RCA NO. EHR295E	
2	CONTROL TRANSMITTER	FUTABA NO. 8SGA/PCM	
3	CONTROL TRANSMITTER	FUTABA NO. 8SGA/PCM	
4	CONTROL TRANSMITTER	FUTABA NO. 8SGA/PCM	
5	COMMUNICATION BAND AUDIO/VIDEO RECEIVER	REF 1	
6	DISH RECEIVING ANTENNA	REF 1	
7	STEER/THROTTLE/BRAKE JOYSTICK	POTENTIOMETER CH PRODUCTS NO. S30CL080C	
8	TURRET JOYSTICK-ON/OFF	BURGESS NO. J74,111,213	
9	CAMERA JOYSTICK-ON/OFF	BURGESS NO. J74,111,213	
10	ROCKER SWITCH-MOMENTARY & SNAP ACTION	C AND K PRODUCTS 5100 SERIES	
11	EMERGENCY STOP SWITCH-MOMENTARY MUSHROOM BUTTON	MICROSWITCH NO. TPM23E	

(2)(3)(4)(5)

(6) NOT SHOWN

(10)

(8)

NEXT ASSEMBLY / DWG NO. / TITLE	AMETEK	
DRAWN JARVIT / DATE	TITLE: REMOTELY-OPERATED ROBOTIC FIREFIGHTER CONTROL CONSOLE LAYOUT	
CHECK		
DESIGN		
ENGR APPR	SIZE: D / PROJECT NO.: 108 / DRAWING NO.: D-01080-09009	REV
APPROVED	SCALE: NONE / FIRETRUK\FT-3	SHEET 1 OF 1

REFERENCE DRAWINGS

1) D-01080-09011 REMOTELY-OPERATED ROBOTIC FIREFIGHTER VEHICLE CAB SYSTEM INSTALLATION

FIGURE 17.

ROBOTIC FIREFIGHTER CONTROL CONSOLE

PAGE 37

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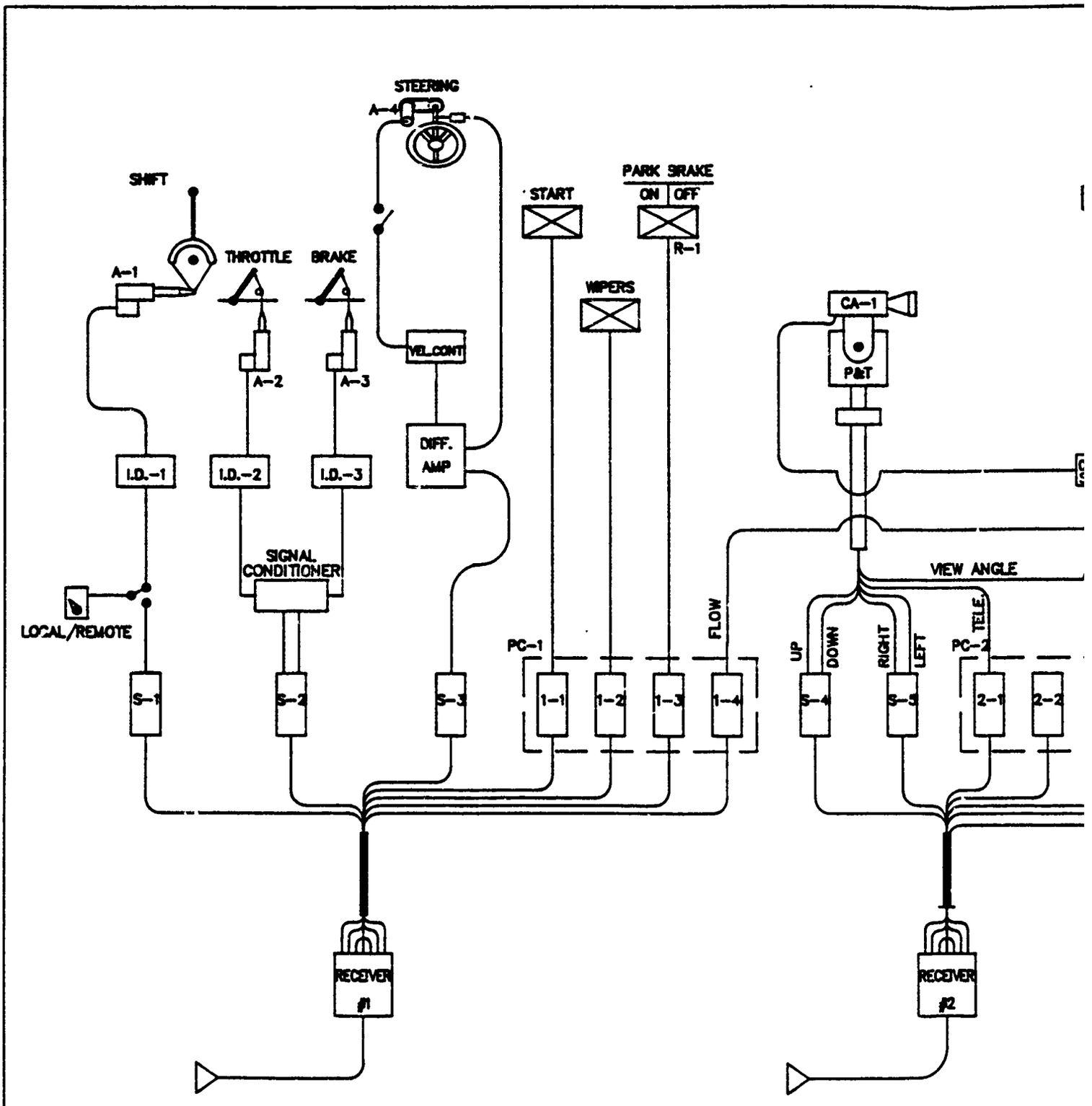
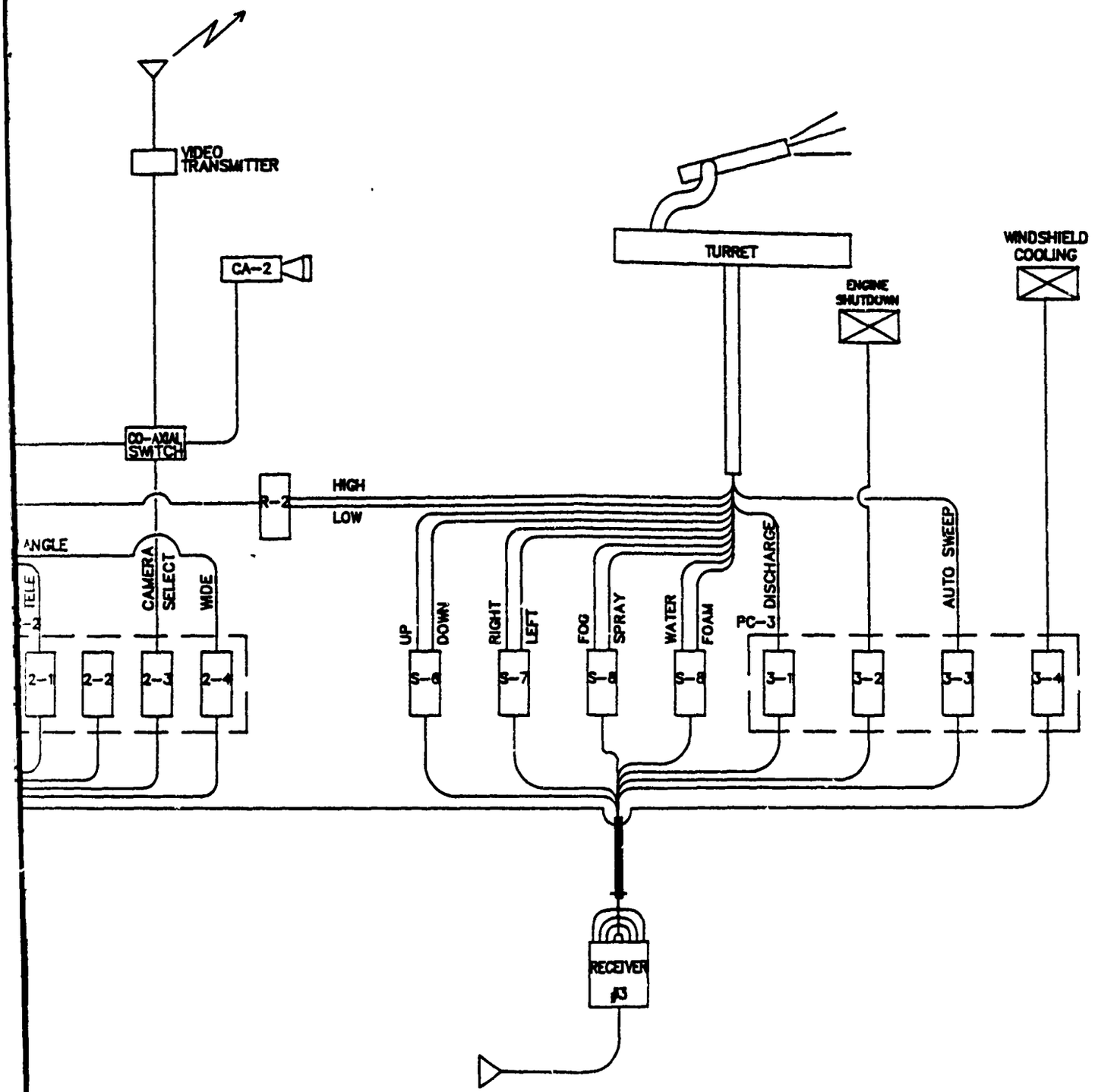


NEXT ASSEMBLY DWG NO. TITLE	AMETEK OFFSHORE TOWER & SUBSEA DIVISION	
DRAWN JARRETT	DATE	TITLE REMOTELY-OPERATED ROBOTIC FIREFIGHTER RC SYSTEM FUNCTIONAL BLOCK DIAGRAM VEHICLE SYSTEM
CHECK		
DESIGN		
ENGR RLSE		SIZE D · PROJECT NO. 108 · DRAWING NO. D-01080-09001 · REV
APPROVED		SCALE NONE · FIRETRUK\FT-1 · SHEET 1 OF 1



TIONS

TURRET FUNCTIONS

FIGURE 18.

ROBOTIC FIREFIGHTER VEHICLE SYSTEM

PAGE 39

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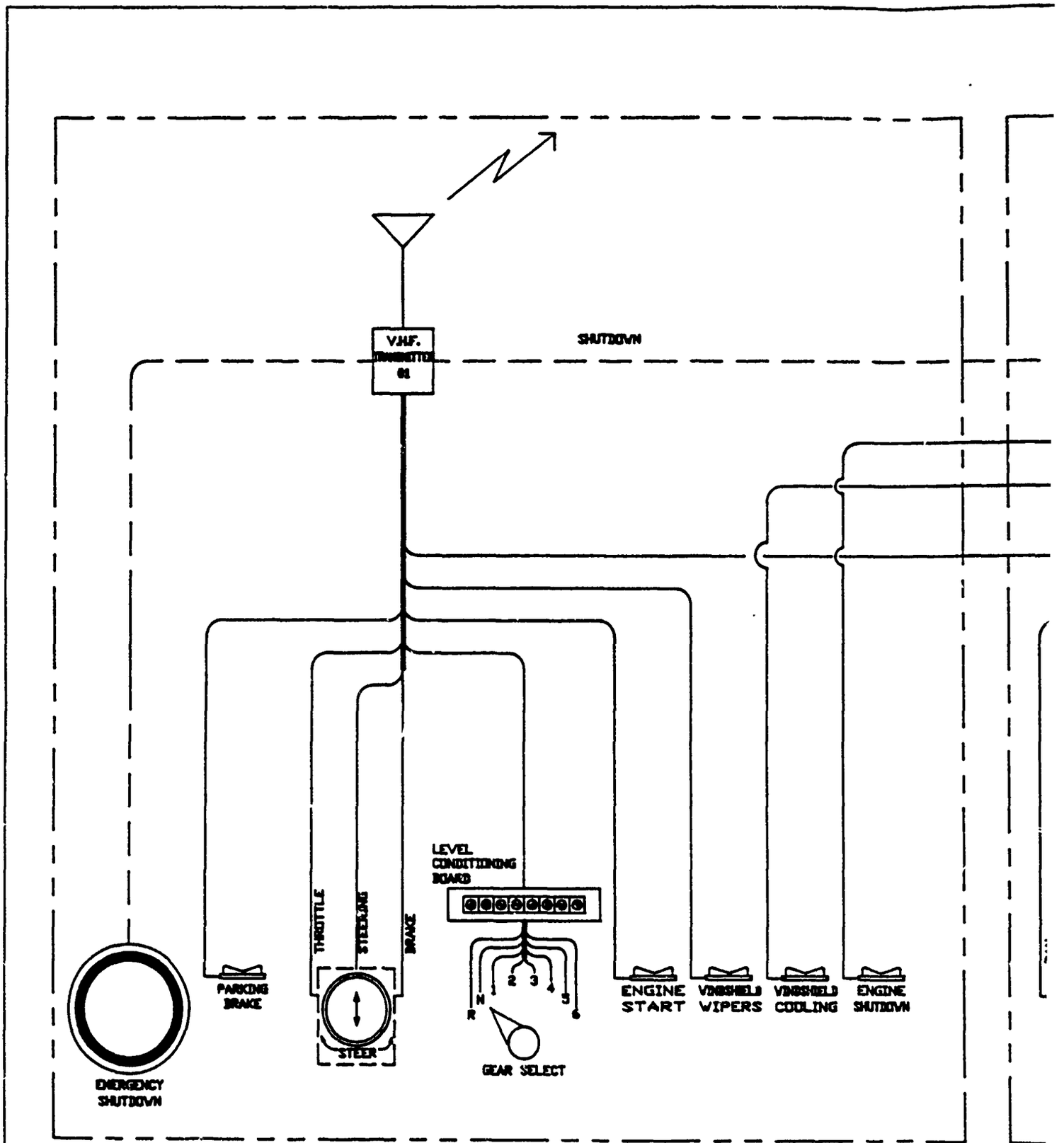

VEHICLE CONTROL

NEXT ASSEMBLY DWG NO. TITLE	AMETEK SPECIAL SYSTEMS DIVISION	
DRAWN JARRETT	DATE	TITLE REMOTELY-OPERATED ROBOTIC FIREFIGHTER RC SYSTEM FUNCTIONAL BLOCK DIAGRAM CONTROL CONSOLE
CHECK		
DESIGN		
USED ON		SIZE D · PROJECT NO. 108 · DRAWING NO. D-01080-09002 · REV
APPROVED		SCALE NONE · FIRETRUK/FT-4 · SHEET 1 OF 1

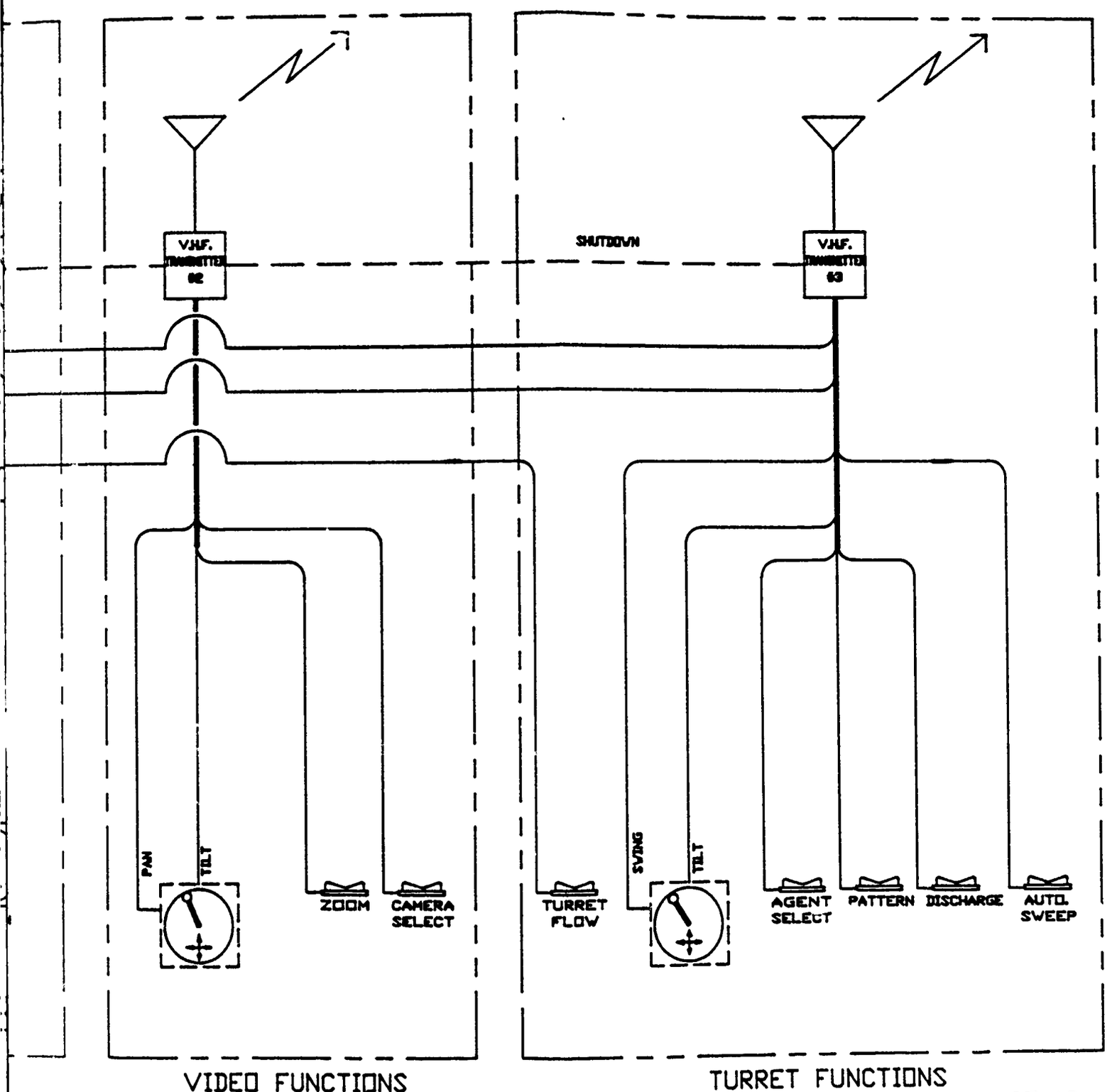

FIGURE 19.

ROBOTIC FIREFIGHTER CONTROL CONSOLE

PAGE 41

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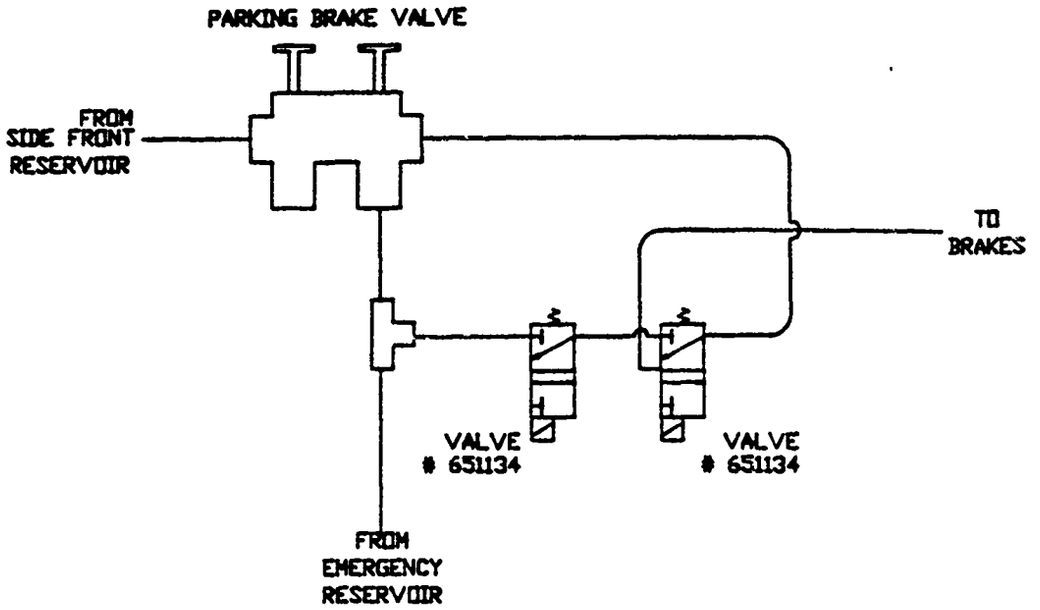
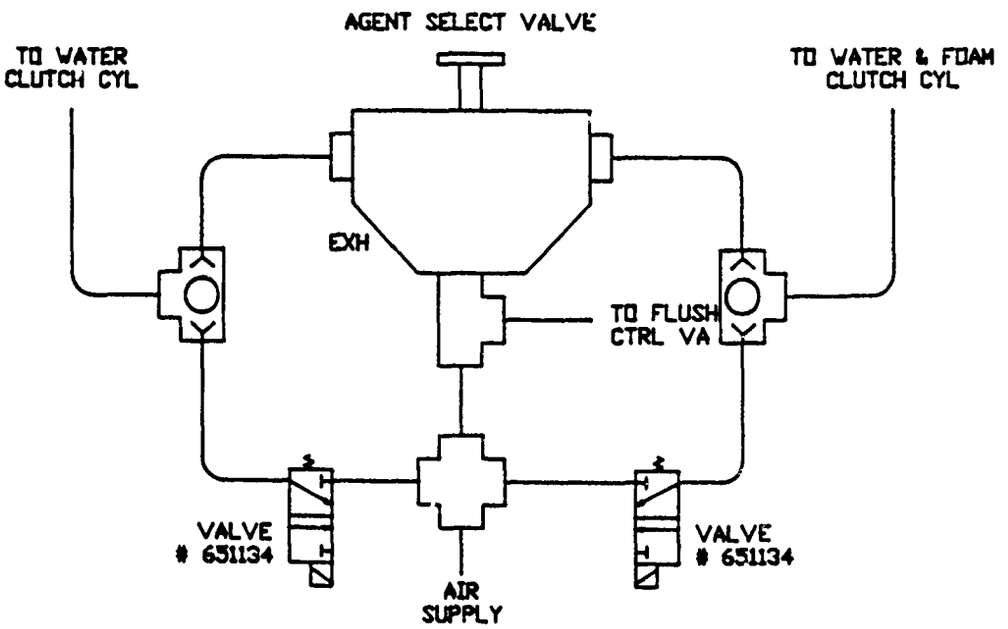
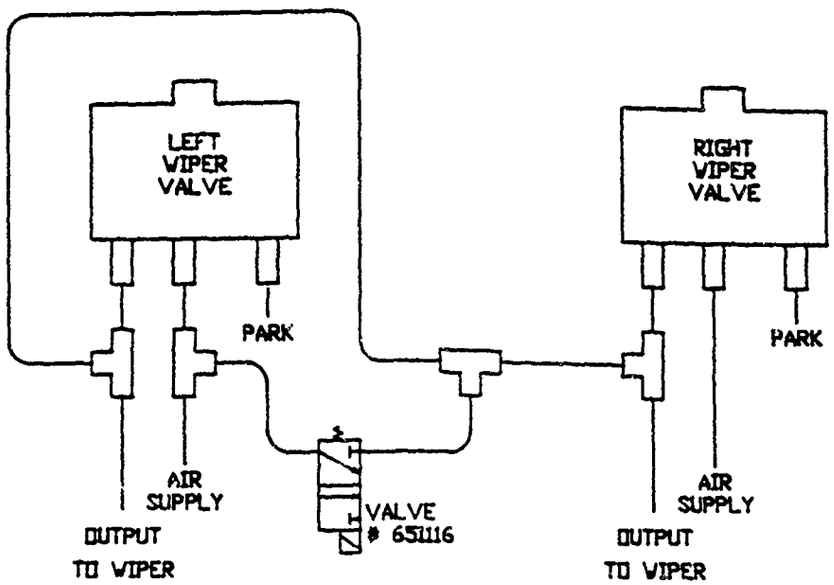


PARKING BRAKE



AGENT SELECT



WINDSHIELD WIPERS

REFERENCE DRAWINGS

1) D-01080-09011 REMOTELY OPERATED
ROBOTIC FIREFIGHTER VEHICLE
CAB SYSTEM INSTALLATION

FIGURE 20.

NEXT ASSEMBLY		AMETEK
DRAWN JARRETT	DATE	TITLE REMOTELY-OPERATED ROBOTIC FIREFIGHTER PNEUMATIC MODIFICATIONS
CHECK		SIZE D · PROJECT NO. 108 · DRAWING NO. D-01080-0901? · REV
DESIGN		SCALE NONE · FIRETRUK\FT-7 · SHEET 1 OF 1
ENGR RLSE		
APPROVED		

ROBOTIC FIREFIGHTER
PNEUMATIC MODIFICATIONS
PAGE 43

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D. PHOTOGRAPHS

The following photographs document the details of the remote control component installations. Manufacturer and model numbers are provided in drawings section 3.3.

1. Modified P-4 Firetruck (Figure 21)

Antennas 1,2,3 are the receivers for multiple commercial transmitters used to collect all data directed at the firetruck. Antenna 4 with the small disc tip is the video transmitting antenna for sending all information to the control console. The replacement FEECON nozzle is shown.

2. Remote Controlled Nozzle Assembly (Figure 22)

a. Location

In cab roof where manual turret was located. Bolt on replacement.

b. Use

To allow the nozzle to be remotely operated.

3. Remote Controlled Nozzle Details (Figure 23)

a. Electro/Hydraulic Valves

b. Gear Assembly for Swing (left/right)

c. Delivery Rate Actuator (low/high)

d. Spray Pattern Actuator (fog/stream)

e. Vertical Direction Actuator (up/down)

4. Brake and Throttle Actuators (Figure 24)

a. Location Cab dashboard center. Under AMETEK/ORED fabricated panel.

b. Use

Two electrical actuators position cables to activate brake and throttle pedals. Position feed back poteniometers on actuators supply information to driver cards. Cable drives to standard foot pedal assemblies allow manual and remote control.

Figure 21. Modified P-4 Firetruck.

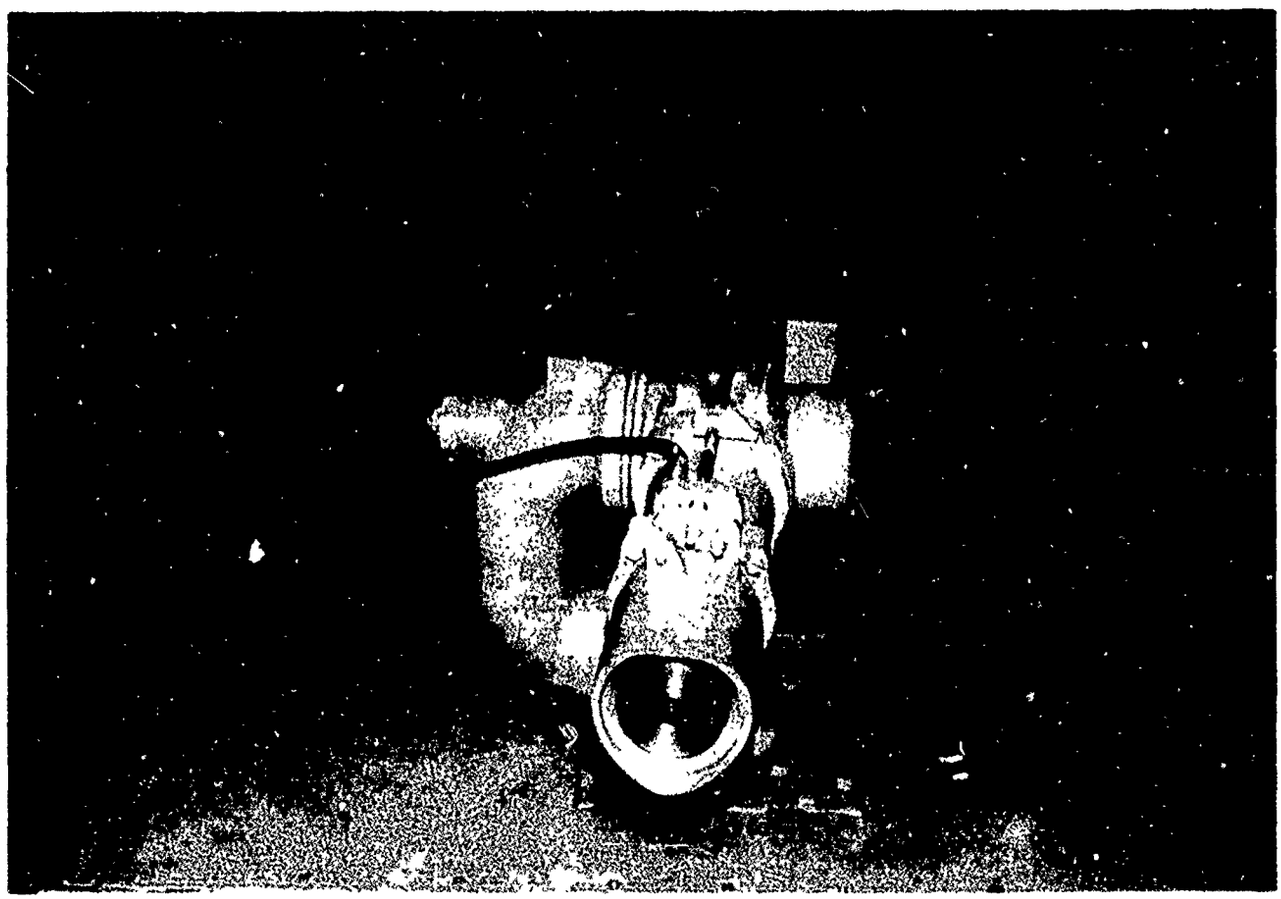


Figure 22. Remote-Controlled Nozzle Assembly.

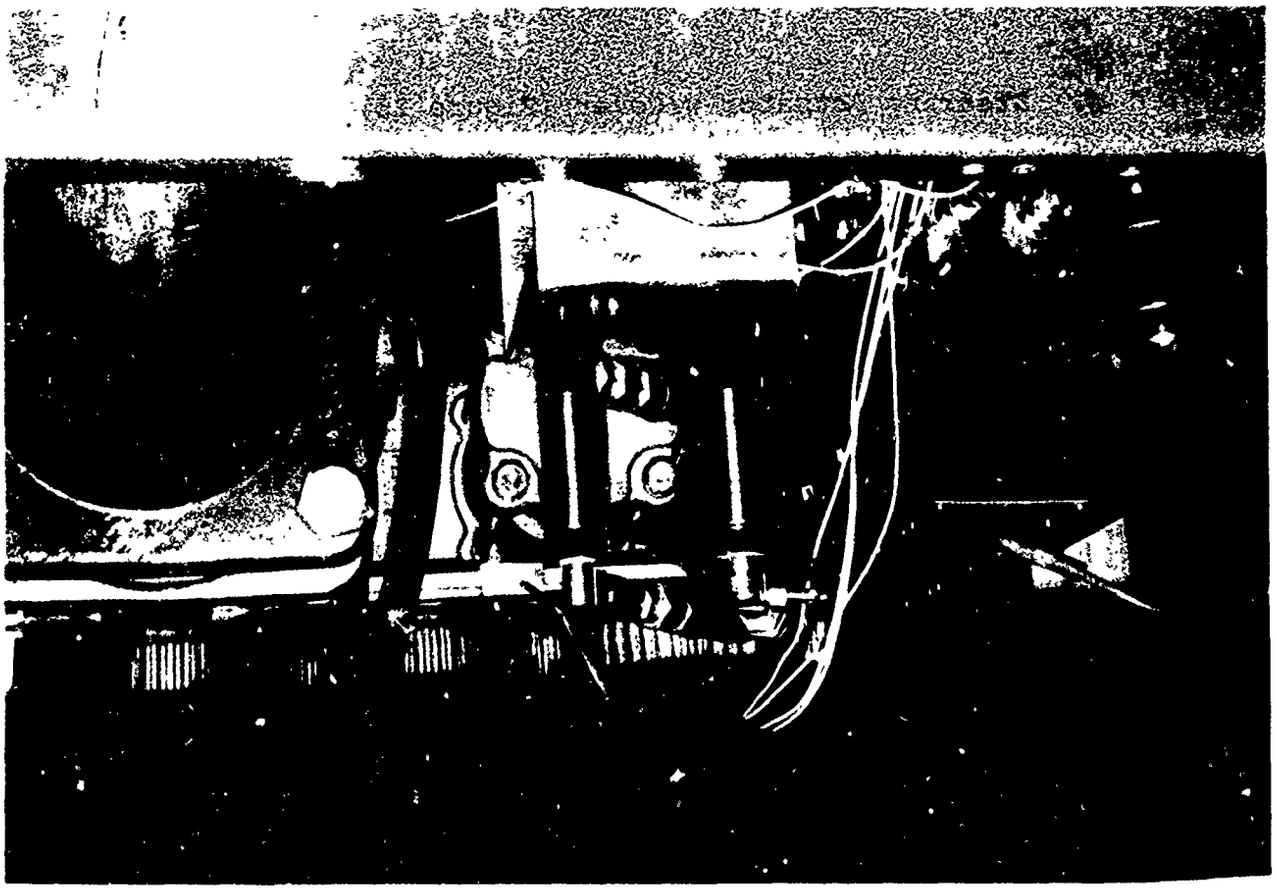


Figure 23. Remote Control Nozzle Details.

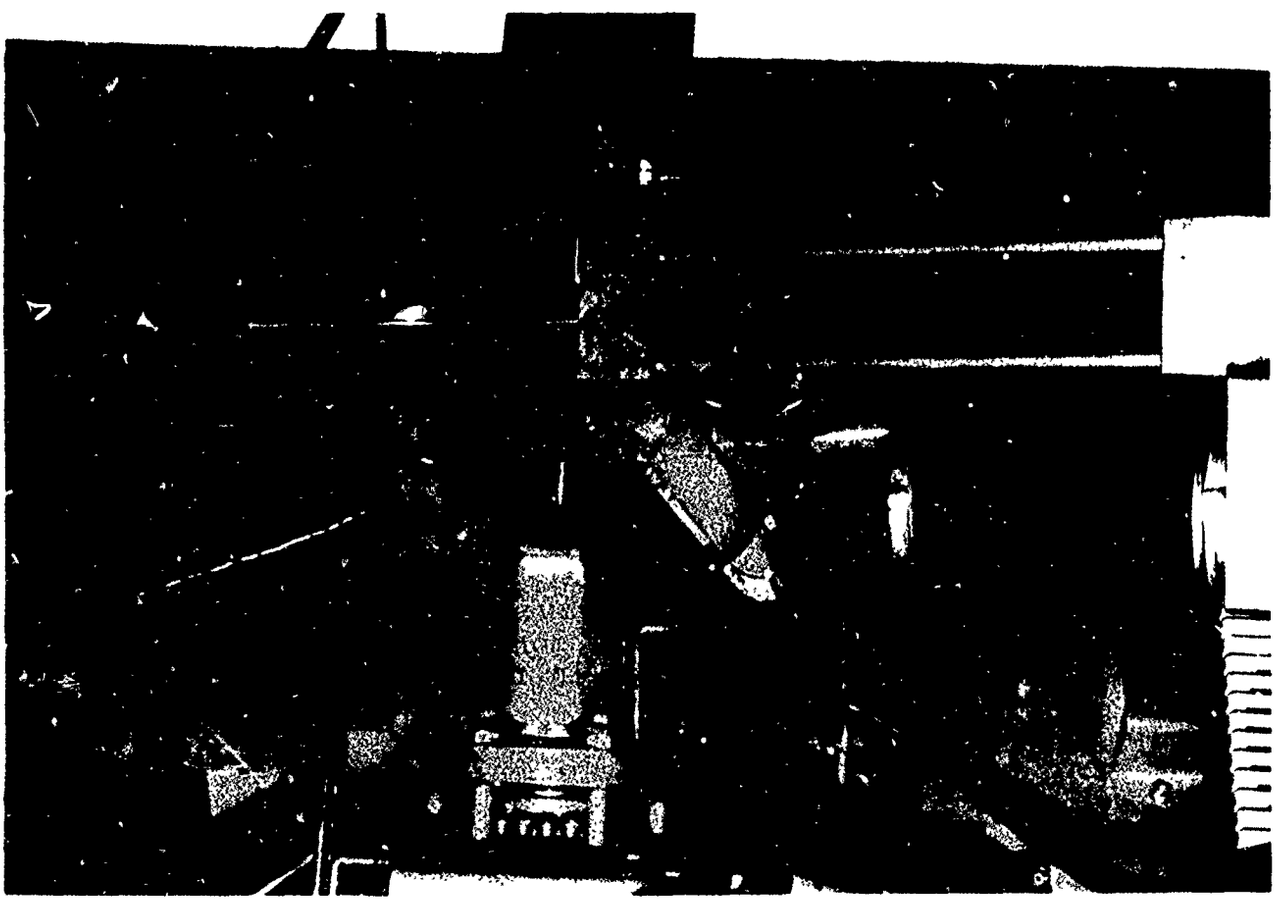


Figure 24. Brake and Throttle Actuators.

5. Steering Actuator w/Cover (Figure 25)

a. Location

Around and to the right of steering column. Drive chain and motor on AMETEK/ORED fabricated intermediate dash panel.

b. Use

Vehicle Steering

6. Steering Actuator Drive Train (Figure 26)

a. Location

Around and to the right of steering column. Actuator mounted under AMETEK/ORED fabricated intermediate dash panel.

b. Use

Vehicle steering and electrical position feed back for driver card.

7. Remote Controlled Gear Shifter (Figure 27)

a. Location

Beside driver's seat on the left side

b. Use

Electrical actuator with position feedback and local control provides local and remote control of gear selection.

8. Fixed Forward Viewing Drivers Camera (Figure 28)

a. Location

Mounted to the cab ceiling behind and above the drivers seat.

b. Use

Primary Camera for driving and secondary camera for firefighting. Provides visual monitoring of vehicle status indicator lights and "road" area in front of truck cab.

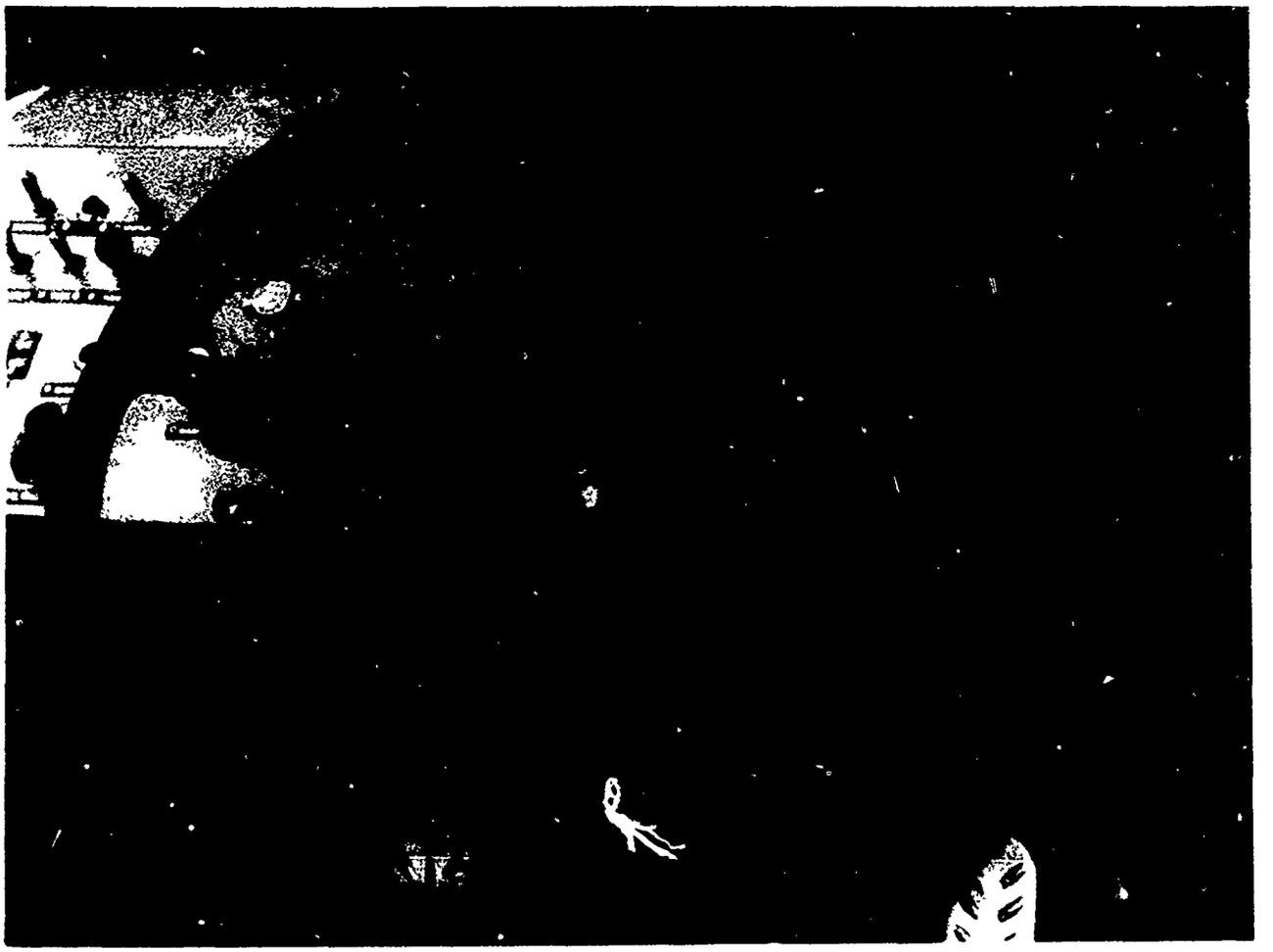


Figure 25. Steering Actuator with Cover.

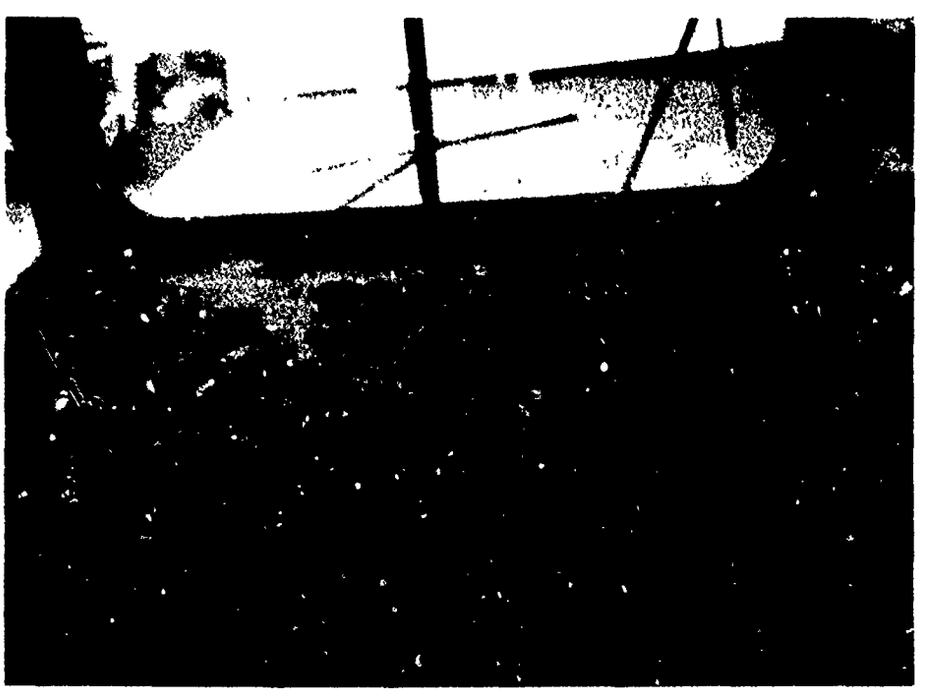


Figure 26. Steering Actuator Drive Train.

Figure 27. Remote-Controlled Shifter.

Figure 28. Fixed Forward Viewing Drivers Camera.

9. Pan & Tilt Camera Assembly (Figure 29)

a. Location

In front of passenger seat above dashboard

b. Use

Primary camera for firefighting and secondary for driving. Remote controlled pan, tilt, telephoto zoom lens assists in location of items and in recognition of depth perception.

10. Video Converter (Figure 30)

a. Location

On upper portion of cab-wall on passenger side.

b. Use

To condition the video signal from the pan and tilt camera for transmission to the control console.

11. Video Transmitter (Figure 31)

a. Location

On upper portion of cab wall above passenger side window.

b. Use

Takes video from the selected camera (P&T or fixed) and sends conditioned signal to transmission antenna. Signal is 2 GHZ, 100 MW, with six selectable channels.

12. Vehicle Status Indicator Display (Figure 32)

a. Location

Above and in the middle of the drivers windshield.

b. Use

The following are used to indicate status of critical vehicle systems by visual inspection from the remote control console operator when using the fixed camera:

- Engine Oil Pressure
- Engine Coolant Temperature
- Brake System Air Pressure
- Water Pressure of Firefighter System
- Hydraulic pressure for Vehicle Accessories.
- Water Tank Level (1/4, 1/2, 3/4, full)
- Foam Tank Level (1/4 full)
- Vehicle Speed (10, 20, 30, 40 mph)

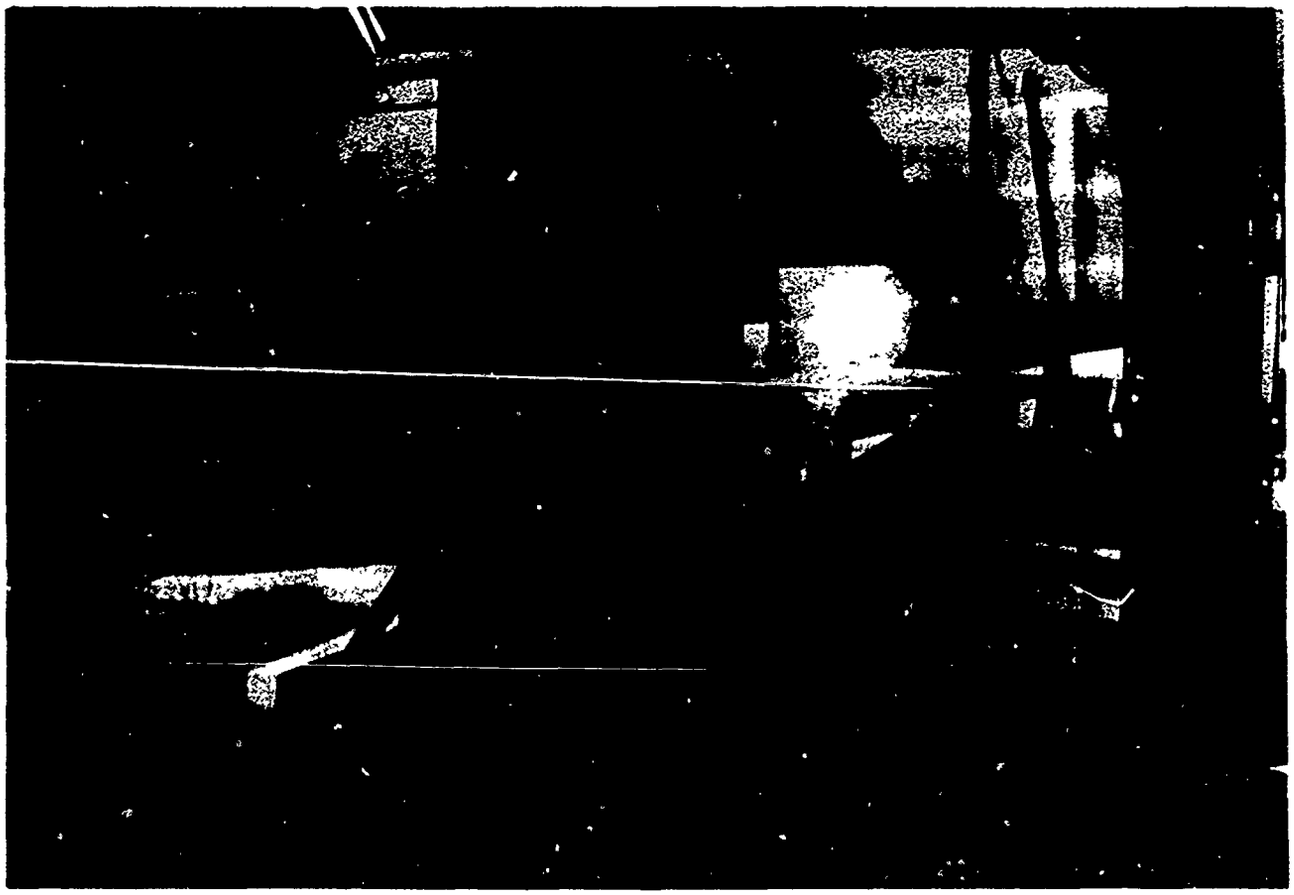


Figure 29. Pan and Tilt Camera Assembly.

Figure 30. Video Converter.

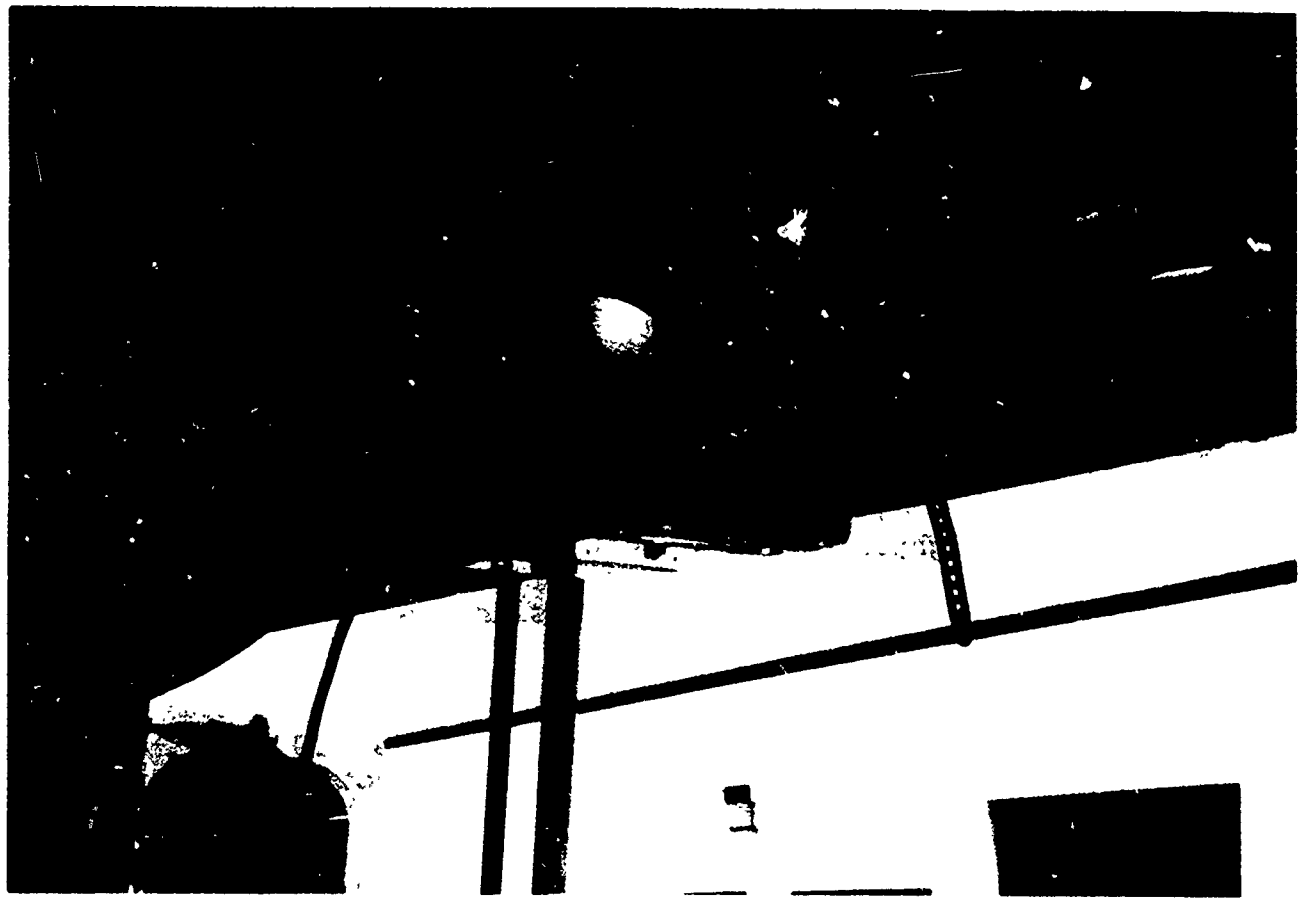


Figure 31. Video Transmitter.

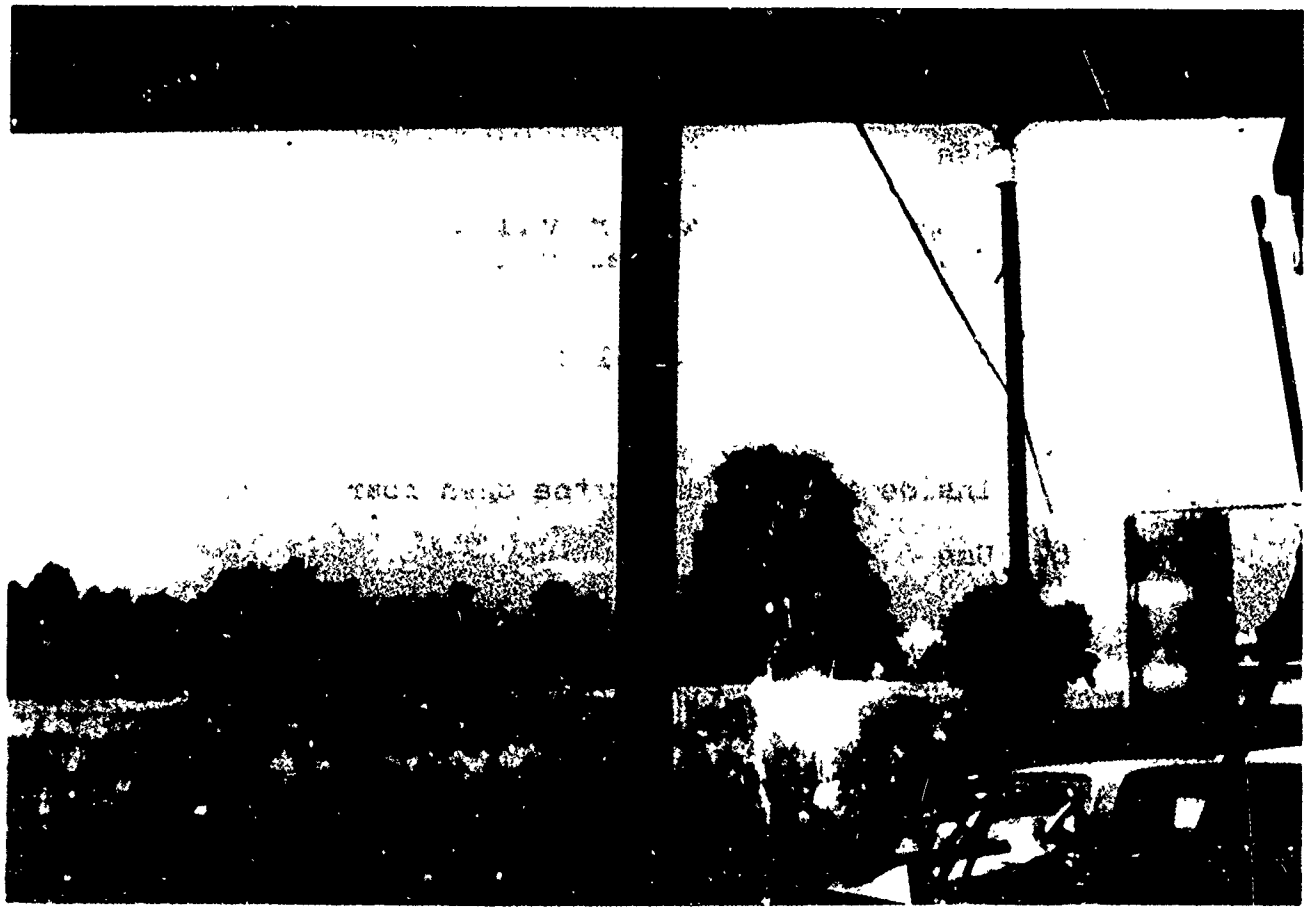


Figure 32. Vehicle Status Indicator Display.

13. Firefighting Agent (Water and Foam Sensors (Figure 33)

a. Location

On cab wall below passenger window

b. Use

Sensors for agent pressure, water tank level and foam tank level are located in this position. The sensors send electrical signals to the signal conditioning circuits for display on the vehicle status indicator display figure 32.

14. Firefighting Agent Select R.C. Valves (Figure 34)

a. In cab below passenger side dashboard

b. Use

These electro/pneumatic valves allow either local manual or remote console control of the selection between foam or water for nozzle supply.

15. Windshield Spray R.C. Valves (Figure 35)

a. Location

Inside the cab on the floor beneath the center of the dash board.

b. Use

This electro/water valve is used to cool the firetruck windshield during firefighting operations.

16. Windshield Wiper R.C. Valves (Figure 36)

a. Location

Inside the cab under the dash board on the driver's side

b. Use

These electro/pneumatic valves remotely activate both the left and right windshield wipers at one time.

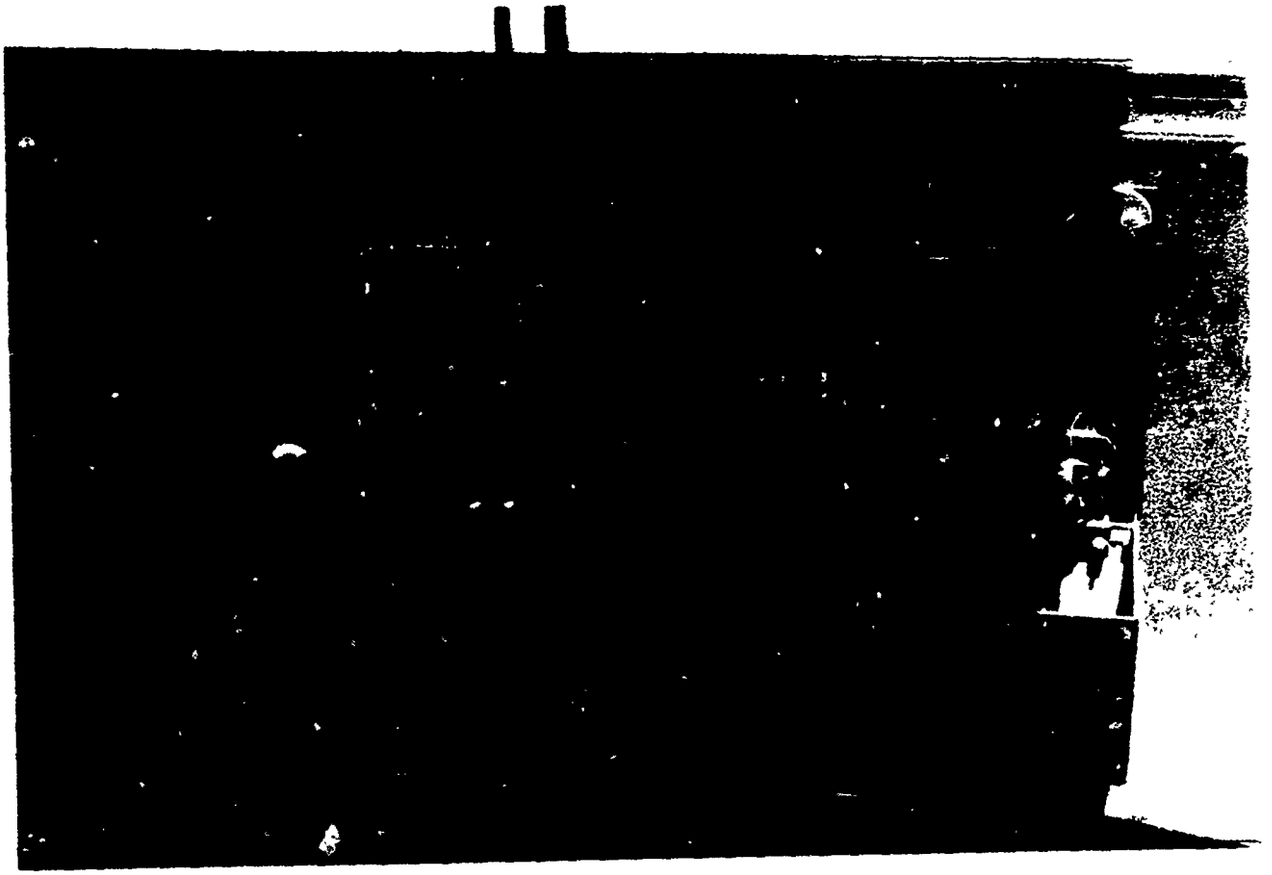


Figure 33. Water and Foam Sensors.

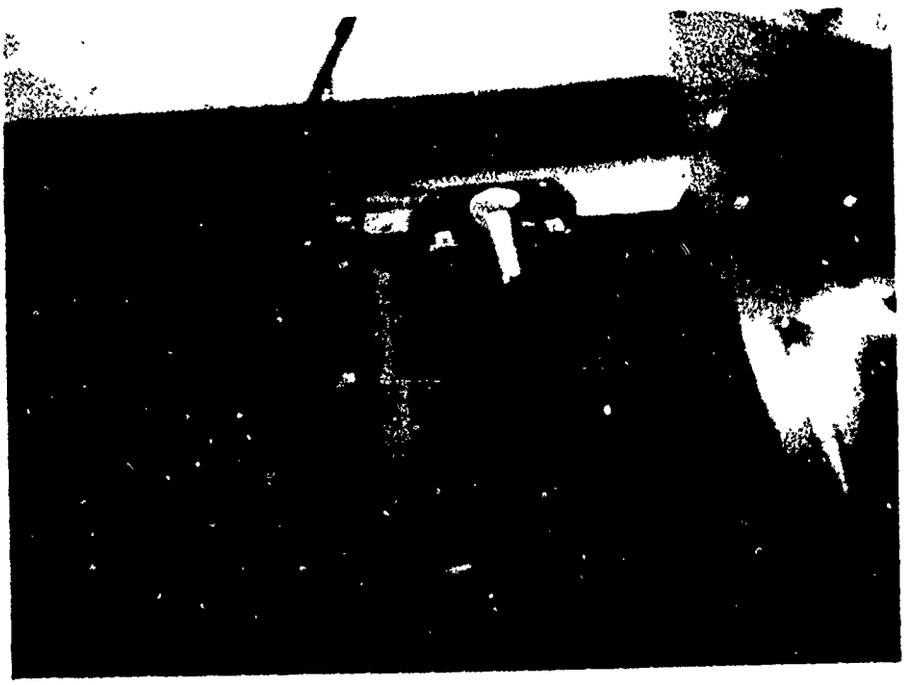


Figure 34. Firefighting Agent Select R.C. Valves.

Figure 35. Windshield Spray R.C. Valves.

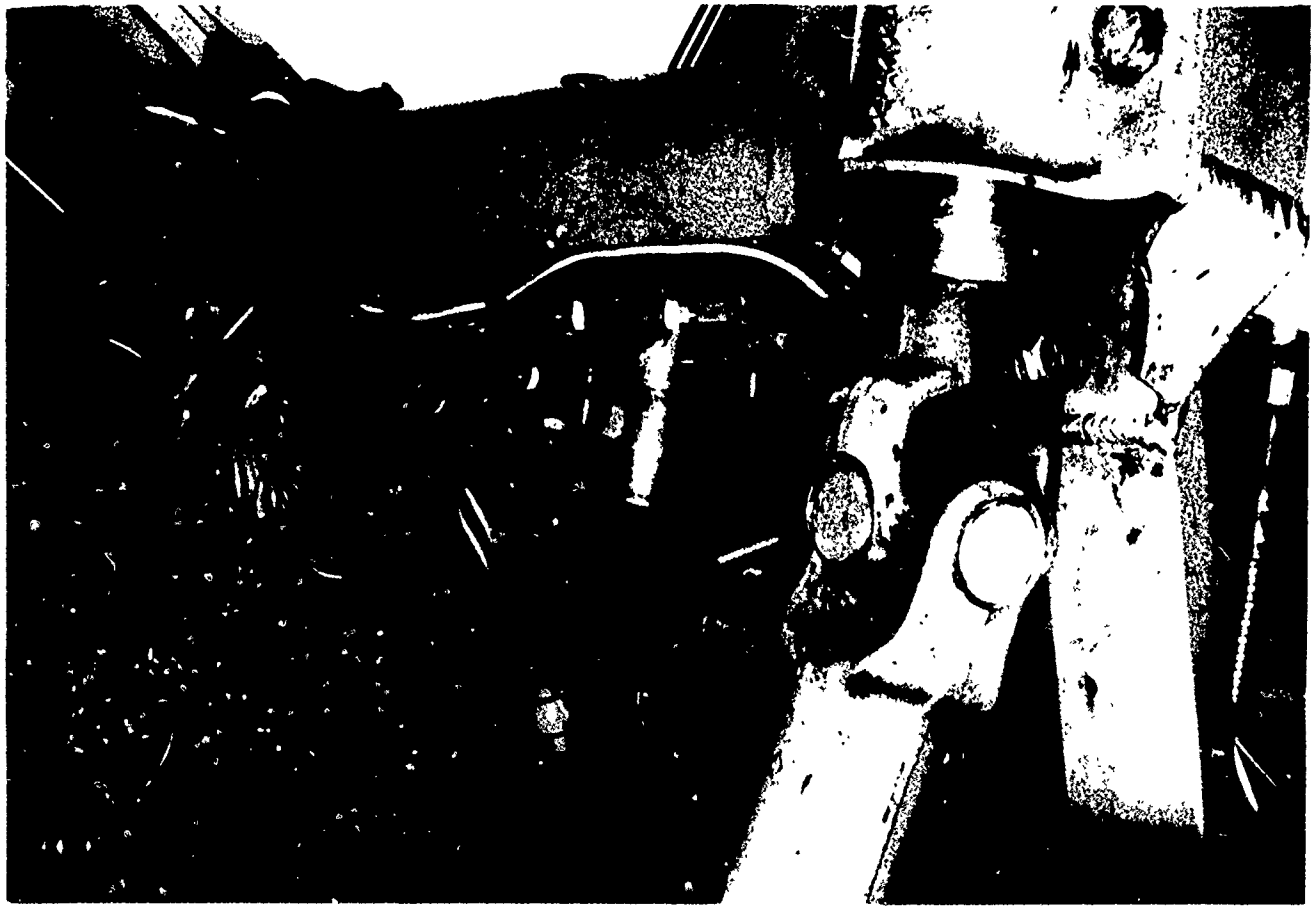


Figure 36. Windshield Wiper R.C. Valves.

17. Parking Brake R.C. Valves (Figure 37)

a. Location

On driver's side of cab below the parking brake control unit.

b. Use

These electro/pneumatic valves engage/disengage the parking brake.

18. Engine Start/Stop Relays (Figure 38)

a. Location

Located on the front cab wall beneath the center of the dashboard

b. Use

To start the vehicle engine remotely or to shut off the engine remotely for normal or emergency purpose.

Note: steering actuator top left and throttle cables on left side.

19. Actuator Driver & Signal Conditioning Circuits (Figure 39)

a. Location

On cap wall beside the driver's seat

b. Use

These circuits are employed to provide electrical control and power to drive actuators and display status information. The circuits provide the following:

- Throttle
- Brake
- Gear Shift
- Steering
* - Steering feedback Conditioning
* - Speed sensor Conditioning
- Remote/Manual Steering relay
* - Water tank level Conditioning
- Fuse Panels

Note: Items denoted with an asterisk are AMETEK/ORED custom circuits, others are vendor supplied.

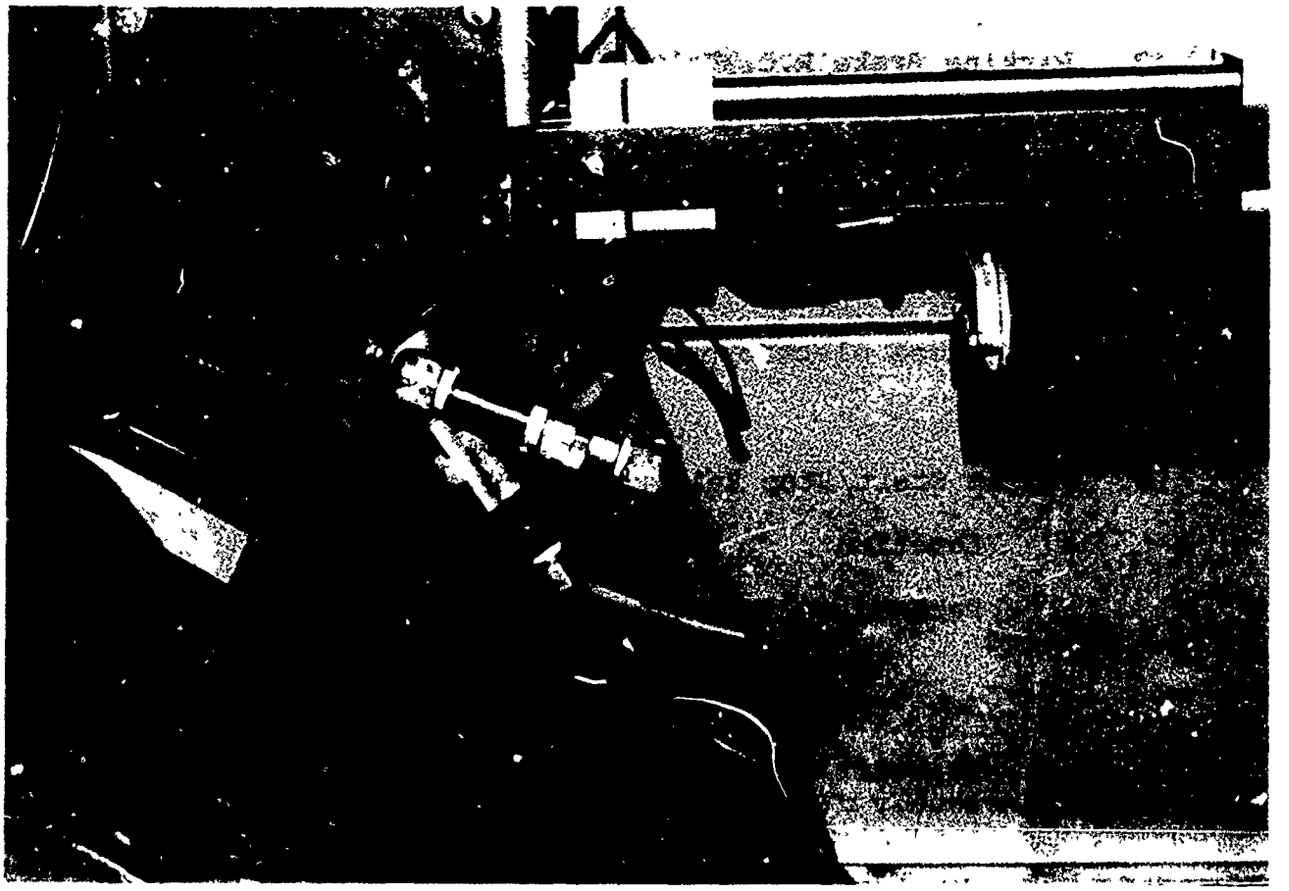


Figure 37. Parking Brake R.C. Valves.

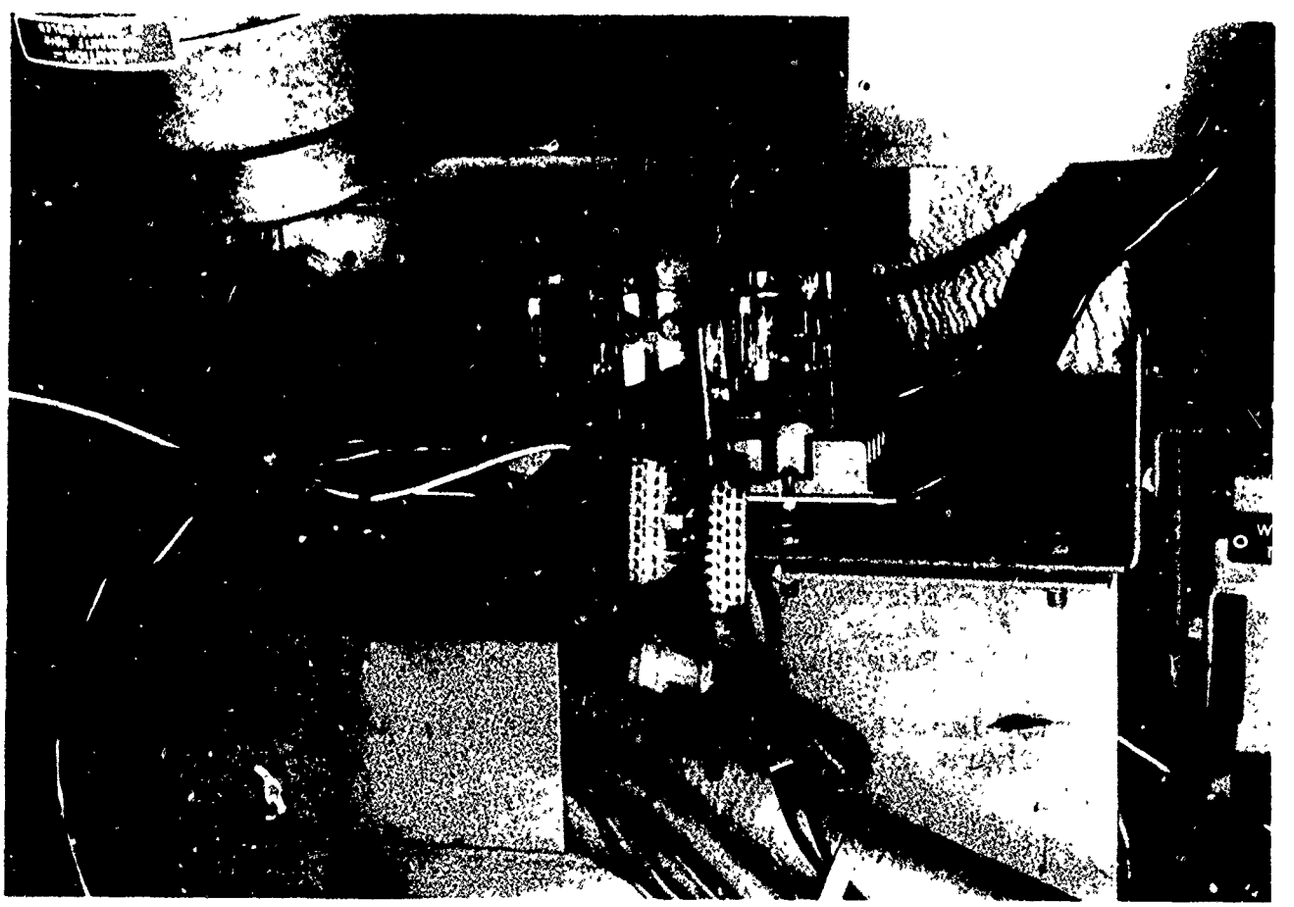


Figure 38. Engine Start/Start Relays.

Figure 39. Actuator Driver and Signal Conditioning Circuits.

20. Signal Processing Cabinet (Figure 40)

a. Location

Behind passengers seat just above the floor.

b. Use

This cabinet houses circuits which interface between the Radio Frequency data receiver units and the driving actuator circuit (Figure 39) / Other actuators/solenoid valves on the vehicle.

21. Remote Control Console Storage Configuration (Figure 41)

This figure shows the console unit with the protective covers in place and prepared for transport.

22. Back Panel of Console (Figure 42)

This figure shows the three Futaba radio sections. Antennas are located on top of the unit and are collapsible manually for ease of transport. The back panel is hinged for easy servicing access.

23. Front Switch Panel (Figure 43)

This figure displays the reverse side of the main operator control panel. The back side of all the control switched can be seen. The interconnecting wiring bundle can be seen headed toward the radio sections at the rear of the unit. Batteries are for power to the Futaba unit.

24. Console Operators Panel (Figure 44)

This figure shows the main console control faces. The controls are all labeled to indicate the remote function controller.

Figure 40. Signal Processing Cabinet.

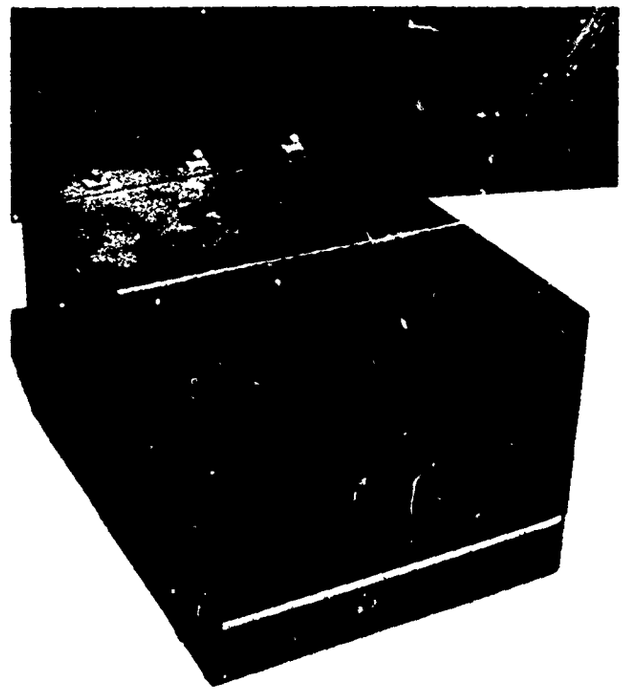


Figure 41. Remote Control Console Storage Configuration.

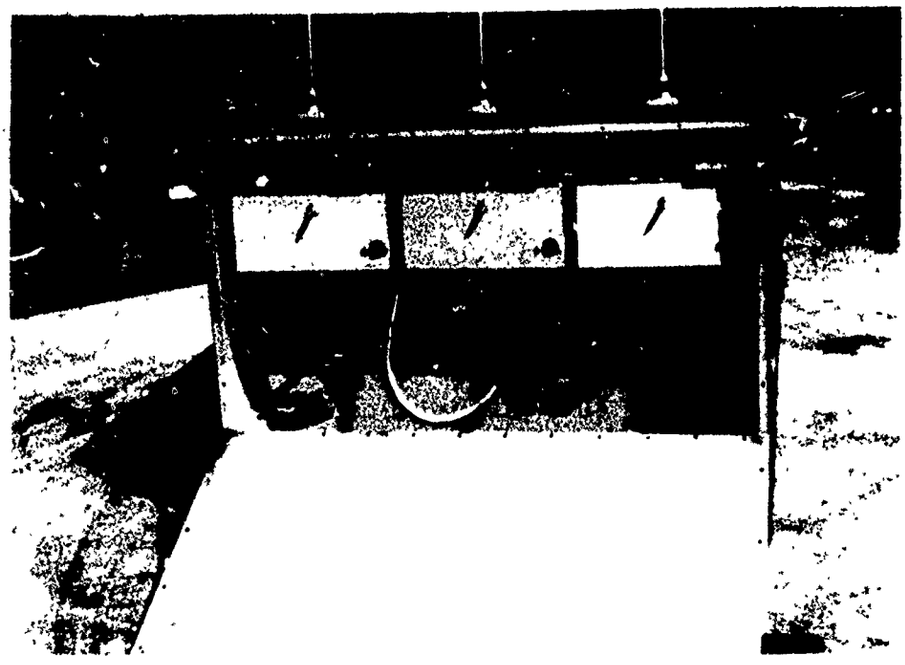


Figure 42. Back Panel of Console.

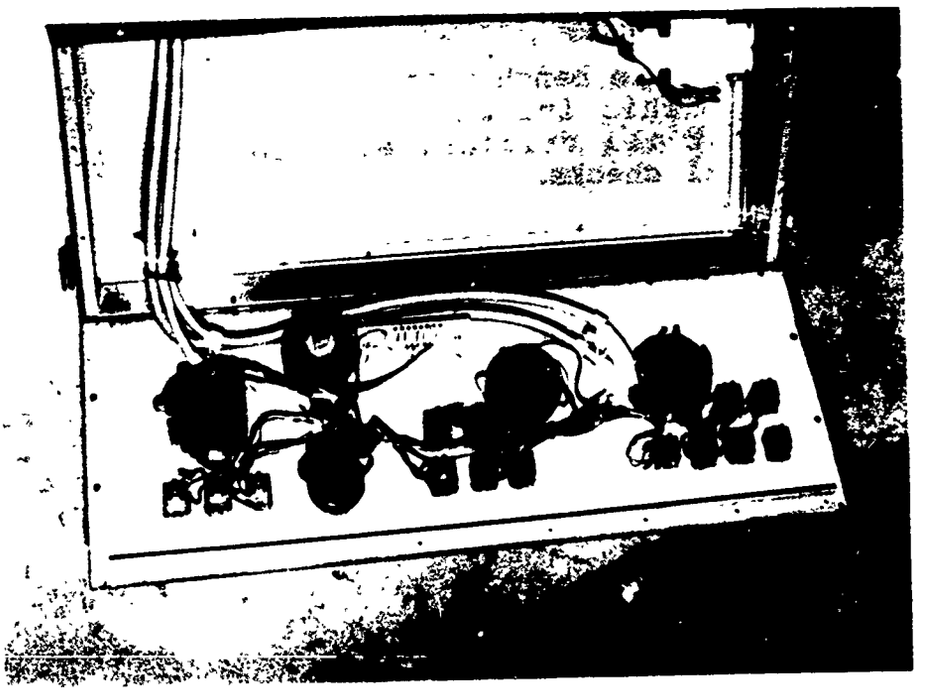


Figure 43. Front Switch Panel.

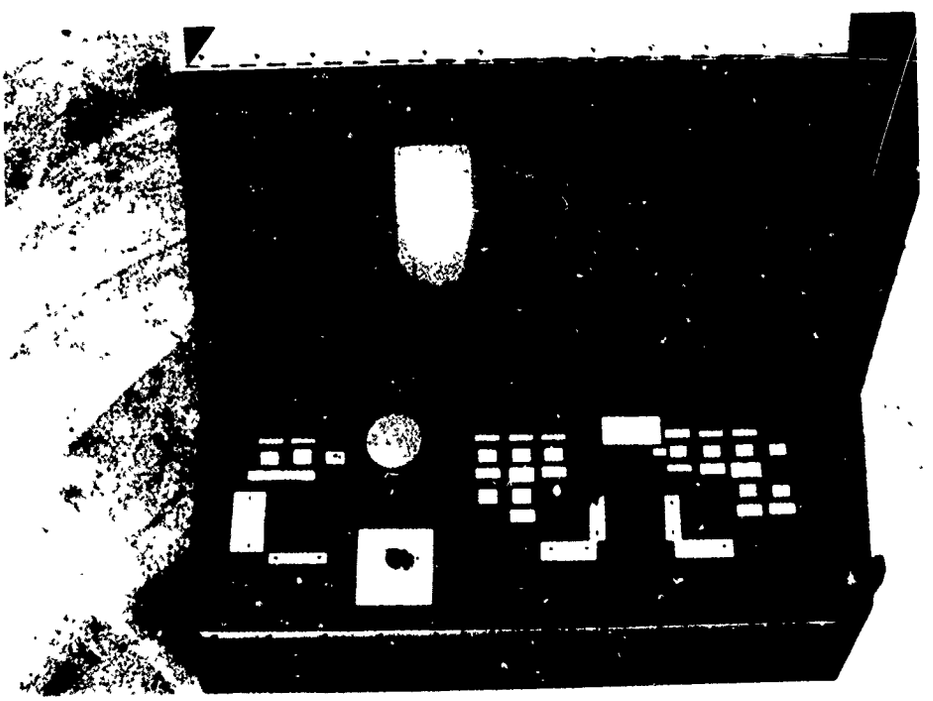


Figure 44. Console Operators Panel.

SECTION IV

COMPONENT AND IN SITU SYSTEM TESTING

A. BENCH TESTS OF CRITICAL NOVEL COMPONENTS

Components were bench tested upon arrival to confirm expected performance. This initial testing was not performed on all equipment, but all critical electro mechanical equipment did undergo initial checks.

B. SIMULATED FIELD TESTING OF COMPONENTS

The data and video transmission links were purchased and rented, respectively and transported to Vandenberg AFB for field tests in advance of the official demonstration. These units were tested at the fire pit training area at ranges planned for the official demonstration. High tension wires in the area presented no interference problems and both transmission systems performed well.

C. VEHICLE DRIVING SYSTEMS TESTING

The truck was outfitted with driving actuators. The truck was raised on blocks to eliminate wheel traction. This allowed initial testing of driving systems without risk to equipment or personnel. Following these tests the vehicle was driven at AMETEK/ORED facilities remotely without a video viewing link. A backup emergency driver was maintained in the truck at all times to resume manual control if necessary. Minor steering problems were experienced and a number of existing truck system deficiencies were discovered. All of these items were corrected. An in-house short range video transmission system was installed for initial driving exercises with a visual video link.

D. FIREFIGHTING SYSTEMS TESTING

Following successful driving tests the remainder of the remote system functions were tested at AMETEK/ORED facilities. The nozzle and pump system exhibited a number of minor problems. The most significant problems were existing truck systems such as several high pressure piping leaks. These deficiencies were corrected.

E. COMPLETE SYSTEM TESTS AT AMETEK/ORED

Following the subsystems tests, the commercial long range video transmission system was rented and installed. The complete system was exercised and demonstrated to the Air Force project manager. Following these tests and minor adjustments, the truck and remote control console were transported to Vandenberg AFB.

SECTION V

VANDENBERG AFB TRAINING AND DEMONSTRATION

A. PREPARATION TESTING AND TRAINING

At the firepit training area a series of fuel fires was initiated by the Air Force fire crews and then extinguished using the remotely operated fire truck. Trained AMETEK/ORED personnel operated the truck and a standby emergency driver was stationed in the truck at all times. Specific procedures for positioning the truck and directing the nozzle were imparted to the AMETEK/ ORED operators during these training/testing firefighting exercises. Videotape recordings of these exercises were made to document the exercises.

B. OFFICIAL DEMONSTRATION

On 18 June 1987 Air Force officials arrived to witness the remote firetruck system. They were briefed on the program and system. The equipment was shown and explained.

The remote control console was set up in the bed of an AMETEK/ORED covered pickup truck. Figure 45 shows this arrangement with the driving operator on the passenger's side and the firefighting operator on the driver's side. The tripod on the lower left supports the video receiver antenna. Figure 46 provides a view of the operator's console during a driving exercise when the truck is being driven around the fuel pit.

A 600 gallons JP-4 fuel fire was then ignited at the training pit under the simulated bomber aircraft.

Figure 47 shows the ignited fire and vehicle approaching the agent spray position. Note the suited emergency backup operator stationed in the truck. Figure 48 depicts the beginning of the spray sequence and figure 49 shows the spray sequence shortly after commencing spray, but also near the completion of the spray sequence.

Figure 45. Demonstration Remote Control Station and AMETEK/ORED Operators.

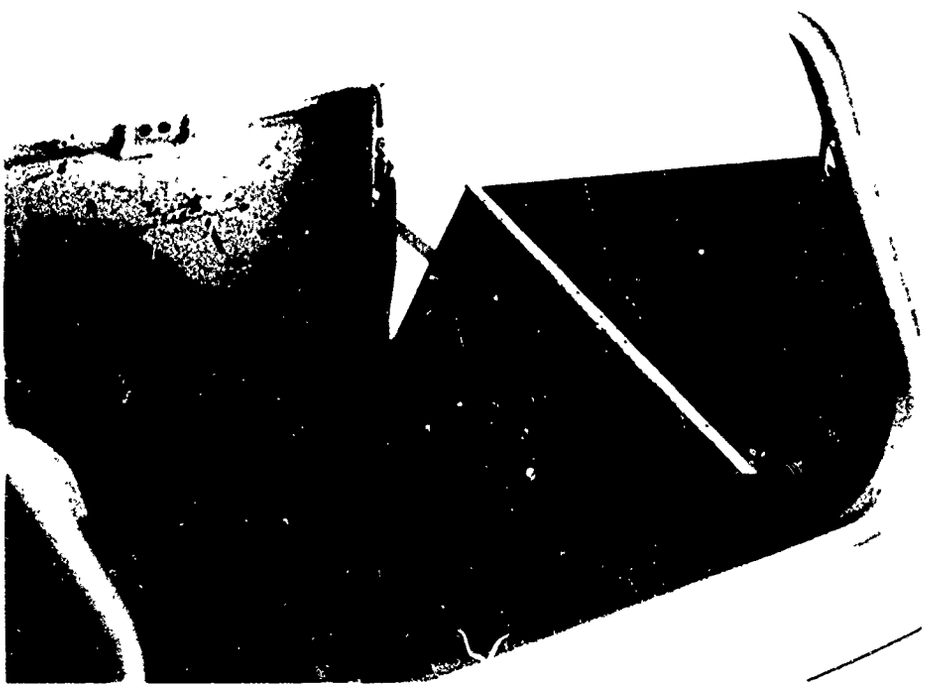


Figure 46. Demonstration Remote Control Console.

Figure 47. Ignited Fire and Vehicle Approach.

Figure 48. Commencement of Spray Sequence.

Figure 49. Spray Sequence Near Completion.

SECTION VI

REFURBISHMENT OF P-4

A. EQUIPMENT REMOVAL

The vehicle and console were returned to AMETEK/ORED. Photographs were taken to provide documentation for the final report.

The rented equipment was removed and returned. AMETEK equipment was removed and returned to inventory. All equipment purchased and charged to the project was removed from the vehicle. Systems were returned to original except minor alterations which were approved by Air Force project management.

B. EQUIPMENT PACKAGED

The components removed were packaged in boxes ready for shipment.

C. P-4 RETURNED

The P-4 was transferred from the AMETEK/ORED facility in Goleta, CA. to Edwards AFB, CA. on 15 July 1987.

SECTION VII

CONCLUSIONS AND RECOMMENDATIONS

A. FEASIBILITY DEMONSTRATION MODEL CONCLUSION

1. Study Findings

As presented in Sections I and II a well founded baseline conceptual design was established. This specialized design would offer a number of advantages and disadvantages over the conversion of a P-4 or P-19 to remote operation.

A primary advantage is increased quantities of firefighting agents when supplied with a sufficiently sized nursing truck. The specialized robotic firefighter would also be smaller, more maneuverable, more accurate and easier to operate. The baseline offers a number of disadvantages as well:

High Cost

Longer Deployment Time

Limited Special Use

For the majority of aircraft fires the disadvantages are judged to outweigh the advantages when compared to the FDM concept. If other types of base fires such as; structure and munition storage fires are considered the baseline concepts would be considered, more desirable based on fluid volumes required.

2. FDM Findings

The P-4 conversion to remote operation proved to be very successful for aircraft fires of the type normally encountered. The new FEECON nozzle used for remote operation provided a significant improvement in range over existing P-4 and P-19 nozzles. The remotely operated truck system could perform all of the critical functions a manned version is capable of with very little risk to personnel. The majority of components selected to convert the truck were found to be very satisfactory and offer good potential for reliable long term applications. Several components offer insufficient long term reliability or are not functionally suitable for a system other than FDM. The linear actuator position cards are an example of a component with insufficient reliability and the data system is an example of a component which is judged to be not functionally suitable for a prototype or production model.

It was found that significant training was required to operate the vehicle because depth perception was limited. Improved optic systems would help significantly improve these deficiencies.

It was found that the direction and position of the turret nozzle was difficult for the operator to track once the spray stream was initiated.

It was found that the steering actuator with velocity-controlled drive card worked very well in both manual and remote modes.

B. PROJECT CONCLUSIONS

A strong baseline concept design is presented in this report which would be very acceptable to further develop an advanced robotic firefighter. Such an advanced robotic firefighter would be very useful for a multitude of base fires.

The remote firetruck performed well completing all of the assigned tasks. This FDM concept provides a good base from which a prototype and production model can be developed.

The actual firefighting experience revealed a significant number of improvements/modifications are desirable to facilitate the use of the system.

The FDM system along with the new modified nozzle demonstrated a number of superior performance characteristics over conventional P-4s and P-19s supported with fire crews and hoses. Significant safety increases were experienced with the FDM concept, although conventional rescue capabilities are not available until fire extinguishing activities are completed.

Because of the FDM demonstration experience, the FDM concept should be considered for "normal" aircraft fires as well as the more "unusual" weapon-involved incidents.

C. PROJECT RECOMMENDATIONS

It is recommended that all the uses for a remote firefighting system should be carefully considered. True need will drive future development direction. The greatest need expressed to AMETEK/ORED is for weapons-related aircraft fires. A portion of existing P-19s should be converted to allow either manual or remote control. Two converted vehicles per base would provide suitable redundancy for acceptable preparedness.

Further development work should be pursued on the advanced robotic firefighter concept for base munitions storage facility fires, fuel dump fires, and decontamination/contaminated materials handling systems.

Several improvements are recommended for the development of a remote-control firetruck prototype:

1. Improved higher-quality video optics, including lens, and CCD-type cameras.

2. Improved video viewing of the nozzle, its position and stream.

3. Improved linear actuator device cards.

4. Larger video monitor(s) with possible split screen.

5. Professional quality duplex data link to provide feedback from truck.

6. Dual video links for both driving and firefighting stations.

7. Single "flip-the-switch" remote control system activation from manual to remote.

8. Rear view camera for backing up.

9. Pistol-grip controller for turret control.

10. Self-contained power supplies

11. Erroneous data transmission sonic alert.

12. Assigned military frequency and band width for video and data transmission.

13. External indicators of remote status and shut down switches.

14. Remotely directed spotlights for night exercises.

15. Reduce console size and weight.

16. Minimize impact of remote devices on vehicle.

APPENDIX A

CONCEPT FEASIBILITY REVIEW

3 OCTOBER 1985

CONCEPT FEASIBILITY REVIEW

REMOTELY OPERATED ROBOTIC FIREFIGHTER

Contract # FO8635-85-C-0107

CDRL Item # A007, Conference Report

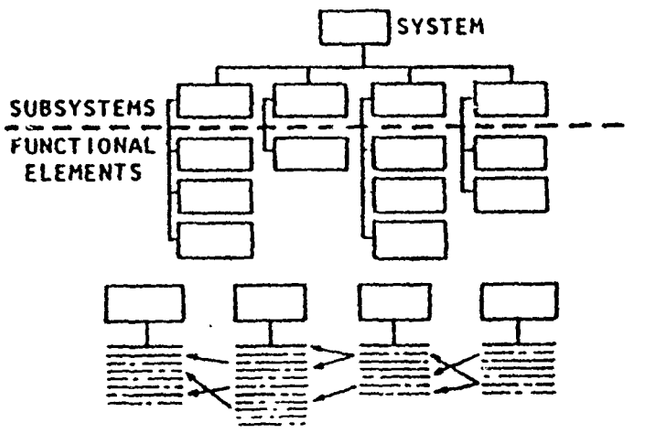
3 OCTOBER 1985

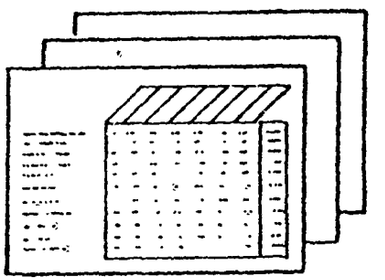
AIR FORCE ENGINEERING AND SERVICES CENTER/RDCS
TYNDALL AFB, FLORIDA

SYSTEMS ANALYSIS

FUNCTIONAL BREAKDOWN ANALYSIS

- IDENTIFY SYSTEM MAJOR FUNCTIONS (SUBSYSTEMS)
- EXTEND BREAKDOWN TO SUBSYSTEM (FUNCTIONAL) ELEMENTS
- LIST ALTERNATIVE TECHNOLOGIES/DESIGN APPROACHES FOR SUBSYSTEMS/ELEMENTS
- NOTE SYSTEM OPTION COMPATIBILITIES
- DEFINE RELATIVE PERFORMANCE CHARACTERISTICS
- RELATE PERFORMANCE CHARACTERISTICS TO TECHNICAL REQUIREMENTS (OPERATIONAL ENVELOPE)

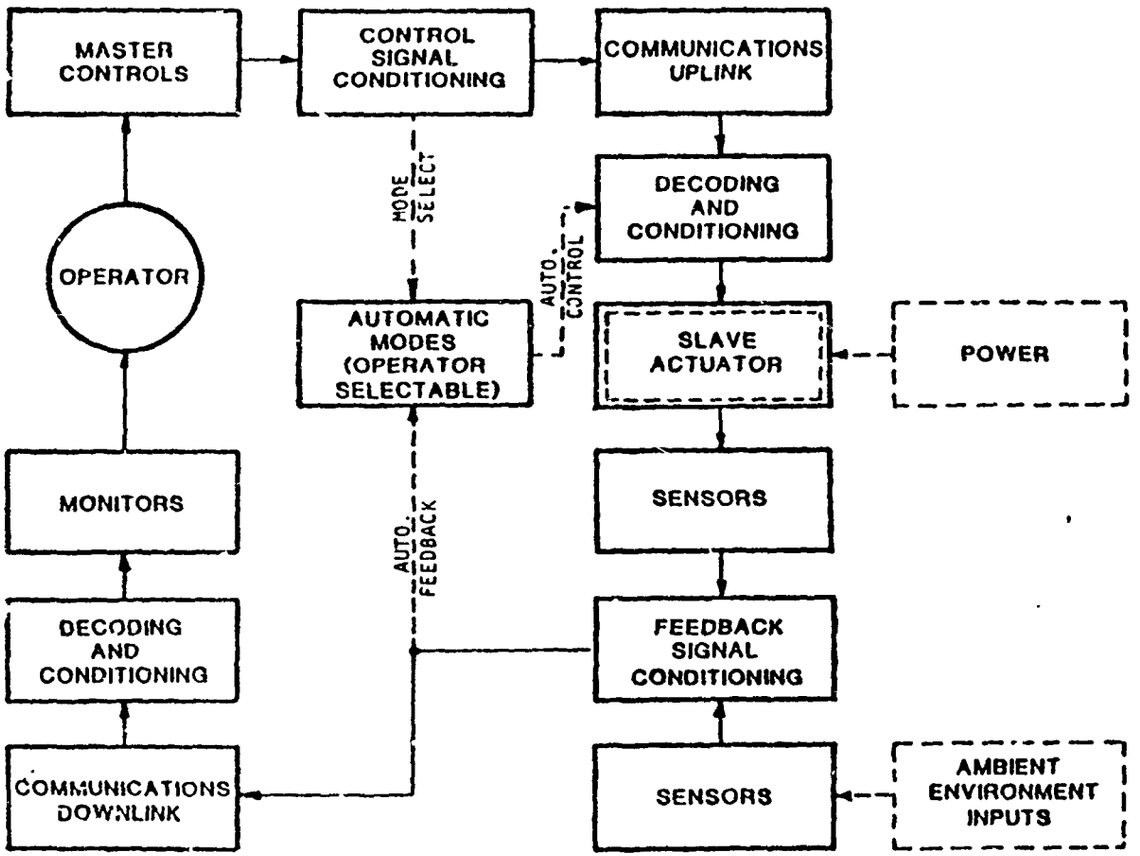




SYSTEMS ANALYSIS

FUNCTIONAL BREAKDOWN

CONTROL/FEEDBACK SUBSYSTEM



SYSTEMS ANALYSIS

MAN-MACHINE INTERFACE OPERATOR CONTROLS & SENSORY FEEDBACK

SUBSYSTEM/FUNCTION	FEEDBACK SIGNAL	CONTROL PARAMETERS
● MOBILITY SUBSYSTEM		
– DRIVE – MANEUVERING	VISUAL - VIDEO DISPLAY SPEED SENSOR AND READ-OUT SOUND - STEREO HEADPHONES	ACCELERATE/DECELERATE BRAKE REVERSE STEERING, DIRECTION OF TURN TURN RADIUS RATE OF CHANGE
– SELF-RIGHTING	GRAVITY REFERENCE AND VISUAL	ACTIVATE RIGHT OR LEFT
– DEPLOYMENT STAGING	VISUAL AND STATUS INDICATION	VEHICLE UNIT SEPERATION
● FIREFIGHTING SUBSYSTEM		
– WATER/AFFF	VISUAL - AS ABOVE SOUND - AS ABOVE AGENT PRESSURE SENSOR AND READ-OUT AGENT FLOW SENSOR & READ-OUT	FLOW RATE SLEW AND PITCH ANGLE AND RATE STEAM FOG TURRET ELEVATION FLOW RATE
TURRET NOZZLE		
SPAAT		
SELF-COOLING NOZZLES		ON - OFF
BOOSTER PUMP		ON - OFF
– HALON	VISUAL - AS ABOVE SOUND - AS ABOVE FORCE - AXIAL ON SPAAT - SENSOR AND READ-OUT TORQUE - ON SPAAT DRILL - SENSOR AND READ-OUT TACTILE - CONTACT ONLY PROXIMITY SENSOR AGENT REMAINING SENSOR AND READ-OUT CHARGING PRESSURE SENSOR & READ-OUT	DRILL ON OFF HALON FLOW ON - OFF VERTICAL AND HORIZONTAL REACH WRIST YAW, PITCH & EXTEND SLEW & PITCH ANGLE & RATE HALON ON - OFF
SPAAT		
MANIPULATOR ARM		
TURRET NOZZLE (DUAL-AGENT)		

SYSTEMS ANALYSIS

MAN-MACHINE INTERFACE OPERATOR CONTROL & SENSORY FEEDBACK

SUBSYSTEM/FUNCTION (CONT.)	FEEDBACK SIGNAL (CONT.)	CONTROL PARAMETERS (CONT.)
● FIREFIGHTING SUBSYSTEM (CONT.)		
– SELF-COOLING	TEMPERATURE SENSOR AND READ-OUT STATUS - ON - OFF	MANUAL OVERRIDE
– HOSE HANDLING		
FLAT PACK HOSE	"KICKER" OPERATION STATUS	DEPLOYMENT PULLED FROM STOWAGE
RIGID-WALL HOSE	REEL MOTOR ON - OFF STATUS	DEPLOYMENT PULLED OFF REEL POWERED REEL RETRACTION ON - OFF
● CONTROL/FEEDBACK SUBSYSTEM		
– VISUAL	VIDEO CAMERAS IR OVERLAY - IR CAMERA	CAMERA PAN/TILT ANGLE AND RATE IR OVERLAY ON - OFF LIGHTS ON - OFF FOCUS - AUTO W/MANUAL OVERRIDE SHOCK & VIBRATION ISOLATION
– SOUND	STEREO MICROPHONES AND HEADPHONES	GAIN
– CHEMICAL DETECTION	SELECTED CHEM. DETECTORS & ALERT INDICATORS	STATUS CHECKS, ALARMS, SELECTOR SWITCHES
– GRAVITY REFERENCE	GRAVITY VECTOR SENSOR & INDICATOR	
– AIRFLOW	SPEED AND DIRECTION SENSORS AND INDICATORS	
● POWER SUBSYSTEM		
– PRIME DRIVER	ENGINE STATUS SENSORS AND INDICATORS	ENGINE START - STOP OTHER ENGINE CONTROLS
– SECONDARY HYDRAULIC	HYDRAULIC PRESSURE SENSORS AND INDICATORS FLUID TEMPERATURE SENSORS AND INDICATORS	HYDRAULIC PUMP(S)
– SECONDARY ELECTRIC	VOLTAGE AND CURRENT SENSORS AND INDICATORS	POWER ON - OFF

SYSTEMS ANALYSIS

MAN-MACHINE INTERFACE

CONTROL CONCURRENCY

- **DEPLOYMENT :**
  - MOBILITY
  - FIREFIGHTING
  - → DRIVE, MANUEVER; DECOUPLE UNITS; DEPLOY HOSE
  - (1)
- **ATTACK EXTERNAL FIRE :**
  - MOBILITY
  - FIREFIGHTING
  - → DRIVE, MANEUVER; OPERATE TURRET NOZZLE
  - (2)
- **ATTACK INTERNAL FIRE :**
  - MOBILITY
  - FIREFIGHTING
  - → DRIVE, MANEUVER; DEPLOY MANIPULATOR ARM; OPERATE SPAAT
  - (3)

. . . WHILE OPERATING SENSORS, e.g., CAMERA PAN, TILT

NOTE: (2) AND (3) MAY BE CONCURRENT, AS THE TURRET NOZZLE MAY BE USED TO CONTROL AN EXTERNAL FIRE IN PROXIMITY OF THE ROBOT UNIT WHILE UTILIZING THE SPAAT TO ATTACK AND INTERNAL FIRE.

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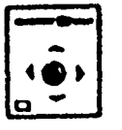
SYSTEMS ANALYSIS

MAN-MACHINE INTERFACE	CONTROLS ALLOCATION
MOBILITY DRIVE, MANEUVER	FOOT CONTROLS, e.g. 
FIREFIGHTING HOSE DEPLOYMENT	AUTOMATIC DEPLOYMENT OF HOSE PANEL SWITCHES FOR UNIT DECOUPLING MOMENTARY CONTRACT "TRIGGER" FOR HOSE REEL RETRACTION
FIREFIGHTING TURRET NOZZLE	TURRET NOZZLE CONTROL PANEL FOR RIGHT HAND (CONVENTIAL) 
FIREFIGHTING SPAAT AND ARM	MASTER POSITIONAL CONTROL FOR LEFT HAND/ARM WITH HAND CONTROL FOR WRIST AND TRIGGER CONTROLS FOR SPAAT 
CONTROL/FEEDBACK	MASTER CAMERA CONTROL FOR HEAD (HEADGEAR) PANEL SWITCHES FOR OTHER 
POWER	PANEL SWITCH FOR START-STOP

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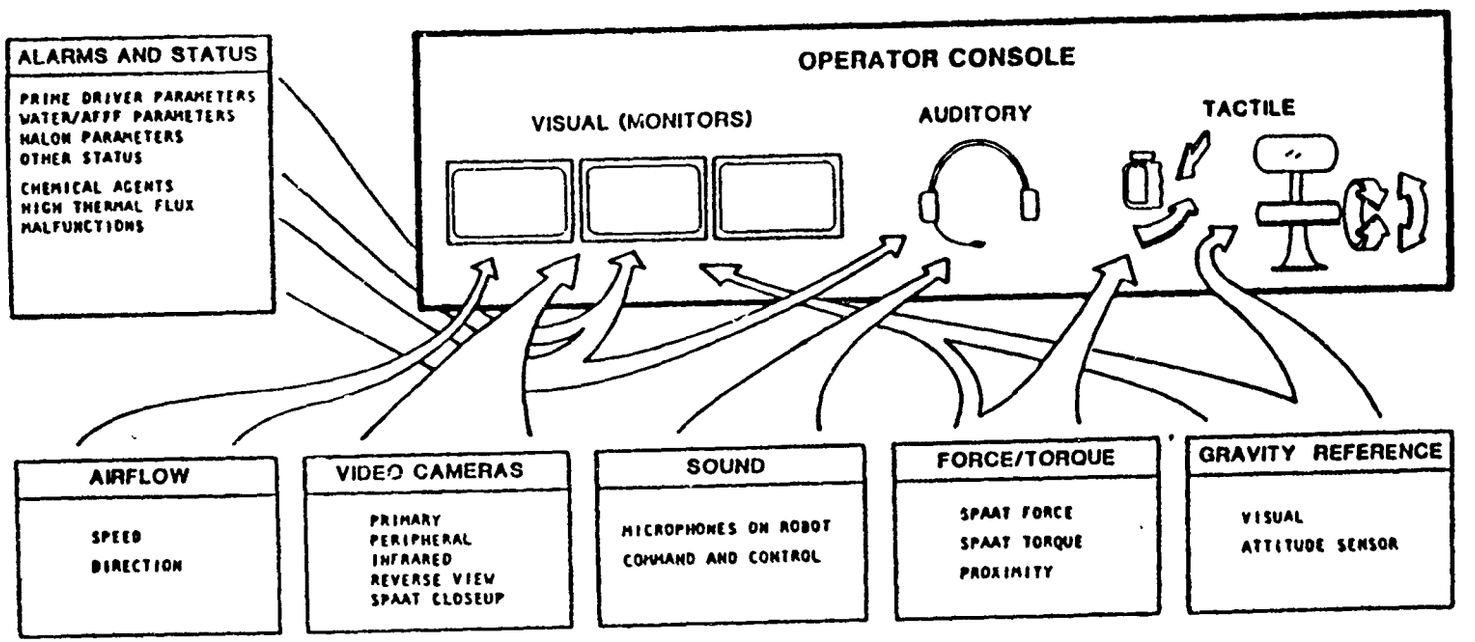
SYSTEMS ANALYSIS

MAN-MACHINE INTERFACE

OPERATOR FEEDBACK DATA FLOW



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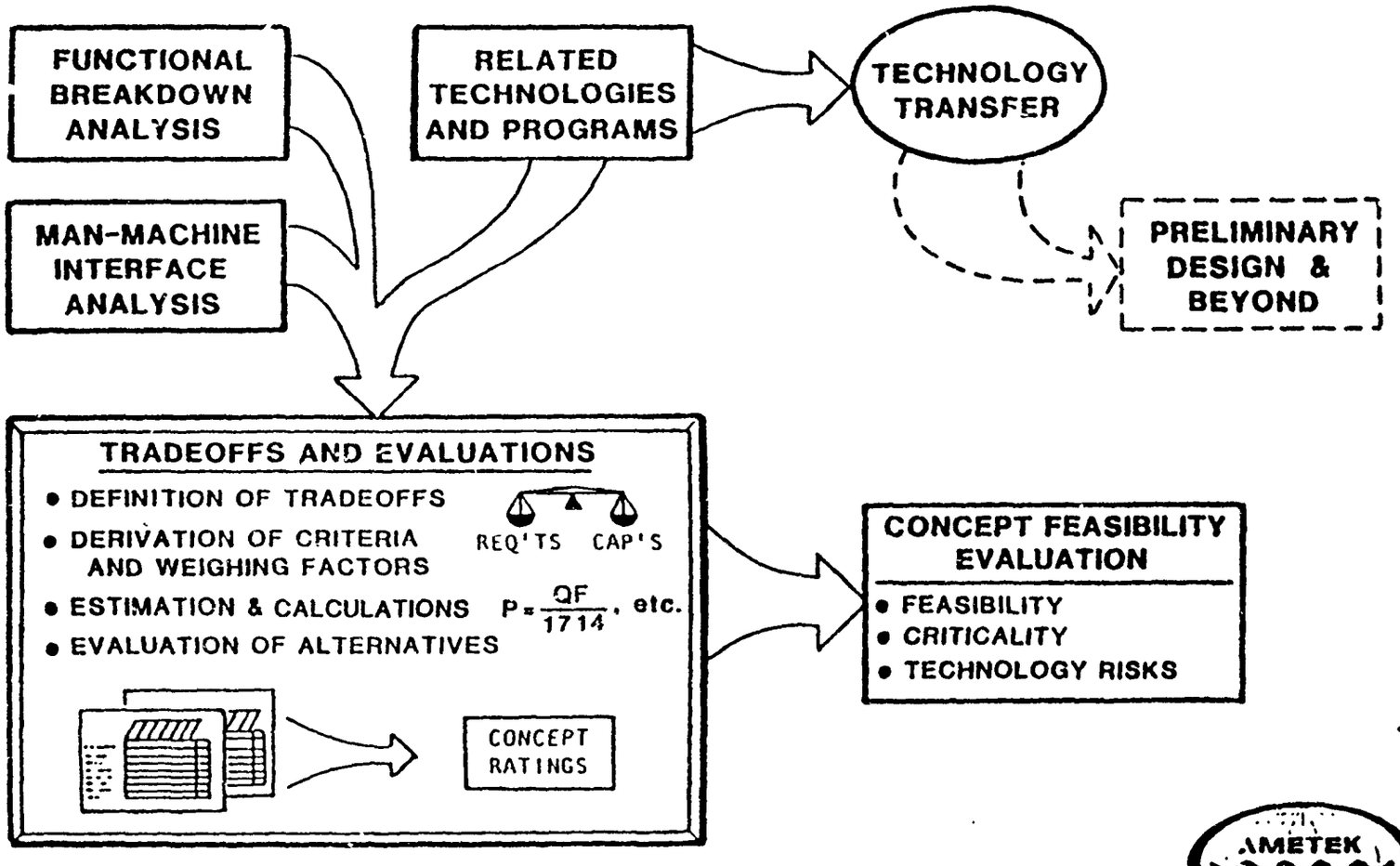
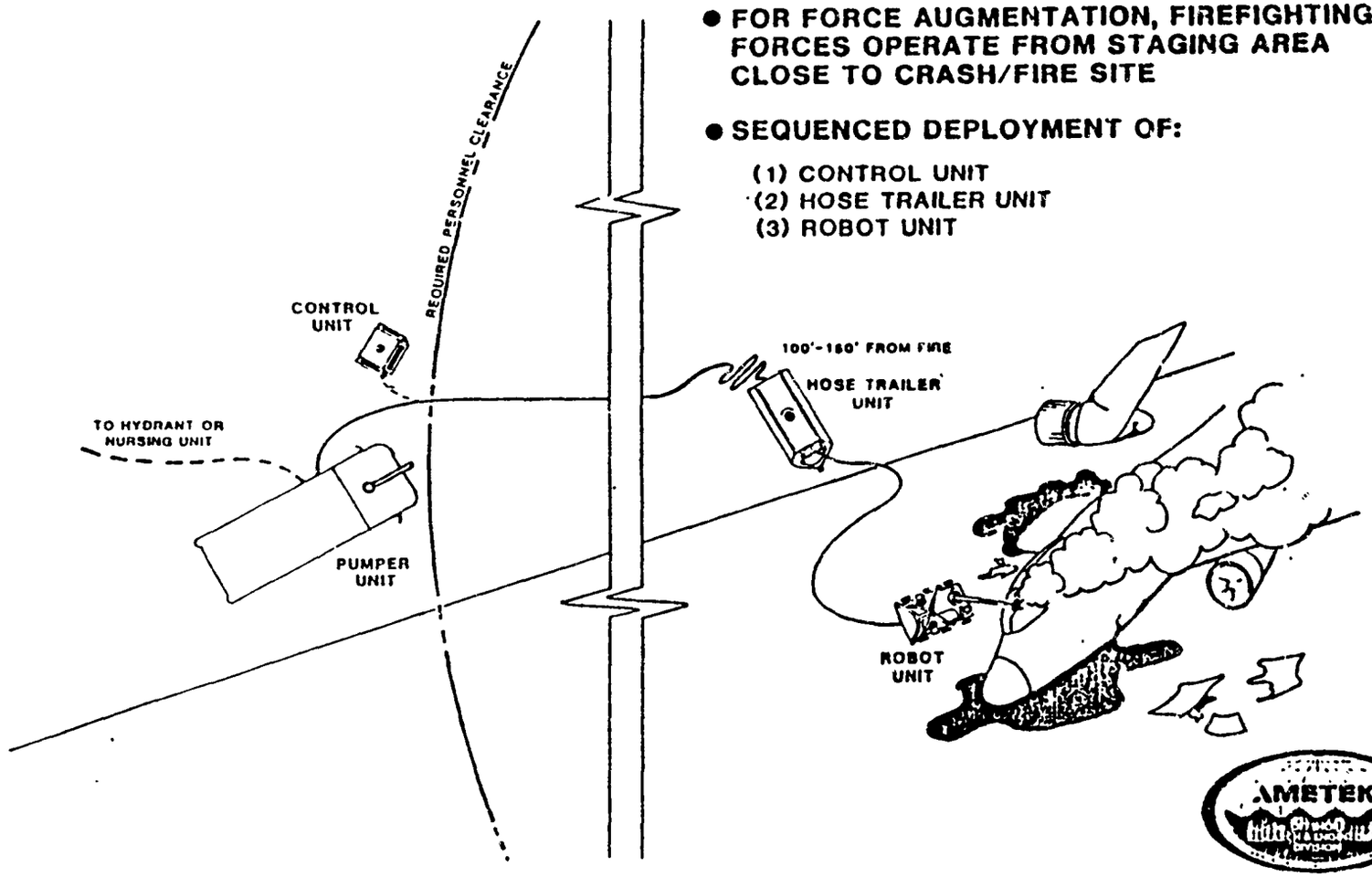
FUNCTIONAL CAPABILITIES AND TRADEOFFS



DEPLOYMENT CONCEPT

- COMPOSITE OPERATIONAL SCENARIOS ILLUSTRATED
- FOR FORCE AUGMENTATION, FIREFIGHTING FORCES OPERATE FROM STAGING AREA CLOSE TO CRASH/FIRE SITE
- SEQUENCED DEPLOYMENT OF:
  - (1) CONTROL UNIT
  - (2) HOSE TRAILER UNIT
  - (3) ROBOT UNIT



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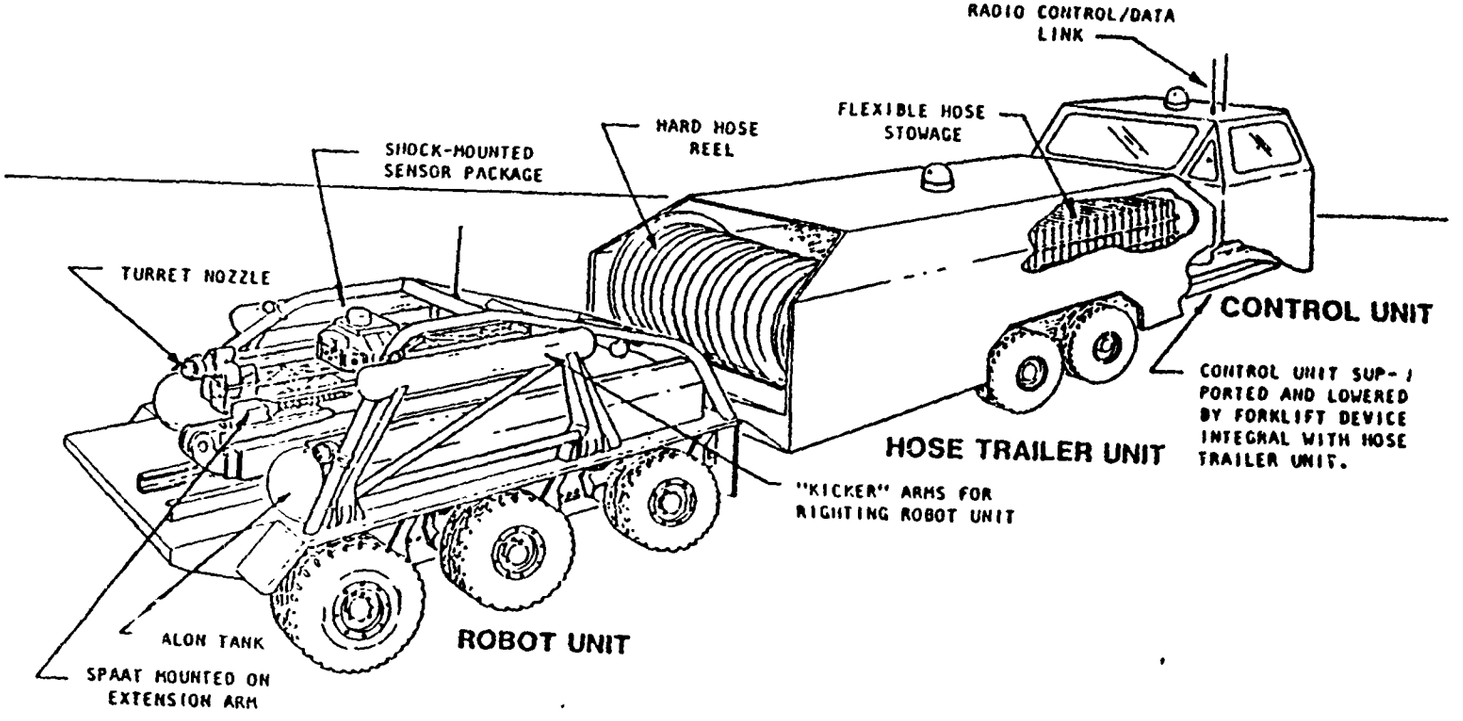
CFR

3 OCTOBER 1985

SYSTEM CONCEPT DESIGN ILLUSTRATION



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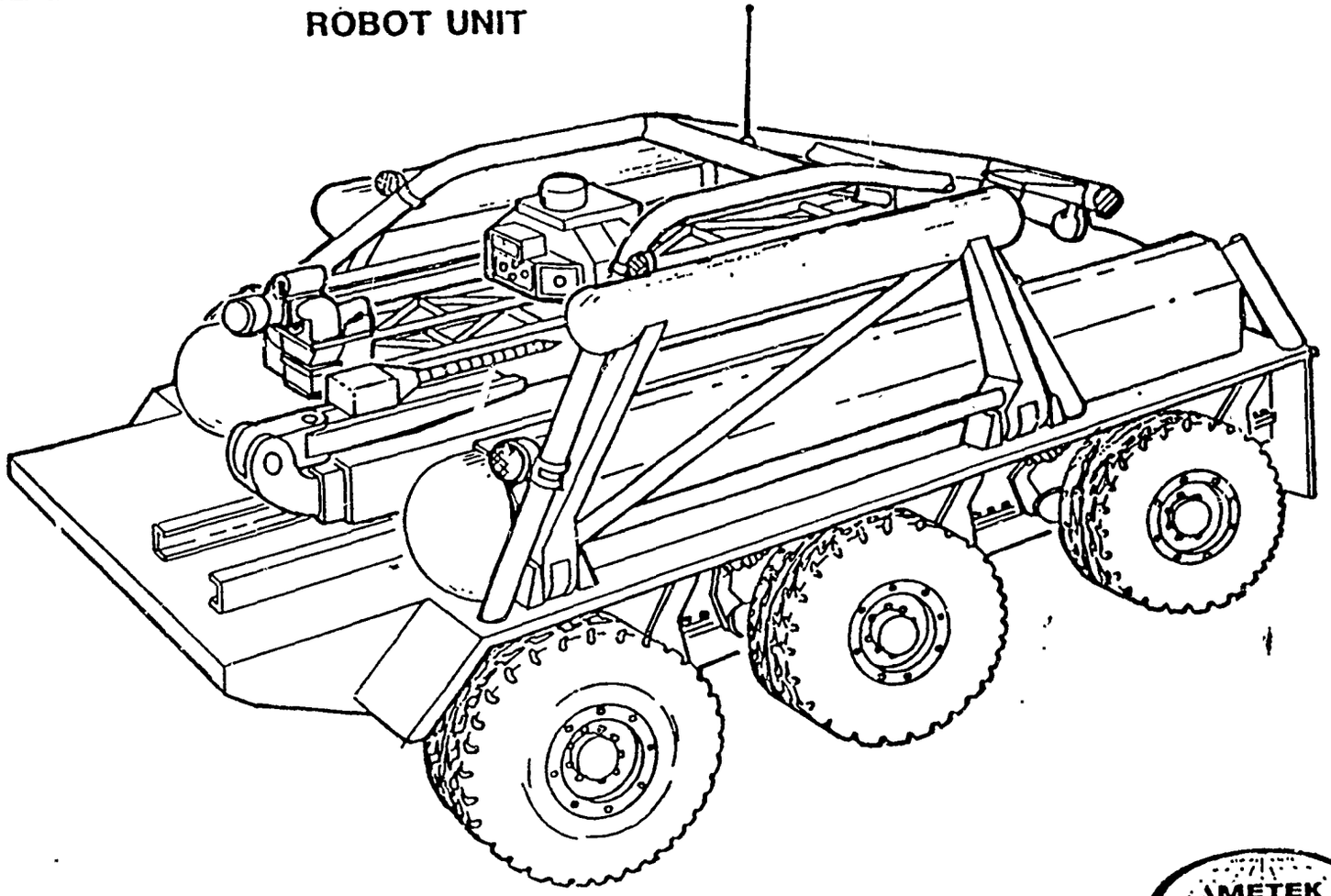
3 OCTOBER 1985

SYSTEM CONCEPT DESIGN ILLUSTRATION

ROBOT UNIT



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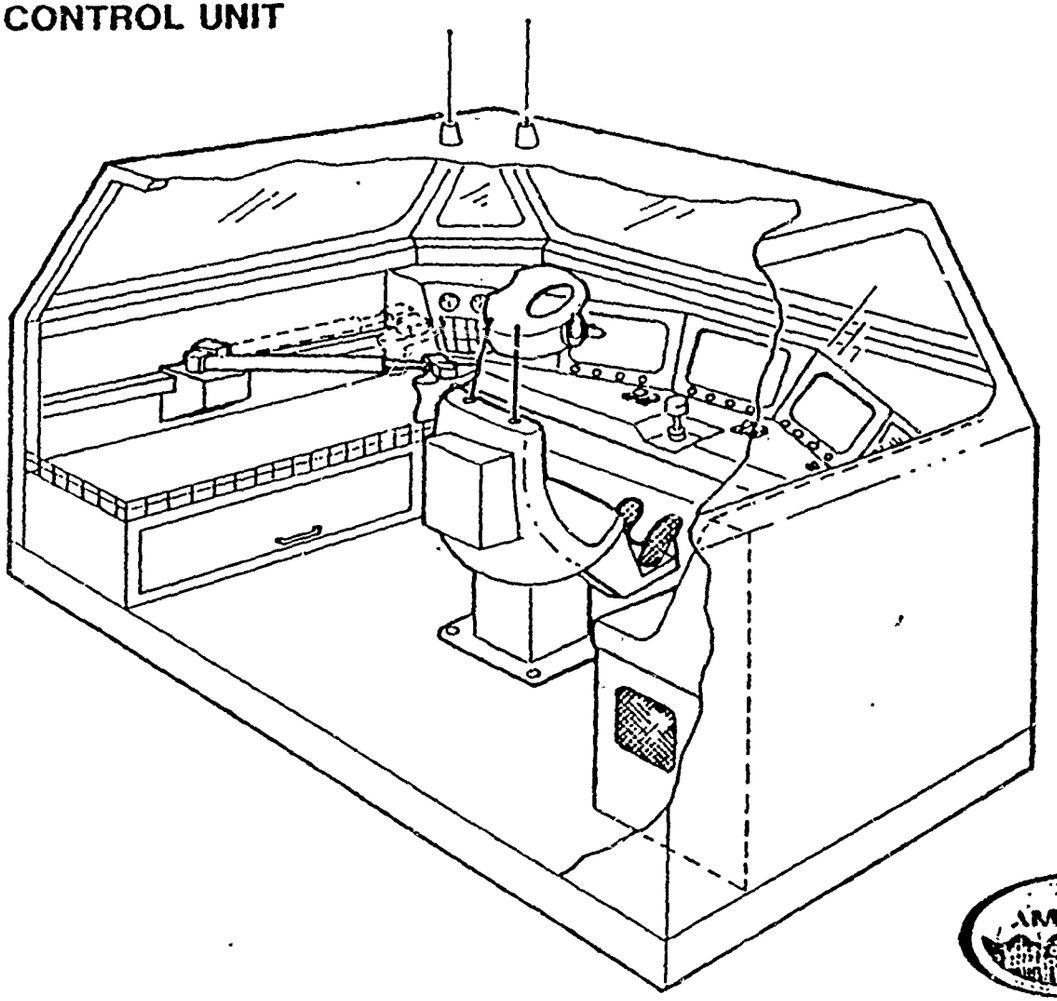
CFR

3 OCTOBER 1985

SYSTEM CONCEPT DESIGN ILLUSTRATION

CONTROL UNIT



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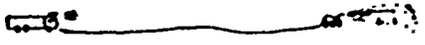
HAZARDOUS MATERIALS

POTENTIAL ROLES

INITIAL SITE SURVEY

- DETECT & CHARACTERIZE HAZMATS (1)
- MAY BE TIME CRITICAL

NEUTRALIZATION/CONTAINMENT



- AREA WASHDOWN (2)
- NEUTRALIZING AGENTS
- SHUT OFF VALVES, ETC.
- BUILD CONTAINMENT DIKES

REQUIRED ADDITIONAL CAPABILITIES

- ADDED CHEMICAL AGENT DETECTORS
- CONTAMINATION/DECONTAMINATION DESIGN
- LOW-OXYGEN-ATMOSPHERE OPERATION
- EXPLOSIVE-PROOF

- NEUTRALIZING AGENT DISPENSING
- DEXTROUS MANIPULATOR ARMS & END-EFFICTORS
- "PLOW" AND SPECIAL FEATURES

(1) DETECTORS FOR SPECIAL WEAPONS CHEMICAL AGENTS SHOULD PROVIDE LIMITED HAZMAT DETECTION CAPABILITY

(2) AREA WASHDOWN WITH WATER GENERALLY WITHIN CAPABILITY OF BASELINE CONCEPT

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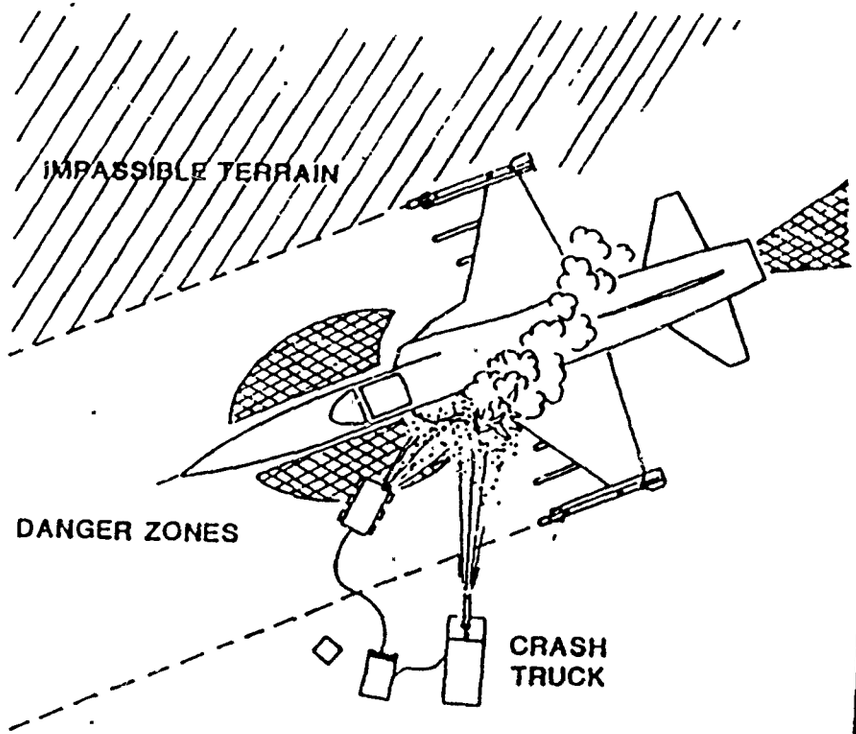
FORCE AUGMENTATION

POTENTIAL ROLES

- ROBOTIC FIREFIGHTER AUGMENTS DEPLOYMENT OF EXISTING EQUIPMENT AND PERSONNEL
- DEPLOY ROBOTIC FIREFIGHTER INTO AREAS OF POOR ACCESSIBILITY, e.g. ADVERSE WIND, DEBRIS
- DEPLOY ROBOTIC FIREFIGHTER INTO PERSONNEL HAZARD DANGER ZONES

ADDITIONAL REQUIRED CAPABILITIES

- EXTRA QUICK DISCONNECT ON HOSE TRAILER UNIT TO BYPASS FLEXIBLE HOSE



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EOD POTENTIAL OPERATIONAL ROLES

- **ORDNANCE LIFT AND CARRY**
  - ARM WITH (WRIST, ELBOW, SHOULDER) 6 DOF
  - END-EFFECTOR WITH FORCE AND TACTILE FEEDBACK FOR DELICATE GRABBING, LIFTING, AND POSITIONING
  - VEHICLE SHIELDING AND PROTECTION
- **ORDNANCE TRANSPORT**
  - OPERATE OVER LONG DISTANCES - UP TO SEVERAL MILES
  - OPERATE IN ROUGH TERRAIN OF BOMB DISPOSAL SITE
- **ORDNANCE DISPOSAL**
  - COUNTER CHARGE EMPLACEMENT/DISARM CAPABILITY
  - CLEAN-UP/PICK-UP ORDNANCE PARTS AT DISPOSAL SITE
- **IMPROVED VISIBILITY**
  - 3-D COLOR CAMERA
  - CONTROLLABLE (PAN, TILT, TELESCOPING)

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APPENDIX B

ENGINEERING CHANGES

PROPOSALS

AMETEK

OFFSHORE RESEARCH & ENGINEERING DIVISION
[illegible] P.O. BOX [illegible]
[illegible]

TELEPHONE [illegible]
TELEX [illegible]

SER/966/JHM

January 28, 1985

AD/PMR/PCO Code FQ7621
Eglin AFB, FL 32542-5000

Reference: P.O. #8635-85-C-0107
Remotely Operated Robotic Firefighter

Subject: Proposed revision of technical effort

Pursuant to the technical results of Phase I of the program and the Concept Feasibility Review, AMETEK/ORED recommends clarification and revision of the technical approach as specified herewith. The purpose of this proposed revision of technical effort is to minimize technical risks and provide meaningful, practical deliverables, i.e., a system design which is consistent with the state-of-the-art of robotics technology development and which can be reasonably extrapolated into a fieldable system.

Attachment 1 summarizes the recommended revised technical effort. This effort does not supercede the requirements of the contract Statement of Work, but directs specific efforts within the context of the SOW. Technical requirements and functional specifications will be consistent with the revised technical effort. The GFE firefighting vehicle noted in the attached will be returned upon completion of the program.

This revision does not involve any changes to the monetary value, delivery schedule, or other provisions of the contract, and is submitted in accordance with contract FO8635-85-C-0107, Section I, AFSC FAR SUP 52.243-9002, "Changes Requiring No Equitable Adjustment".

Please address any questions to the undersigned.

Sincerely,

AMETEK/OFFSHORE RESEARCH & ENGINEERING DIVISION

John H. McNally

John H. McNally
Controller

cc: AFESC/RDCS

ATTACHMENT 1

RECOMMENDED REVISED TECHNICAL EFFORT

Reference: Contract F08635-85-C-0107
Remotely Operated Robotic Firefighter

1. Data and drawings of the selected firefighting vehicle (P-4 or P-19) will be obtained through Hq AFESC/ RDCS.

2. Commercially available remote-control equipment will be surveyed for applicability to operation of the vehicle mobility and firefighting capabilities.

3. Performance criteria will be developed for remote operation of the vehicle in addressing the operational and technical requirements for the Robotic Firefighter.

4. Systems analysis and tradeoff studies will be performed to determine the feasibility of remote operation of the selected firefighting vehicle. This will include a self-contained and self-powered portable control module for the operator which can quickly be set up at the required Personnel Clearance distance, and wireless communications links for control and feedback signals.

5. The concept feasibility of remote operation of the selected firefighting vehicle will be reviewed with AFESC/RDCS during the Program Review meetings. Presentation materials will include concept sketches.

6. Preliminary Design will be conducted for the approved concept approach. Emphasis will be given to application of commercially available components. Drawings and specifications will be reviewed during Program Review meetings (Preliminary Design Review).

7. Detailed Design will be accomplished, incorporating any changes from the PDR.

8. As required to confirm system performance, key system components will be procured, configured, and tested. For this purpose, a firefighting vehicle (P-4 or P-19) will be provided as Government-Furnished Equipment (GFE), along with necessary maintenance, parts, and consumables. Any modifications performed on the GFE P-19 will not preclude restoration to the original configuration upon completion of testing and evaluation. The GFE vehicle will be delivered to AMETEK/ORED by the Government, as requested to support this task; for operational testing, the Government will transport the P-19 from AMETEK/ ORED to the Government test site, and will provide operating and maintenance personnel for testing. Upon completion of testing and evaluation, the GFE vehicle will be turned over to the Government.

ENGINEERING CHANGE PROPOSAL, PAGE 1 (SEE MIL-STD-480 FOR INSTRUCTIONS)

DATE PREPARED: 15 Aug 1986

PROCURING ACTIVITY NO.

ORIGINATOR NAME AND ADDRESS: AMETEK/OFFSHORE RESEARCH & ENGINEERING DIV (ORED)
P. O. Box 6447, Santa Barbara, CA 93160-6447

CLASS OF ECP: I | JUST CODE: D | PRIORITY: R

ECP DESIGNATION

a. MODEL/TYPE	b. MFR. CODE	c. SYS. DESIG.	d. ECP NO.	e. TYPE	f. REV	g. CHAR.
None				F		

a. BASELINE AFFECTED: [ ] FUNCTIONAL [ ] ALLOCATED [ ] PRODUCT

i. SPEC. SYS./CONFIG. ITEMS AFFECTED: [ ] YES [X] NO

h. SPECIFICATIONS AFFECTED - TEST PLAN	MFR CODE	SPEC./DOC. NO.	SCN
a. SYSTEM			
b. ITEM			
c. TEST PLANS			

j. DRAWINGS AFFECTED	MFR CODE	NUMBER	REV	MOD NO.

k. TITLE OF CHANGE: Oscillating Turret Nozzle for GFE P-4 Truck

l. CONTRACT NO. & LINE ITEM: F08635-85-C-0107 CLIN 0001

m. CONFIGURATION ITEM NOMENCLATURE

n. IN PRODUCTION: [ ] YES [X] NO

o. NAME OF PART OR LOWEST ASSEMBLY AFFECTED

p. PART NO. OR TYPE DESIGNATION

q. DESCRIPTION OF CHANGE

Purchase a specially-adapted Oscillating Turret Nozzle* for adaptation to the GFE P-4 vehicle to be used as a demonstration prototype for remote operation of firefighting and mobility functions. The Feecon nozzle and control panel are described in Attachment 1. (CONTINUED ON NEXT PAGE)

r. REASON FOR CHANGE

Ametek/ORED change proposal (letter, 28 Jan 86), approved 6 May 86, included a request for a GFE P-19 vehicle to serve as a test bed for demonstration of remote firefighting capabilities. The P-19 has automatic oscillating turret nozzles. The Government approved the recommended revision of technical effort (CONTINUED ON NEXT PAGE)

s. PRODUCTION EFFECTIVITY BY SERIAL NUMBER

t. EFFECT ON PRODUCTION DELIVERY SCHEDULE

u. RECOMMENDED ITEM EFFECTIVITY

v. SHIP/VEHICLE CLASS AFFECTED

w. COSTS

x. LOCATIONS OF SHIP/VEHICLE NUMBERS AFFECTED

y. ESTIMATED COSTS/SAVINGS: DOD $ 11,086. CONTRACT $

z. ESTIMATED NET TOTAL COSTS: $ 15,751.

aa. SUBMITTED BY (NAME/TITLE/SIGNATURE): Controller

ab. APPROVALS

ASSIGNED	ACTION			
[ ] APPROVAL RECOMMENDED	[ ] APPROVED	[ ] DISAPPROVED	[ ] CONCUR W/ CLASSIFICATION OF CHANGE	[ ] DO NOT CONCUR W/ CLASSIFICATION OF CHANGE

ac. RECOMMENDED BY: SIGNATURE: DATE:

DD FORM 1692

FIGURE 2A. ECP page 1 (DD Form 1692).

* Feecon is uniquely qualified to supply a fully-compatible oscillating turret nozzle as they are the manufacturer of the existing manual turret nozzel on the P-4 and can satisfy all the interfaces, precluding permanent interface modification of the GFE P-4.

(CONTINUATION)

16. Description of Change

Remove manual roof turret nozzle and replace with the oscillating turret nozzle; original manual nozzle to be repalced after demonstration testing.

17. Need for Change

but substituted a P-4 for the requested P-19. The manual turret nozzles on the P-4 cannot be adapted for remote operation, so one manual nozzle needs to be replaced with an oscillating turret nozzle for testing.

FEECON CORP
A Subsidiary of [redacted] Corp
9 Otis Street P O Box 338
Westboro Massachusetts 01581

July 23, 1986

Ametek Offshore Research Engineering Division
P.O. Box 6447
Santa Barbara, CA 9310-6447

Attn: Richard Papina-Chapla

Gentlemen:

In accordance with our discussion of July 16, 1986 we can furnish a roof turret for the P-4 Crash Fire Truck which we believe will meet your requirements. We propose to furnish a turret with the following characteristics and capabilities:

1. The turret panel will be the same size as the existing turret and will interface with existing foam solution and hydraulic connections. A preliminary proposal drawing is enclosed.

2. The flow rate will be the same as the existing turret namely 800 gpm at full rate and 400 gpm at half rate. Interlocks will provide for momentary shut down while changing rates.

3. The turret discharge will be of the non-air aspirating type in accordance with the U.S. Air Force's latest design requirements.

4. The turret control system will be electric over hydraulic utilizing the vehicle's 24 volt electrical system and existing hydraulic power supply. A preliminary circuit schematic is enclosed. The current requirement for the solenoid valves would be 1.4 amps per solenoid in use. Normally we would not expect more than two or three solenoids to operate simultaneously. We would supply a terminal block with terminals adequately identified for you to interface your robotic controls.

5. We are proposing to supply an oscillating capability similar to what we have supplied on the Air Transportable P-4 Modification 1000 gpm Bumper Turret. This would provide oscillation capability up to the full rotation capability of the turret. Control arms can be set manually to set oscillation to any angle above zero degrees and to operate at any location within the

Phone 617 [illegible] 1137 Cable FEECON Westboro Mass Telex 4973172FEEC UI Fax 617-366-6134
Manufacturers and Consultants – Specialty Fire Protection Equipment and Services

FEECON CORP.
A Subsidiary of [redacted] Corp
9 Otis Street, P O Box 338
Westboro, Massachusetts 01581

full rotational arc. If it is necessary to control the arc of oscillation for your robotics we can add actuators to provide remote control.

The price of the turret would be $14,000.00. We would like about 60 days to build the unit but could probably reduce that time somewhat if your program requires a better delivery.

If you need modifications to permit proper interface with your equipment do not hesitate to contact us.

Sincerely,

James F. O'Regan
President

Encl.
JFO'R:srp

Phone 617-366-9137 Cable FEECON Westboro, Mass Telex 4973172FEEC UI Fax 617-366-6334
Manufacturers and Consultants—Specialty Fire Protection Equipment and Services

SER/ /

October 10, 1986

AD/PMR/PCO Code FQ7621
Eglin AFB, FL 32542-5000

Reference: P.O. #8635-85-C-0107
Remotely Operated Robotic Firefighter

Subject: Proposed Engineering Change Proposal

In accordance with the referenced contract, Section I, page 16, DOD FAR SUP 52.243-7000, the attached Engineering Change Proposal is submitted for consideration by the Government. This ECP is in response to changes requested by Government representatives during the Interim Phase II Review meeting, PR-5, held at Tyndall AFB, FL on 3 September 1986.

We have established a priority of Routine for this ECP, but encourage expeditious review and approval, to allow return of the GFE P-4 to the operational unit at the earliest possible date.

Only Page 1 of the DD Form 1692 is submitted, as the system has not yet been developed to the point of a Functional Baseline; the Preliminary Design Review is scheduled to coincide with completion of Phase II on 21 February 1987. There is, therefore, no assigned Configuration Item number or nomenclature at this time.

Please address any questions to the undersigned.

Sincerely,

AMETEK/OFFSHORE RESEARCH & ENGINEERING DIVISION

Gary L. Schramm
Controller

cc: AFESC/RDCF

Attachment: DD Form 1692

RECOMMENDED WORDING FOR DD FORM 1692

Block 10, Title of Change:

Remote Control Upgrades for GFE P-4 Truck

Block 16, Description of Change:

1. Modify baseline remote control system for demonstration prototype P-4 vehicle to allow "flip-the-switch" instantaneous conversion from manual to remote operation and vice versa. This entails design, purchase, and installation of electrically-actuated controls for steering, braking, throttle, and other functions.

2. Modify baseline video system to preclude possible damage from direct viewing into the sun. This modification involves special filters for the baseline camera or upgrade to CCD-type cameras.

3. Add a rear-view camera to provide a selectable view to the back of the P-4 for reverse operation. In order to provide this capability, a third video camera, mounting provisions, and associated video switching must be added to the baseline.

4. Reconfigure the baseline remote control module to provide a steering wheel and separate foot pedals for brake and throttle in lieu of a single "joystick" controller for mobility. This modification necessitates a larger control panel, a scaled steering wheel, and separate breakout foot pedals for braking and throttle. The modification includes engineering design, components, and installation.

5. Reconfigure the baseline remote control module to allow two operators to work side-by-side, one for mobility control and the other for firefighting control, and provide fold-up legs. This design change involves reconfiguration of the remote control module design to provide a larger control panel with control clustering, and fold-out legs attached to the underside of the module. The foot pedals in Item 4 above should be secured to the fold-up legs for stability during use.

6. Provide a "pistol-grip" type controller for the oscillating turret nozzle in lieu of a standard joystick controller. This controller is more expensive than the baseline controller, but is more similar to the "standard" controller for oscillating turret nozzles on the P-19.

7. Provide for interface of a "scene monitor" capability in the command vehicle, to allow monitoring of the video from the P-4

at the incident command post. The scene monitor and mounting in the command vehicle are expected to be GFE.

8. Add a remote start (engine restart) capability to the baseline remote demonstration system.

Block 17, Need for Change:

1. The baseline demonstration vehicle design reviewed during the Interim Phase II Review meeting uses a set of procedures, including electrical and mechanical changes, to convert from manual operation to remote and vice versa. This approach is consistent with the requirements for the demonstration prototype. However, in order to make the remote demonstration more operationally meaningful, the Government representatives at PR-5 requested that the P-4 demonstration vehicle be provided with a capability for instantaneous remote-manual conversion capability. This will allow personnel participating in the proof-of-concept demonstration to leave the demonstration vehicle expeditiously at the point that the simulated decision is made to evacuate the fire scene.

2. Demonstration testing procedures for the baseline system included provisions to avoid pointing the cameras directly into the sun, as the baseline video cameras use pickup tubes which can be permanently damaged by direct sunlight. Government representatives at PR-5 requested that special filters be installed or some other measures be taken to preclude camera sensitvity to direct sunlight.

3. The baseline demonstration vehicle relies on the view in the rear-view mirrors using the pan/tilt/telescopic camera to provide a view to the rear for limited backing up of the vehicle. Government representatives at PR-5 requested that a rear-view camera be added to provide a better view to the rear when backing up.

4. The baseline demonstration remote control module utilizes a single joystick controller to provide steering, braking, and throttle control; advancing the control advances the throttle, retarding the control applies the brakes, and twisting the control steers the vehicle right or left. Government representatives at PR-5 requested that a "steering wheel" and separate brake and throttles be substituted for the single controller, in anticipation that these types of controls will be more natural for firefighters.

5. The baseline remote control module was set up for operation of all functions, mobility and firefighting, by a single operator; this allowed the module to be compact and light. Government representatives at PR-5 requested that the module be increased in size to allow two operators to work side-by-side,

one operating mobility controls and the other firefighting controls, and that the module be provided with fold-up legs to stand in place during operation.

6. The baseline controller for the oscillating turret nozzle which was proposed is a simple four-way controller for elevation and sweep, with a push-button for discharge. Government representatives at PR-5 requested that a "pistol-grip" controller similar to that used with the oscillating turret nozzle on the P-19 be substituted for the standard controller. They feel that this would be more natural for firefighters.

7. As an adjunct to the monitoring of video feedback by the operators at the remote control module, Government representatives at PR-5 requested that provisions be added to the system such that command personnel could monitor the video from the remote vehicle in the command vehicle. In order to provide for this capability, a video signal jack, coaxial cable, and associated connectors will be added with the remote control module.

8. For the purposes of the feasibility demonstration testing, the remote control system did not include a remote start capability, as the vehicle would be left running at the start of testing, and it was considered appropriate to approach the vehicle for restart in the event that the engine died. Government representatives at PR-5 requested that a remote start capability be added to the baseline system. This entails adding a start switch and indicator to the remote control console, and adding additional channels to the remote data link (telemetry and signal conditioning circuitry).

NOTE:

Block 22 should be just under $50,000.00. Attached sheet shows our estimates presented to Vickers and Grimm on 22 Oct 86; these need to be scaled upward to match the $49.x K with added engineering.

PROGRAM MEMORANDUM

21 October 1986

REMOTELY-OPERATED ROBOTIC FIREFIGHTER
Contract #F0835-85-C-0107, ORED #G-OS-WO-108

Preliminary Proposed ECP#2 Revisions and Estimated Costs

This memorandum summarizes the proposed revisions in technical effort and associated estimated costs resulting from the Interim Phase II Review Meeting PR-5 held on 3 September 1985 at HqAFESC/RDCF, Tyndall AFB, FL for the referenced contract.

#	Subject	Revisions	Est. Cost
1	"Flip Switch" Remote/ Local Control	Single-switch changeover for steering, braking, throttle, transmission, cameras, stowage, etc.	14.1 K
2	Video Insensitive to Direct Sunlight	Upgrade cameras to CCD-type (two each)	1.8 K
3	Rear-View Camera	Added camera, lens, mount, wiring, switching, and associated telemetry	5.1 K
4	Mobility Control Configuration	Steering wheel, throttle & brake pedals, and mounts in lieu of joystick	4.4 K
5	Two-Operator Control Configuration	Larger control module case and control panel, revised layout	6.5 K
6	"Pistol-Grip" Nozzle Controller	Special controller and mounted pistol-grip with agent dispense trigger	2.3 K
7	"Scene Monitor" Compatibility	Auxiliary signal jack and impedance matching terminator, plus mounting	1.5 K
8	Remote Start Capability	Added switches and associated telemetry	3.8 K
		Total Estimated Cost	39.6 K

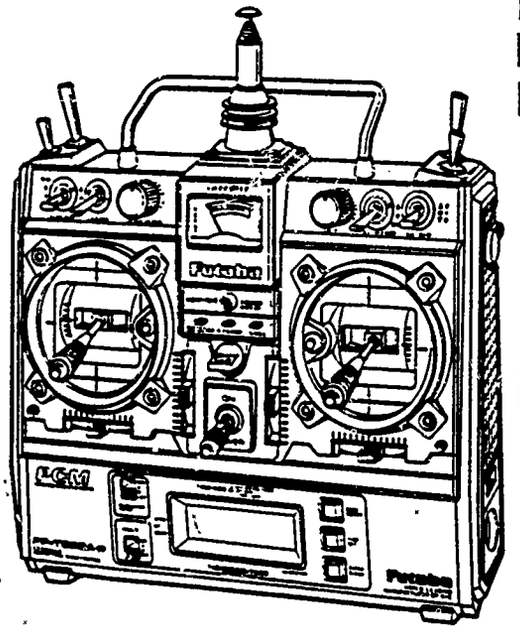
Note: "Light Armor" addition to be subject of separate ECP.

APPENDIX C

FDM EQUIPMENT DATA SHEETS

Futaba®

DIGITAL PROPORTIONAL
RADIO CONTROL



PCM

PULSE CODE MODULATION SYSTEM

INSTRUCTION MANUAL

FP-8SGAP

PCM 8 CHANNELS
FOR F3A AIRCRAFT

FUTABA CORPORATION OF AMERICA
FUTABA CORPORATION

O60354

●FEATURES

The FP-8SGAP was specially developed to use PCM (pulse code modulation) for FAI RC aerobatics F3A aircraft. It is an extremely noise and dead-point resistant digital proportional RC set with a microprocessor in the transmitter and the receiver. Please read this manual before using your set.

TRANSMITTER FP-T8SGAP

- RF module system. The frequency band can be changed with one touch.
- DSC (Direct Servo Controller) allows operation of the servos without turning on the transmitter. Wire operation is possible by using the special cord supplied (FSC.1)
- Servo reversing switch for all channels allows reversing of the servos with the flip of a switch.
- Dual rate or non-linear VTR (variable trace ratio) aileron, elevator, and rudder. Two-stage dual rate on aileron.
- Rudder auto dual rate. Rudder dual rate is turned on and off automatically with operation of the throttle stick.
- Newly designed slantable open gimbal sticks provide maximum operation feel. Stick angle and spring strength can be adjusted.
- Non-slip adjustable lever head. The stick length ❷ can be adjusted by turning the knob head.
- New throttle → pitch control mixing is perfect for variable pitch propeller which maximizes engine power and propeller efficiency.
- Mutual mixing function allows aileron + elevator, aileron + flaps, and aileron + rudder mixing and aileron differential operation.
- Elevator → flap mixing is especially advantageous in circle aerobatics.
- Flap, spoiler → elevator mixing allows control of the aircraft attitude while using the air brake (flap, spoiler).
- Throttle → (flap, spoiler) → elevator mixing allows enhancement of the air braking effect by throttle stick operation when diving and landing.
- Programmable mixing function permits mixing with the desired channel.
- Four-function snap roll switch (timer is optional)
- Idle-up lever, the engine idling speed can be independently adjusted during throttle → pitch control mixing.
- New single-chip microprocessor allows one-touch fail safe setting and introduction of an automatic transmission system which eliminates the need for fail safe setting at the beginning of each flight and improves safety.
- Pitch control lever. HIGH side pitch of variable pitch propeller can be adjusted during throttle → pitch control mixing.
- New ATV (Adjustable Travel Volume) on all channels allows independent adjustment of servo left, right, up, and down throw.
- Second ATV. Besides new pushbutton ATV on aileron and elevator, conventional trimmer ATV is also installed.
- Monitor lamp comes on when throttle → flap, spoiler → elevator mixing or throttle → pitch control mixing and flap, spoiler → elevator mixing and snap roll are set and goes out when they are in use.
- Fail-safe switch (function OFF switch) is provided for each function so that only the desired functions need be turned on.
- Throttle ATL (Adjustable Throttle Limiter) makes throttle linkage simple and positive.
- Two servo test functions. A slow sweep to check neutral characteristic, trackability cycle servo to test servo operation.
- Tachometer/timer with built-in tachometer, up timer, down timer, integrating timers, and battery alarm functions.
- Built-in power error back-up circuit. When the internal Nicd battery approaches the fully discharged state, an LED flashes to indicate that the memories presetted (memory, ATV, FS, etc.) are gone. Please charge battery and set all memory functions again.
- Highest quality extruded aluminum case. Sophisticated transmitter design gives easy fitness and comfortable feeling to your hands.
- Neck strap supplied as a standard accessory. The numerous functions of the transmitter can be easily performed by supporting the transmitter from your neck.

CONTENTS AND RATINGS

Ratings and specifications are subject to change without prior notice.

Model	FP-8SGAP
Transmitter	FP-T8SGAP x 1 with module FP-TF-FM
Receiver	FP-R118GP x 1
Servos	FP-S130 x 4
Switch	SWH-5 x 1 (R4-SWJ x 1)
Nicd battery	NR-4J x 1
Accessories	Battery charger, landing gear adaptor, DSC cord, CHG adaptor, DSC-CHG cord, servo tray, frequency flag, spare horn, neck strap, screws

Transmitter FP-T8SGAP

Operating system : Two-stick, 8 channels for F3A pattern

Transmitting frequency : 50/53MHz BANDS / 72/75MHz BANDS } Chosen band
53MHz ↔ 72MHz
Frequency change to any of above bands is possible by merely changing RF module.

Modulation : PCM, FM

Power requirement : 9.6V 8/500mAH internal Nicd battery

Current drain : 250mA

Receiver FP-R118GP

Receiving frequency : 50/53MHz BANDS / 72/75MHz BANDS } Chosen band

Intermediate frequency : 455kHz

Power requirement : 4.8V Nicd battery (shared with servo)

Current drain : 42mA (4.8V reception)

Dimensions : 2.23 x 1.65 x 0.94 in (57 x 52 x 24mm)

Weight : 1.85oz (53g)

Receiving range : 500m on the ground
1000m in the air
When FP-T8SGAP used.
(At the best radio wave condition of environment)

Servo FP-S130

Control system : +pulse width control, 1520 μS.N

Operating angle : One side 45° or greater (including trim)

Power requirement : 4.8V (shared with receiver)

Current drain : 5mA (at idle)

Output torque : 55.6oz.in (4kg-cm)

Operating speed : 0.24 sec/60°

Dimensions : 1.52 x 0.77 x 1.36 in (38.5 x 19.5 x 34.5mm)

Weight : 1.47oz (42g)

Landing Gear Servo FP-S130G (Option)

Control system : +pulse width control

Operating angle : Rotary approx 160°

Power requirement : 4.8V (shared with receiver)

Current drain : 8mA (at idle)

Output torque : 65.3oz.in (4.7kg-cm)

Operating speed : 0.34 sec/60°

Dimensions : 1.52 x 0.77 x 1.36 in (38.5 x 19.5 x 34.5mm)

Weight : 1.48oz (42g)

Battery Charger FBC-8B(2)

Input voltage : 120VAC, 50/60Hz

Output : TX side 9.6V/45mA
RX side 4.8V/45mA

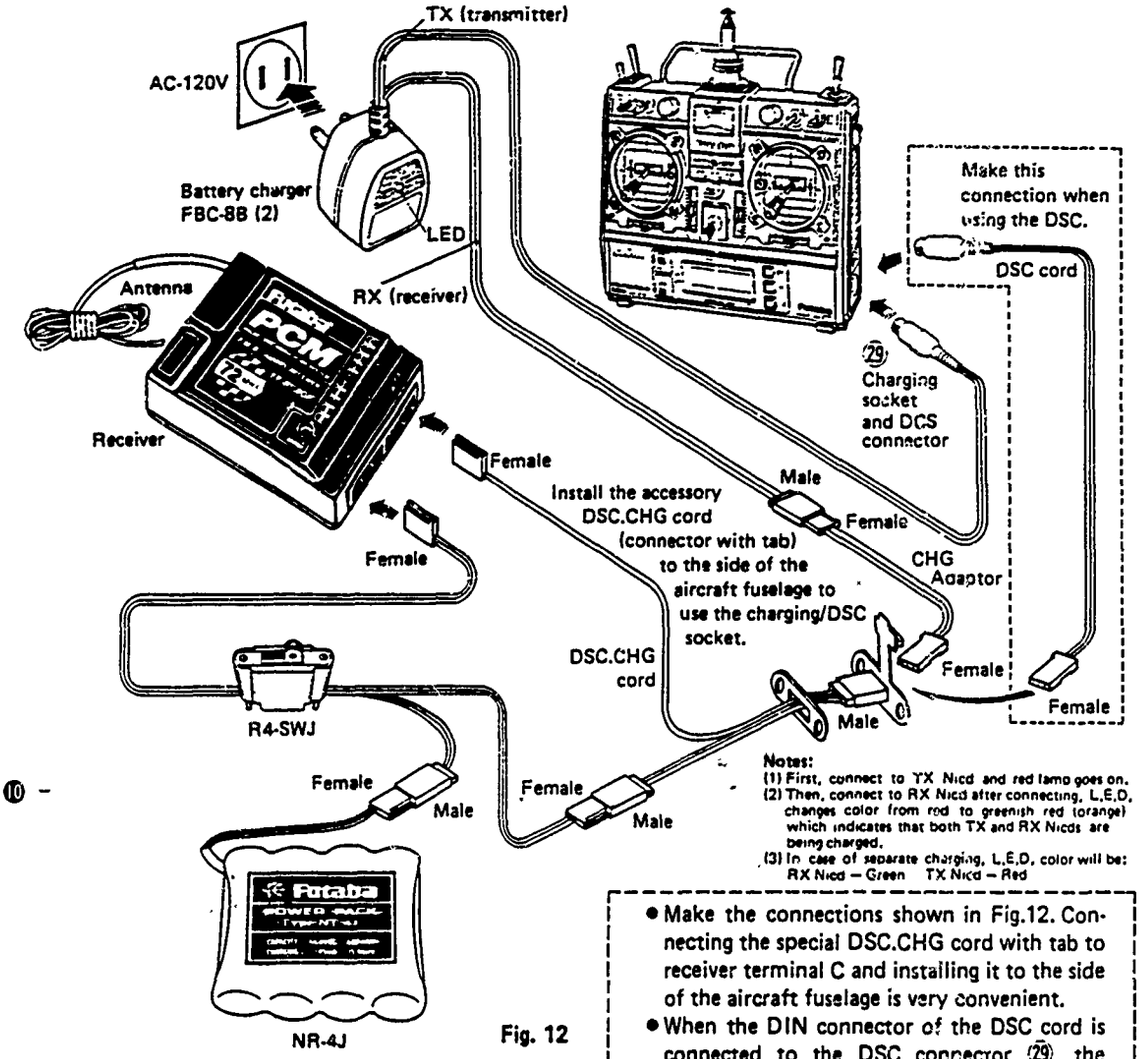
Receiver Servo Nicd Battery NR-4J

Voltage : 4.8V, 4/500mAH

Dimensions : 2.01 x 2.28 x 0.59 in (51 x 58 x 15mm)

Weight : 3.35oz (95g)

●BATTERIES AND CHARGING INSTRUCTIONS



Notes:
(1) First, connect to TX Nicd and red lamp goes on.
(2) Then, connect to RX Nicd after connecting, L.E.D. changes color from red to greenish red (orange) which indicates that both TX and RX Nicds are being charged.
(3) In case of separate charging, L.E.D. color will be:
RX Nicd – Green TX Nicd – Red

Fig. 12

- Make the connections shown in Fig.12. Connecting the special DSC.CHG cord with tab to receiver terminal C and installing it to the side of the aircraft fuselage is very convenient.
- When the DIN connector of the DSC cord is connected to the DSC connector 29, the power to the encoder inside the transmitter is turned on. The transmitter power switch is OFF.
- When not using the DSC, disconnect the DIN connector.
- To operate the servos, turn on the receiver and servo switch.

- The Direct Servo Controller system connects the signals from the transmitter directly to terminal C of the receiver through a wire and controls the servos without radiating radio-waves. It is extremely convenient when flying on the same band or during meets, etc.

Before using your system, recharge the Nicd batteries as follows:

- Connect the DIN connector of the FBC-8B (2) battery charger to the transmitter charging socket 29. Also connect the 3P connector to the airborne NR-4J Nicd battery and plug the battery charger into a 120VAC outlet as shown in Fig.12. The airborne batteries can also be charged through the DSC/CHG harness by connecting the CHG adaptor to the charger as shown in Fig.12. In this manner, the airborne batteries can be charged without removing them from the model.
- Normally recharge the battery for about 15 hours. If it has not been used for some time, discharge and recharge it two or three times and then charge it a full 15 hours.

- The amount of time remaining before the batteries must be recharged can be estimated using the Integrating Timer function of the Tachometer/Timer 21. It is recommended that this function be used to monitor remaining flying time. (See Page 11 for detailed instructions.)

- The transmitter and receiver Nicd batteries can be charged together or independently.
- A fully-charged transmitter battery can be used for about 10 flights of 10 minutes each. The airborne NR-4J Nicd battery can be used for about 6 flights when 6 servos are used and about 4 flights when 10 servos are used.
- If the system is not to be used for some time, it should be fully charged before storage and recharged monthly to avoid full discharge and loss of memory settings (ATV, FS, BFS memory, etc.).

FS (FAIL SAFE) AND HOLD FUNCTIONS

HOW TO USE FS (FAIL SAFE) (THROTTLE CHANNEL AS AN EXAMPLE.)

1. Set Function Select Switch 49 to FS SELECT.
2. Set transmitter and receiver power switches to ON and check servo movements.
3. While switching the Channel Select Switch 48 from 1 to 8 in order, set the channel(s) to be used with FAIL SAFE by pressing Button 46 and those to be used with HOLD by pressing Button 47. (In this example, set CH3 to FS with Button 46.)
4. Move the throttle lever to maximum slow position, and press the FS Set Button 36 on the transmitter back.
5. CH3 is now set to LOW throttle for the FS function. After setting FS, turn the Channel Select Switch 48 and Function Select Switch 49 to OFF.
6. Test FS by turning the transmitter power switch to OFF. (In this example, all servos should move to neutral except the throttle servo which should move to the LOW position that was just set.)
7. Fail Safe for all channels selected can be set with one touch by moving the sticks and switches of all the channels to the desired positions and pressing the FS Set Button 36 once. (Switch 49 previously set to FS ALL.)
8. FS settings are retained in the transmitter memory circuit and transmitted automatically every 60 seconds (Monitor Lamp Ⓐ goes out momentarily during data transmission.) Therefore, resetting before each flight is unnecessary even though the receiver switch has been turned OFF.
9. After FS settings have been made, always set Function Select Switch 49 to OFF to prevent erroneous settings.
10. To clear all FS settings, set Switch 48 to Position 1, then press buttons 46 and 47 simultaneously.

FS/HOLD CAN BE CONFIRMED BY MONITOR LAMP.

- Function status can be confirmed by means of Monitor Lamp Ⓐ.
  When Function Select Switch 49 is at FS SELECT: Lamp Ⓐ ON = HOLD
  Lamp Ⓐ OFF = FS
- When Switch 49 is set to FS ALL, Lamp Ⓐ is OFF.
- When Switch 49 is set to ATV and Button 46 or 47 is pressed, Lamp Ⓐ blinks.

BFS (BATTERY FAIL SAFE) AND BFS MEMORY

- BFS (Battery Fail Safe) is a warning function which moves only the throttle servo to the same position as set for FS when there is only a small amount of power left in the receiver Nicd batteries. (If no FS position is set, the throttle servo is moved to medium slow.)
- When BFS occurs, the throttle servo can be released and throttle control regained for 36 seconds by lowering the throttle lever to IDLE.
- The throttle stick position at which throttle control is regained is programmable. This is known as BFS Memory and is set as follows:

1. Set Function Select Switch 49 to BFS MEMO SET and set Channel Select Switch 48 to Pos. 3 (Throttle).
2. Set the Throttle stick to the desired release point (between Slow and Medium Slow recommended) and press Buttons 46 and 47 simultaneously. BFS Memory is now set.
3. Set Switches 48 and 49 to OFF.
4. Whenever BFS occurs in flight, lower the throttle stick to regain control and immediately land the aircraft.

NOZZLE DATA SHEETS

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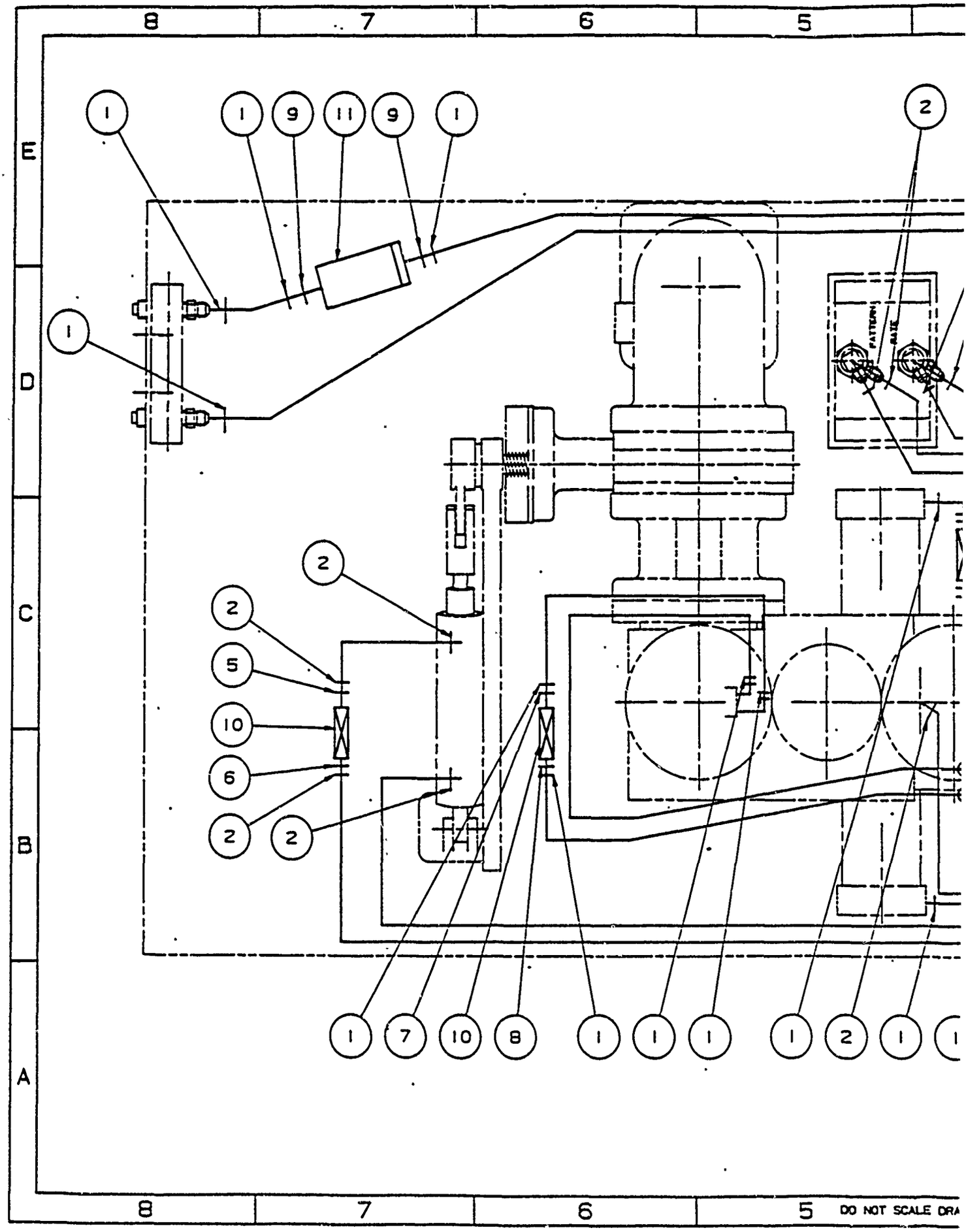
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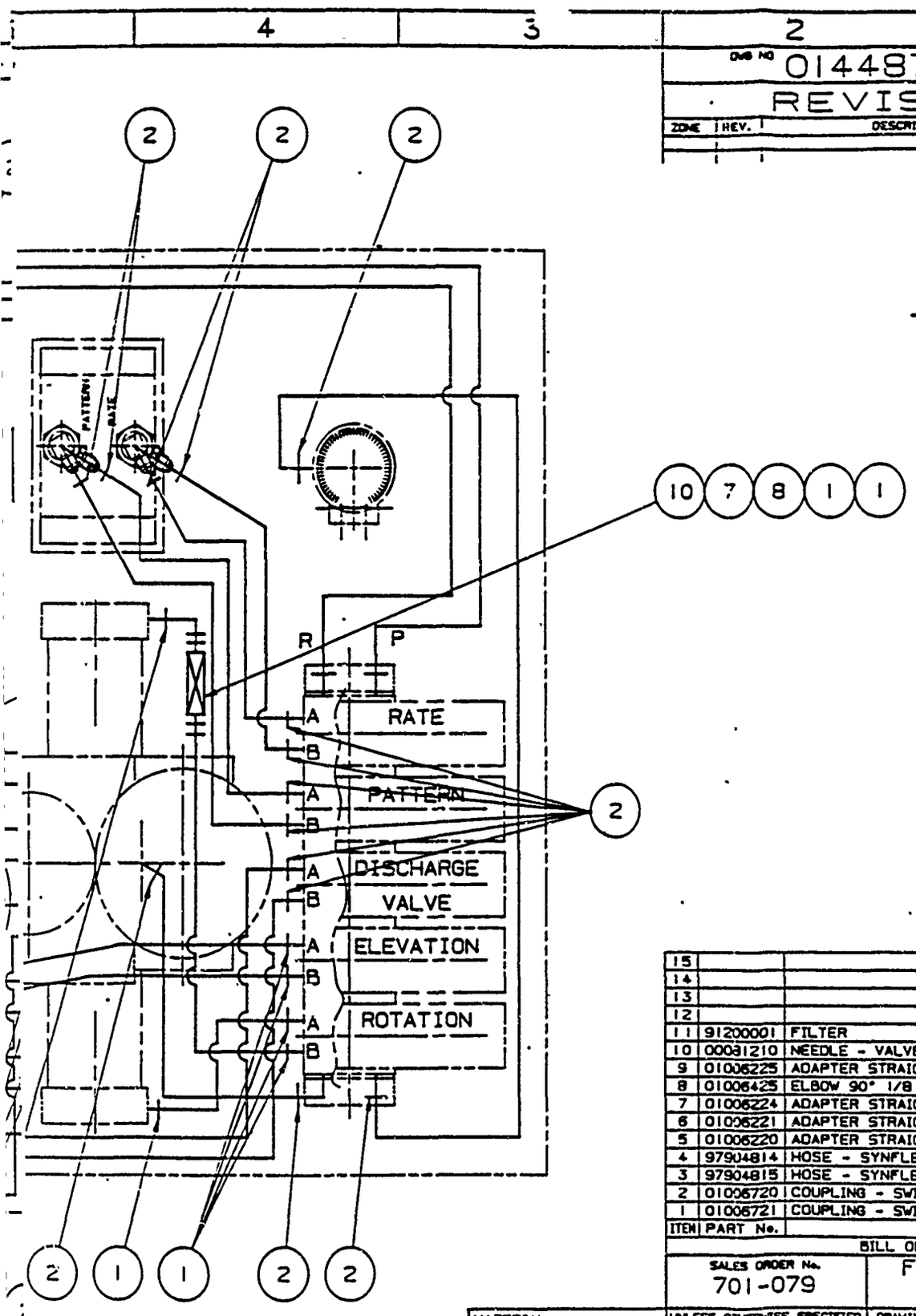

4	3	2	1

DWG NO 01448740 REV

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	REV BY

ITEM	PART No.	DESCRIPTION	QTY
15			
14			
13			
12			
11	91200001	FILTER	1
10	00031210	NEEDLE - VALVE 1/8 NPTM X 1/8 NPTF	3
9	01006225	ADAPTER STRAIGHT 1/4 NPTM X 1/2-20	2
8	01006425	ELBOW 90° 1/8 NPTF X 1/2-20	2
7	01006224	ADAPTER STRAIGHT 1/8 NPTM X 1/2-20	2
6	01006221	ADAPTER STRAIGHT 1/8 NPTF X 7/16-20	1
5	01006220	ADAPTER STRAIGHT 1/8 NPTM X 7/16-20	1
4	97904814	HOSE - SYNFLEX 1/4 I.D.	16"
3	97904815	HOSE - SYNFLEX 5/16 I.D.	13"
2	01006720	COUPLING - SWIVEL 1/4 TUBE	18
1	01006721	COUPLING - SWIVEL 5/16 TUBE	18

BILL OF MATERIAL

SALES ORDER No. 701-079

FEECON CORPORATION
9 OTIS STREET
WESTBORO, MA. 01581

MATERIAL -----

FINISH -----

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES, REMOVE ALL BURRS AND SHARP EDGES. ALL MACHINED SURFACES 125 MICROINCHES OR BETTER. TOLERANCES

.XX ± .015	.XXX ± .005	ANGLES ± .5°

DRAWING NAME: TUBING DIAGRAM

PREP	JFC	3-23-87
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APV'D		

DWG NO 01448740 REV

SCALE 1/2 SHEET 1 OF 1

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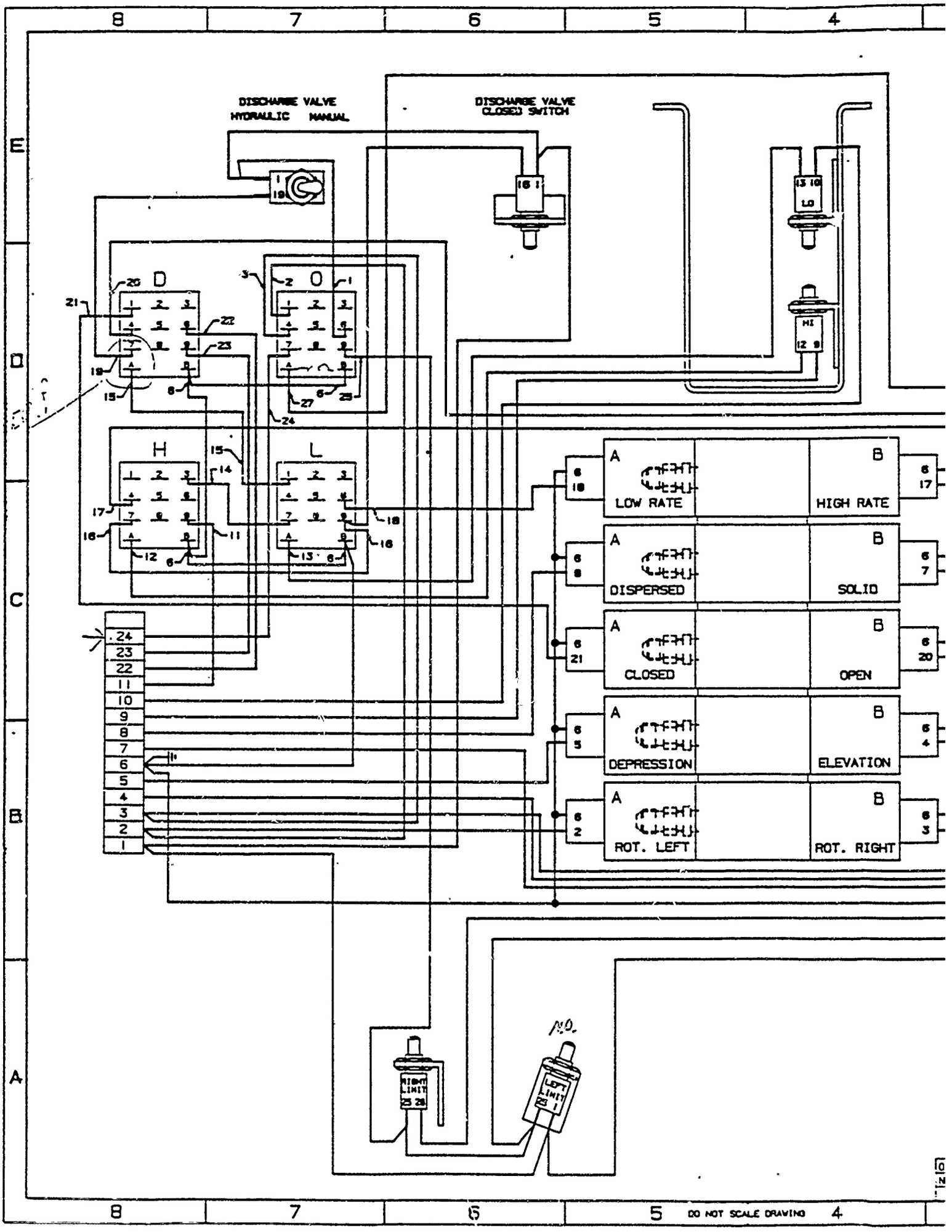
DISCHARGE VALVE HYDRAULIC MANUAL
DISCHARGE VALVE CLOSED SWITCH
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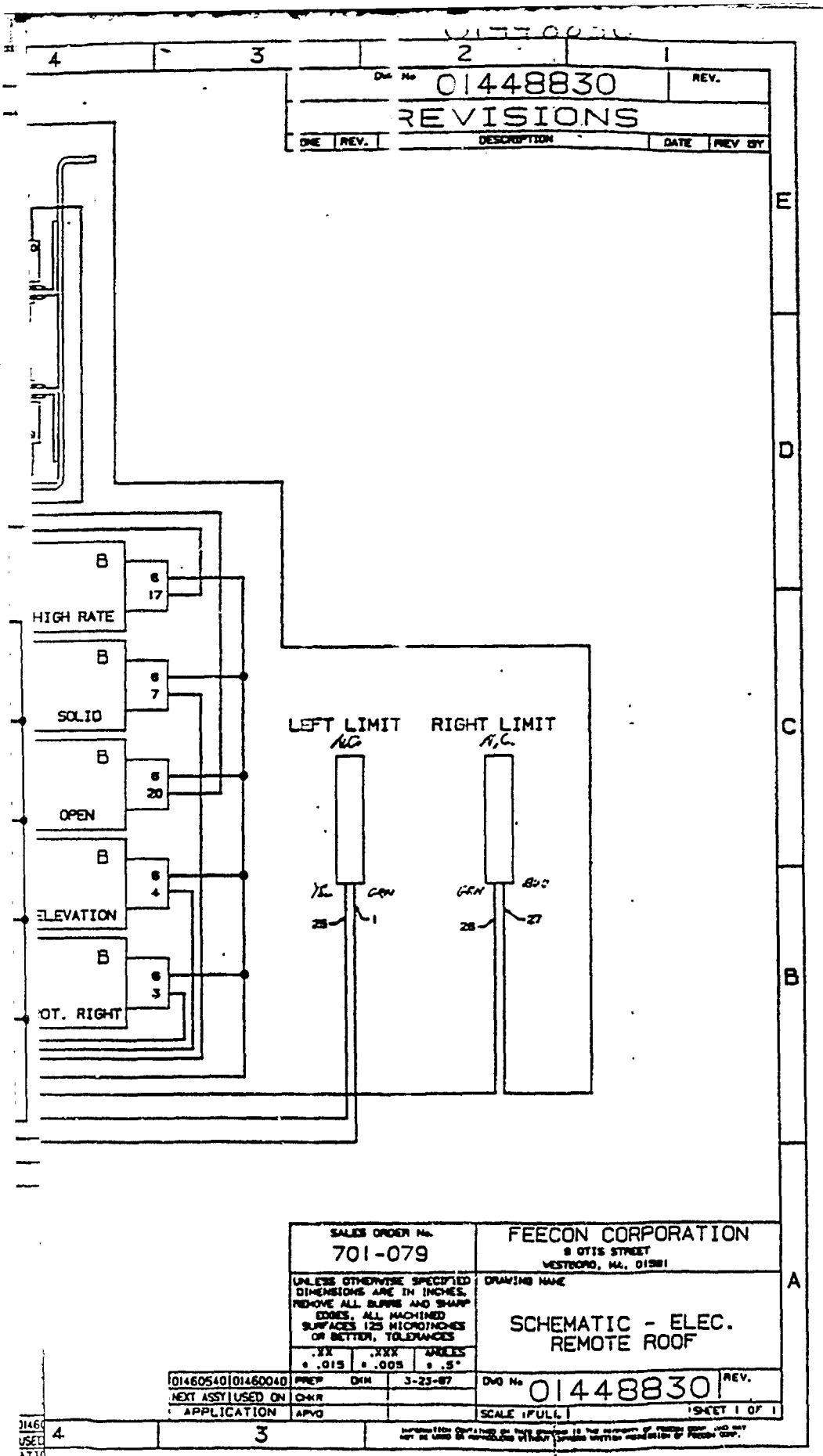

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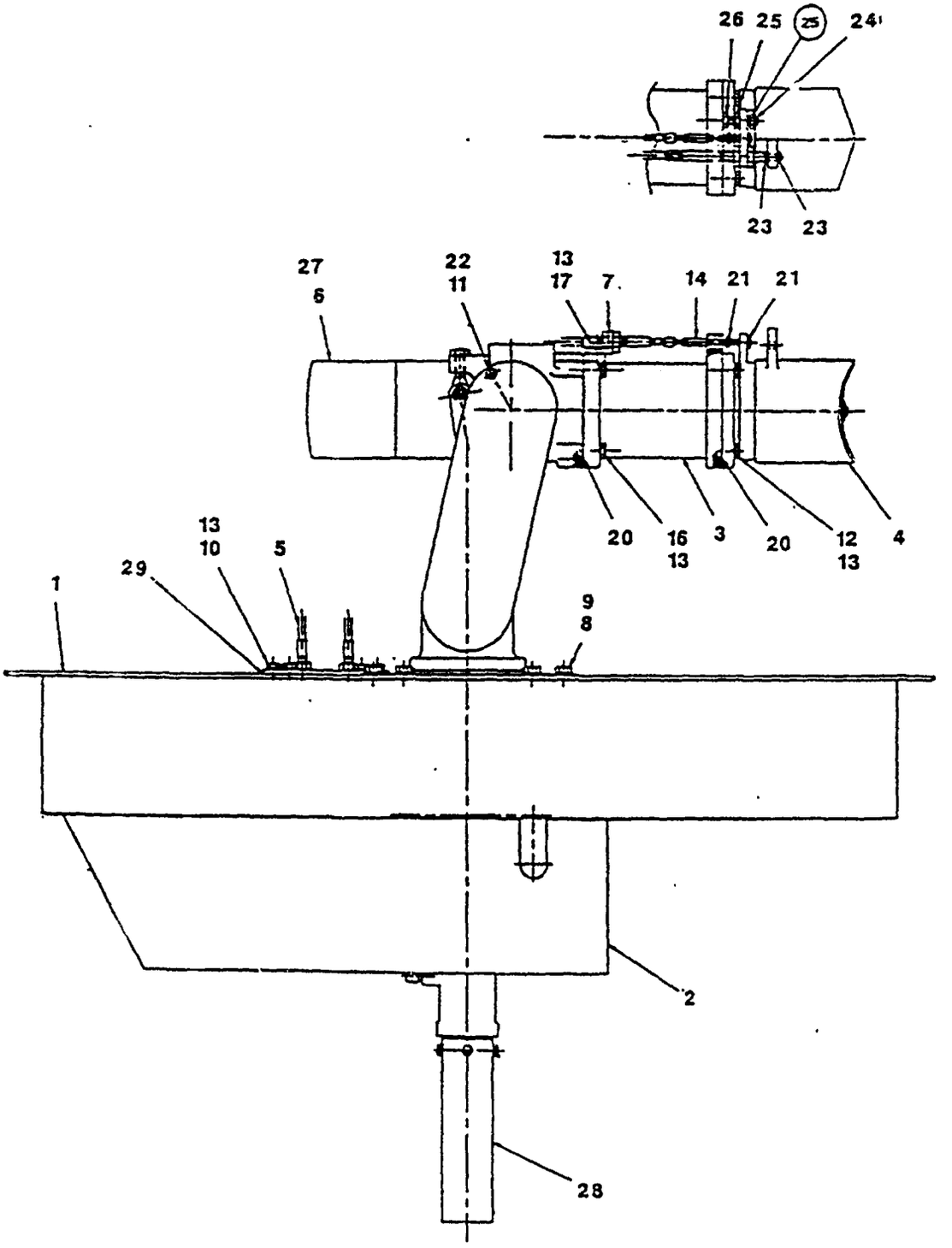
TURRET-HYD.-OSC.-400/800-N.A.-24VDC

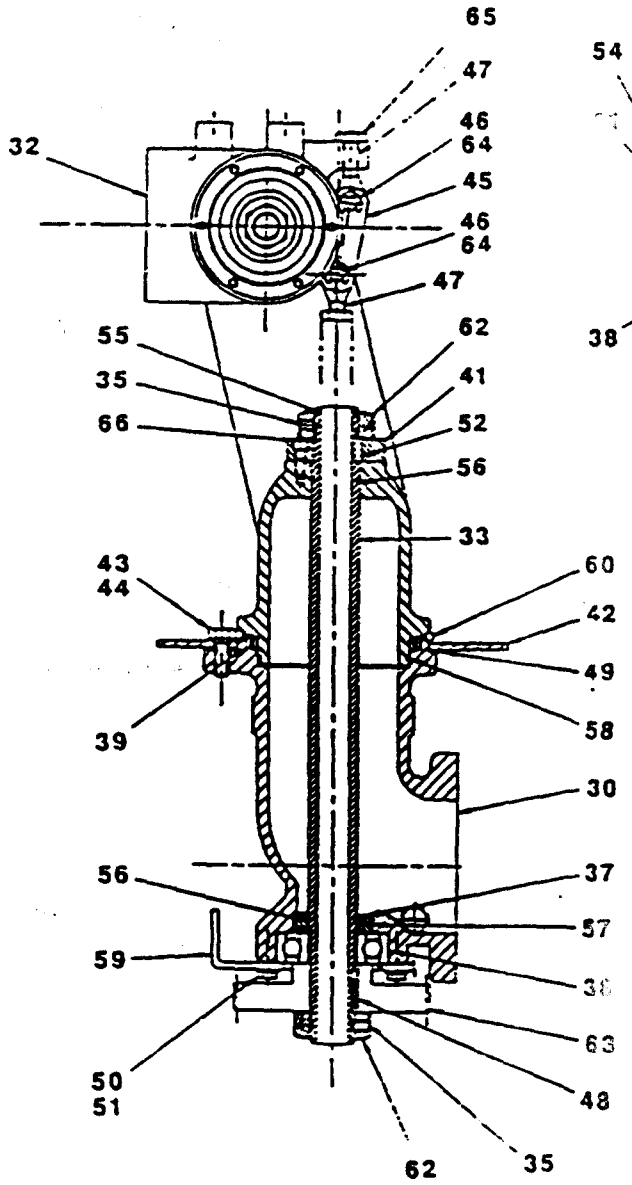
RPL#605

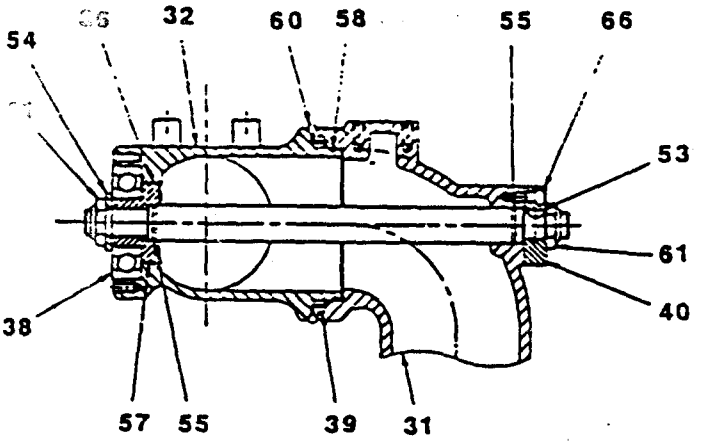
01460040



JAB 4/30/87

FEECON CORP. • NINE OTIS STREET • WESTBORO, MA. • P.O. BOX 338 • (617) 366-9117 • TELEX 4973172FEEC





ITEM-69

ASS'Y 01461540

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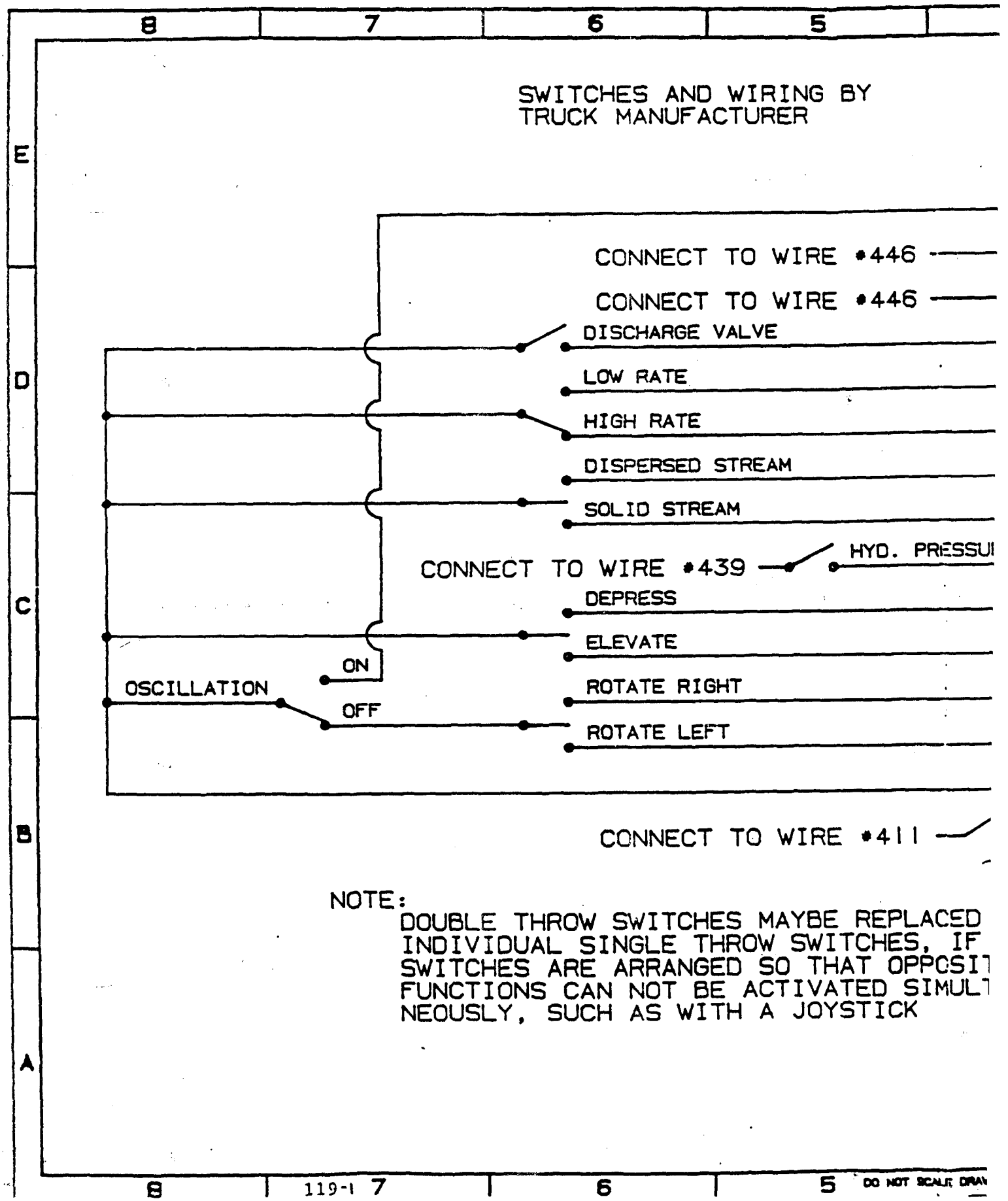
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CONNECT TO WIRE #446
DISCHARGE VALVE
LOW RATE
HIGH RATE
DISPERSED STREAM
SOLID STREAM
CONNECT TO WIRE #439
HYD. PRESSUI
DEPRESS
ELEVATE
ON
OSCILLATION
OFF
ROTATE RIGHT
ROTATE LEFT
CONNECT TO WIRE #411
NOTE:
DOUBLE THROW SWITCHES MAYBE REPLACED
INDIVIDUAL SINGLE THROW SWITCHES, IF
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DWG NO 01449120 REV

REVISIONS

ZONE	REV.	DESCRIPTION	DATE	REV BY

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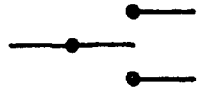
HOOK HERE

KEY

SPST TOGGLE SWITCH

SPDT TOGGLE SWITCH

SPDT MOMENTARY ROCKER SWITCH



E REPLACED BY
TCHES, IF THE
AT OPPOSITE
TED SIMULTA-
STICK

SALES ORDER No. 701-079	FEECON CORPORATION 9 OTIS STREET WESTBORO, MA. 01581
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. REMOVE ALL BURRS AND SHARP EDGES. ALL MACHINED SURFACES 125 MICRO-INCHES OR BETTER. TOLERANCES: .XX ± .015, .XXX ± .005, ANGLES ± .5°	DRAWING NAME: SCHEMATIC - CONNECTION
PREP DSN 3-23-87	DWG NO 01449120 REV
CHKR	SCALE: NONE SHEET 1 OF 1
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01460040	01460040
NEXT ASSY	USED ON
119-2	3

DO NOT SCALE DRAWING 4

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RPL # 605

FIG. 1

REPLACEMENT PARTS LIST

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
1	01460540	Inner Panel Assembly	1
2	01461030	False Ceiling Assembly	1
3	01390630	Tube Extension	1
4	01403530	Nozzle Assembly 400/800 N.A.	1
5	01445940	Control Selector Assembly	1
6	01391120	Counter Balance	1
7	01390920	Bracket - Cable Rate	1
8	93543316	Scr. HX. HD. 3/8-16 x 1" LG.	8
9	93613643	Lockwasher 3/8	8
10	93543212	Scr. HX. HD. 5/16-18 x 3/4 LG.	8
11	93613631	Lockwasher 1/4"	6
12	93543220	Scr. HX. HD. 5/16-18 x 1-1/4 LG.	4
13	93613832	Lockwasher 5/16	18
14	01391310	Extension Cable	1
15			
16	93543224	Scr. HX. HD. 5/16-18 x 1-1/2" LG.	4
17	93543208	Scr. HX. HD. 5/16-18 x 1/2" LG.	2
18	93444732	Scr. HX. HD. 5/8-18 x 2" LG.	4
19	93613647	Lockwasher 5/8	4
20	95830155	"O" Ring -155	2
21	93604431	Nut ESNA 1/4-20	2
22	93543136	Scr. HX. HD. 1/4-20 x 2-1/4" LG.	6
23	93603231	Nut Jam 1/4-28	2
24	99663105	Th'd Rod 5/16-18 x 2-1/2" LG.	.3"

FIG. 1

REPLACEMENT PARTS LIST

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
25	93604332	Nut 5/16-18 Lock	2
26	93604232	Nut 5/16-18 Jam	1
27	95830242	"O" Ring -242	1
28	01446320	Cover Elevation Cylinder	1
29	00041610	Gasket Control	1
30	00236240	Base - Bronze	1
31	00195340	Body - Bronze	1
32	00639120	Head - Bronze	1
33	00870220	Rotation - Tube	1
34	00286920	Elevation Shaft Top	1
35	93593106	Scr. Set 1/4-20 x 3/8	2
36	00197910	Bearing - Seal	1
37	00262220	Bearing - Seal	1
38	00007010	Bearing	2
39	94010003	Bearing - Kaydon	2
40	00000810	Cap	1
41	00109910	Cap	1
42	00641620	Plate - Mounting	1
43	93613643	Lockwasher 3/8	4
44	93544316	Scr. HX. HD. 3/8-16 x 1" LG.	4
45	00274710	Elevation Link	1
46	00109810	Elevation Pin	2
47	99001703	Rod End Male 7/16-20	2
48	93802003	Key 3/16 SQ. x 3/4 LG.	1

FIG. 1

REPLACEMENT PARTS LIST

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
49	00701820	Gasket	1
50	93613631	Lockwasher 1/4"	6
51	93543112	Scr. HX. HD. 1/4-20 x 3/4 LG.	6
52	93802009	Key 3/16 SQ. x 1/2 LG.	1
53	93802001	Key #3 Woodruff	1
54	00004410	Washer	1
55	95830020	"O" Ring -020	3
56	95830026	"O" Ring -026	2
57	95831034	"O" Ring -034 LCR	2
58	95831155	"O" Ring -155 LCR	2
59	01440130	Bracket - Mounting Actuator	1
60	95830429	"O" Ring -429	2
61	93603448	Nut ESNA 3/4-16	2
62	00179810	Nut ESNA 1-1/4 - 12	2
63	00910420	Rotation - Gear	1
64	98120037	"E" Ring 5133-37	4
65	93603244	Nut 7/16-20	2
66	93553112	Scr. Soc. HD. 1/4-20 x 3/4 LG.	8

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TURRET-HYD.-OSC.-400/800-N.A.-24VDC

RPL#605

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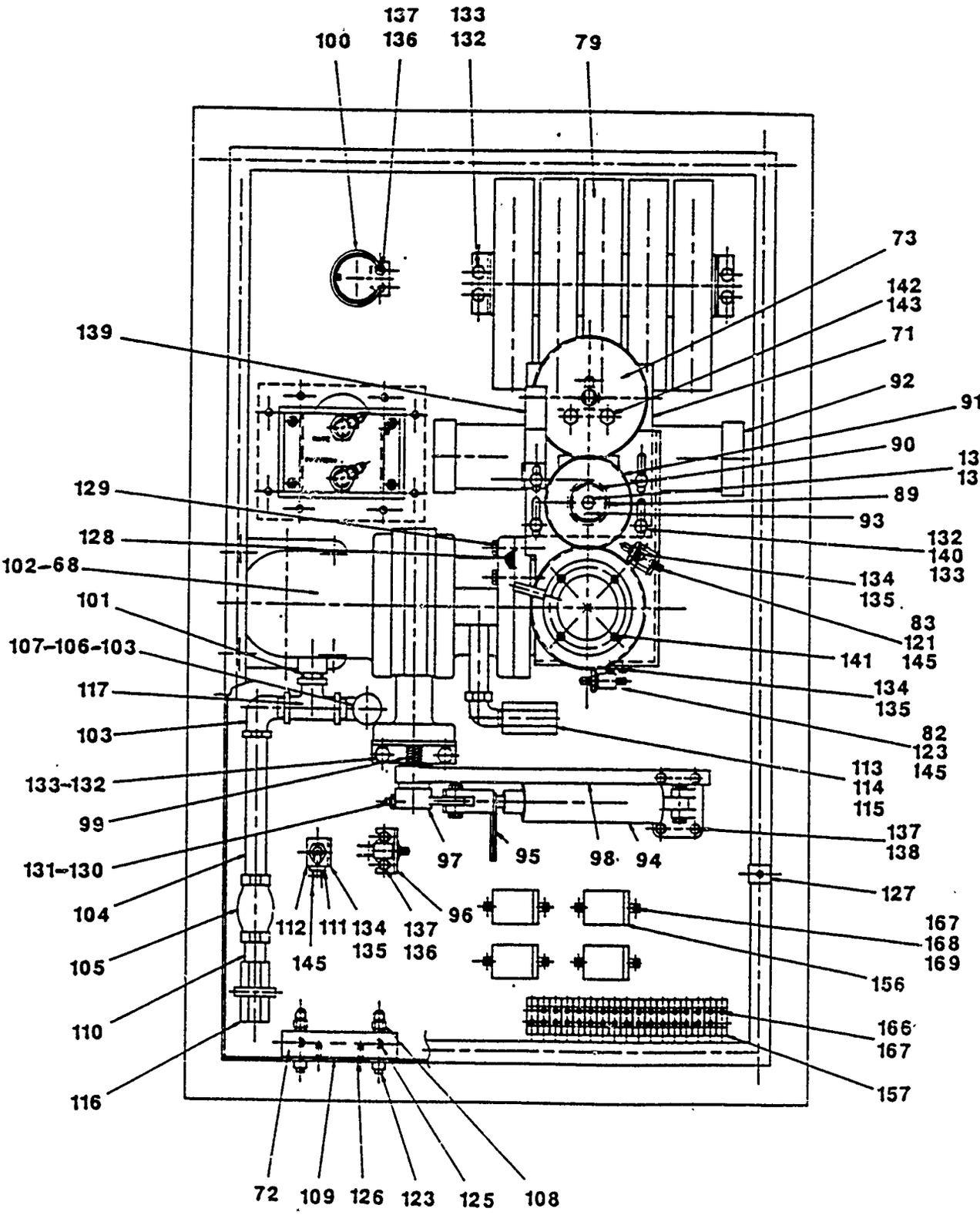
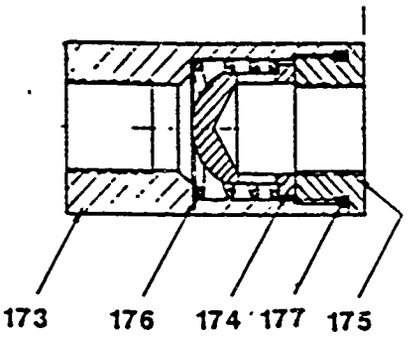


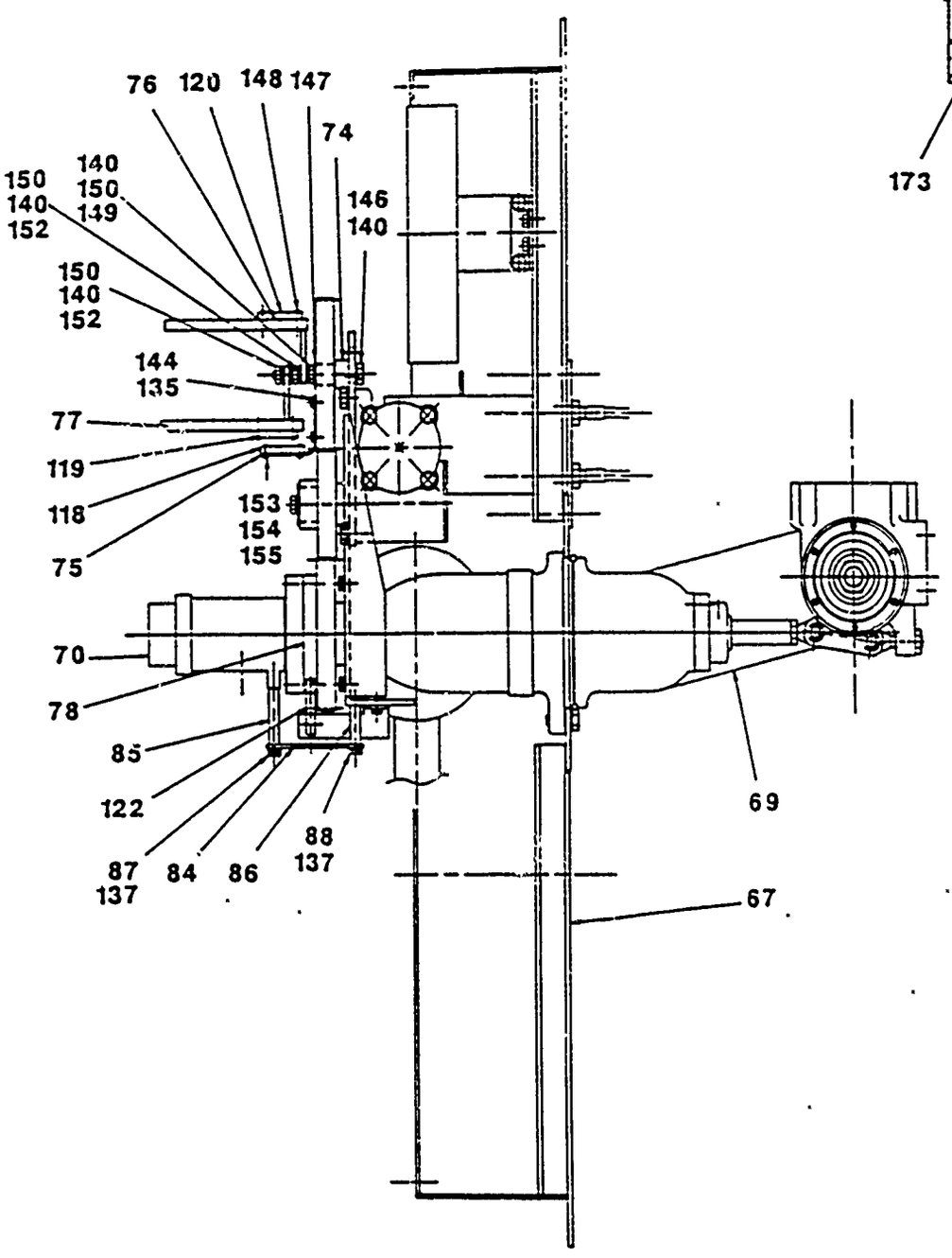
ITEM-1

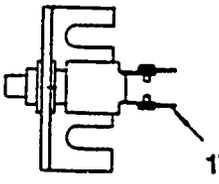
ASS'Y 014605

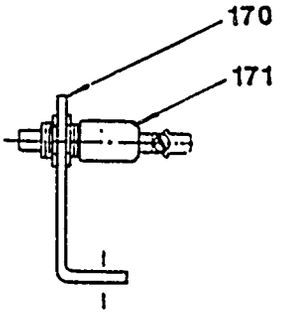
JAB 4/30/87



ITEM-113
ASS'Y 00053720







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ITEM-1
01460540

ITEM-96
ASS'Y 00085220

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FIG. 2

REPLACEMENT PARTS LIST

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
67	01436240	Panel	1
68	00072830	Inlet Valve Assembly	1
69	01461540	Base Body Assembly	1
70	01083530	Elevation Cylinder Assembly	1
71	01437120	Actuator Mounting Plate	1
72	00022720	Manifold	1
73	01440820	Gear Oscillation	1
74	01440310	Post Gear Oscillation	1
75	01441310	Bracket Magnet	1
76	01441420	Arm Switch Oscillating	1
77	01441620	Arm Switch Oscillating	1
78	00910322	Spacer Elevation Cylinder	1
79	01442140	Solenoid Manifold Assembly	1
80	01448830	Wiring Assembly	1
81	01448740	Tubing Assembly	1
82	01444320	Bracket - Switch	1
83	01444410	Bracket - Switch	1
84	00915.10	Plate - Mounting	1
85	01445710	Spacer	2
86	00855410	Spacer	2
87	93543144	Scr. HX. HD. 1/4-20 x 2-3/4 LG.	2
88	93543132	Scr. HX. HD. 1/4-20 x 2" LG.	2
89	00598910	spacer Drive Gear	1
90	00082810	Rotac Disk	1

FIG. 2

REPLACEMENT PARTS LIST

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
91	00026420	Drive Gear	1
92	01028430	Actuator Hydraulic	1
93	99633305	Key SQ. 5/16 x 1"	1
94	01046020	Valve Cylinder Assembly	1
95	00038410	Switch Arm	1
96	00085220	Switch Assembly N.O.	1
97	00015220	Lever	1
98	00015120	Valve Handle	1
99	00053810	Spring	1
100	01027120	Gauge Assembly	1
101	97140003	Nipple 3/4 Close	1
102	95830351	"O" Ring -351	1
103	97372005	Elbow Street 3/4 NPT	2
104	97140002	Nipple 3/4 NPT x 7-1/4" LG.	1
105	00083420	Check Valve 3/4"	1
106	97512001	Reducer 3/4 x 1/2	1
107	97300010	Aeroquip Fitting	1
108	01006225	Fitting Straight 1/4 NPT x 7/16-20 T	2
109	00230710	Gasket - Manifold	1
110	97142201	Nipple 3/4 x 2" LG.	1
111	00076010	Switch	1
112	00992712	Bracket Switch	1
113	00053720	Automatic Drain Valve Assembly	1
114	97372012	Elbow Street BR. 1/2 x 90°	1

FIG. 2

REPLACEMENT PARTS LIST

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC — 01460040

No.	Part Number	Part Name	No. Req'd.
115	97140001	Nipple - Brz. 1/2 x 4" LG.	1
116	00083320	Valve - Ball 3/4	1
117	97400001	Tee - 3/4 Brz.	1
118	00764710	Magnet - Actuator	1
119	01075210	Harness - Switch Yellow/Green	1
120	01075212	Harness - Switch Blue/Green	1
121	92010001	Switch - Normally Open	1
122	95213724	Pin Roll 3/8 Dia. x 2" LG.	1
123	00075010	Plug Plastic 3/8 NPT	2
124	92010002	Switch - Normally Closed	1
125	97503018	Plug 1/8 NPT	2
126	93523112	Scr. Flt. HD. 1/4-20 x 3/4 LG.	2
127	00081910	Clip Receptacle	8
128	95830244	"O" Ring -244	1
129	93543220	Scr. HX. HD. 5/16-18 x 1-1/2 LG.	6
130	93593216	Scr. Soc. Set 5/16-18 x 1" LG.	1
131	93604232	Nut HX. Jam 5/16-18	1
132	93543212	Scr. HX. HD. 5/16-18 x 3/4 LG.	11
133	93613632	Washer Lock 5/16	11
134	93243508	Scr. HX. HD. #10-32 x 1/2" LG.	6
135	93611635	Washer Lock #10	8
136	93543108	Scr. HX. HD. 1/4-20 x 1/2" LG.	4
137	93613631	Washer Lock 1/4"	12
138	93543112	Scr. HX. HD. 1/4-20 x 3/4" LG.	4

FIG. 2

REPLACEMENT PARTS LIST

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
139	01449320	Bracket Wire Guard	1
140	93613032	Washer Flat 5/16	9
141	93553212	Scr. Soc. HD. 5/16-18 x 3/4" LG.	4
142	93543312	Scr. HX. HD. 3/8-16 x 3/4 LG.	4
143	93613633	Washer Lock 3/8	4
144	93343508	Scr. HX. HD. #10-24 x 1/2 LG.	2
145	92120003	Terminal Soderless	6
146	93503256	Scr. HX. HD. 5/16-18 x 3-1/2" Full Th'd	1
147	93613033	Washer Flat 3/8	1
148	936163110	Scr. Self Tap #2 x 5/8 LG. Pan HD.	4
149	93604132	Nut St'd 5/16-18	1
150	01451110	Washer Delrin	4
151	93604332	Nut Lock 5/16-18	1
152	93604432	Nut ESNA 5/16-18	2
153	93313208	Scr. RD. HD. #4-40 x 1/2" LG.	2
154	93611632	Washer Lock #4 Split	2
155	93602332	Nut #4-40	2
156	00984910	Relay 24 VDC	4
157	92200008	Terminal Strip 15 Position	1
158	92120026	Terminal Solderless	26
159	92120001	Terminal Solderless	12
160	92120002	Terminal Solderless	40
161	92120004	Terminal Solderless	20
162	92120014	Terminal Solderless	14

FIG. 2

REPLACEMENT PARTS LIST

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
* 163	92120029	Plug Male	2
* 164	92120028	Pin	4
* 165	92210006	Wire 18 Gage	20'
166	93313312	Scr. RD. HD. #6-32 x 3/4 LG.	2
167	93611633	Lockwasher #6	10
168	93313304	Scr. RD. HD. #6-32 x 1/4 LG.	8
169	93611033	Washer Plain #6	8
170	00041920	Switch Bracket	1
171	92010001	Switch, N.O.	1
172	92120003	Terminal Solderless Stud	2
173	00035210	Automatic Drain Valve Body	1
174	00035310	Automatic Drain Valve Plug	1
175	00035410	Automatic Drain Valve Cap	1
176	00053810	Spring	1
177	95830024	"O" Ring -024	1

NOTE: All items marked * not shown on Figure.

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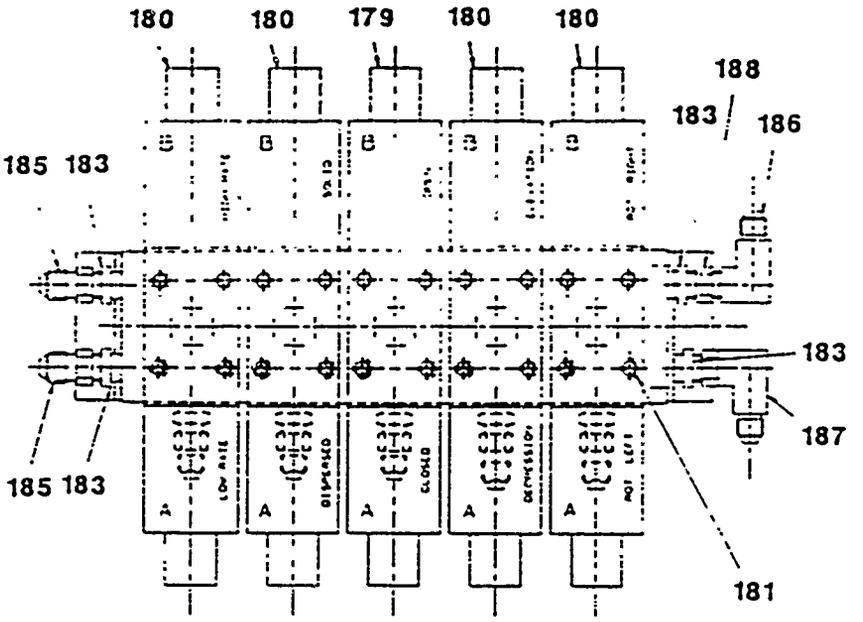
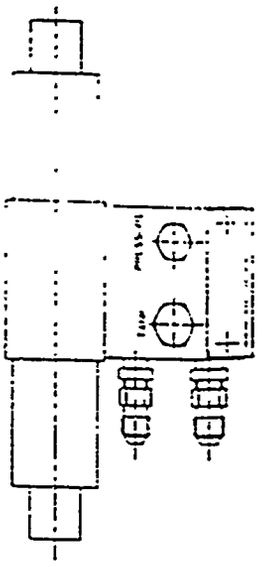
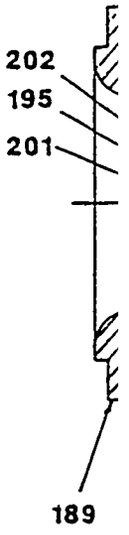
TURRET-HYD.-OSC.-400/800-N.A.-24VDC

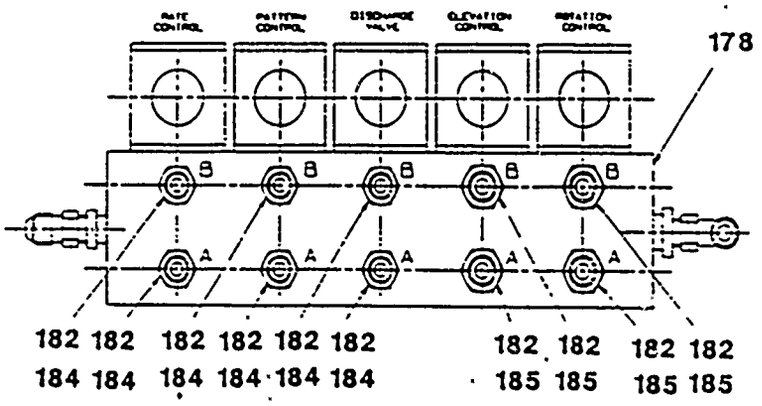
RPL#605

01460040



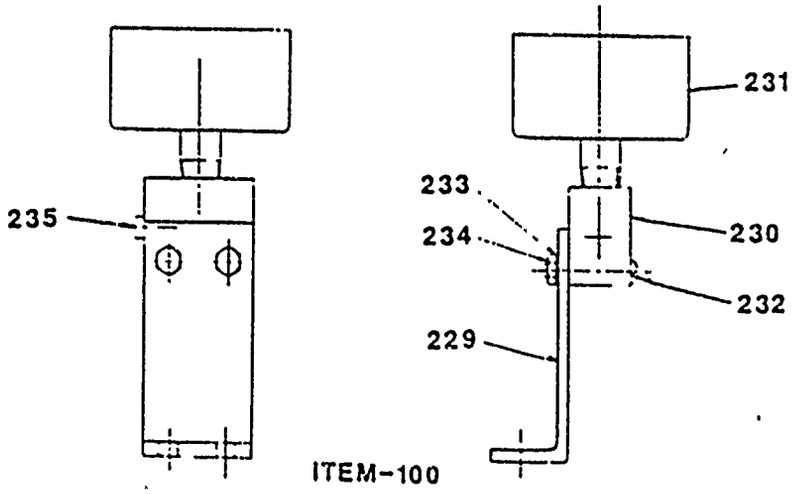


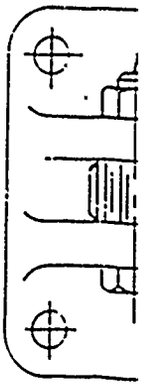




ITEM-79

ASS'Y 01442140

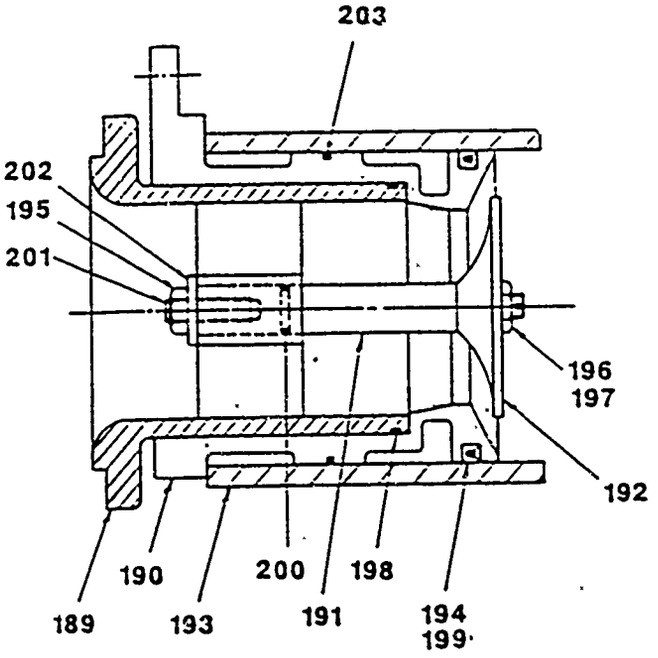




ITEM-100

ASS'Y 01027120

JAB 4/30/87



ITEM-4

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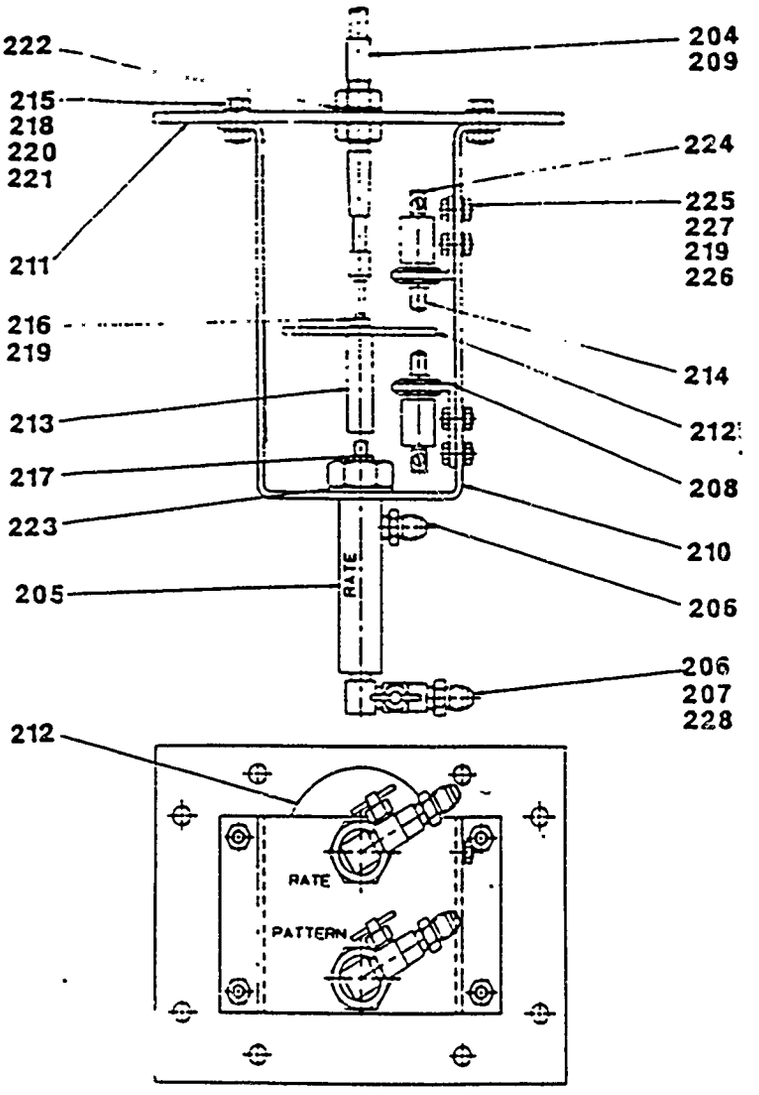
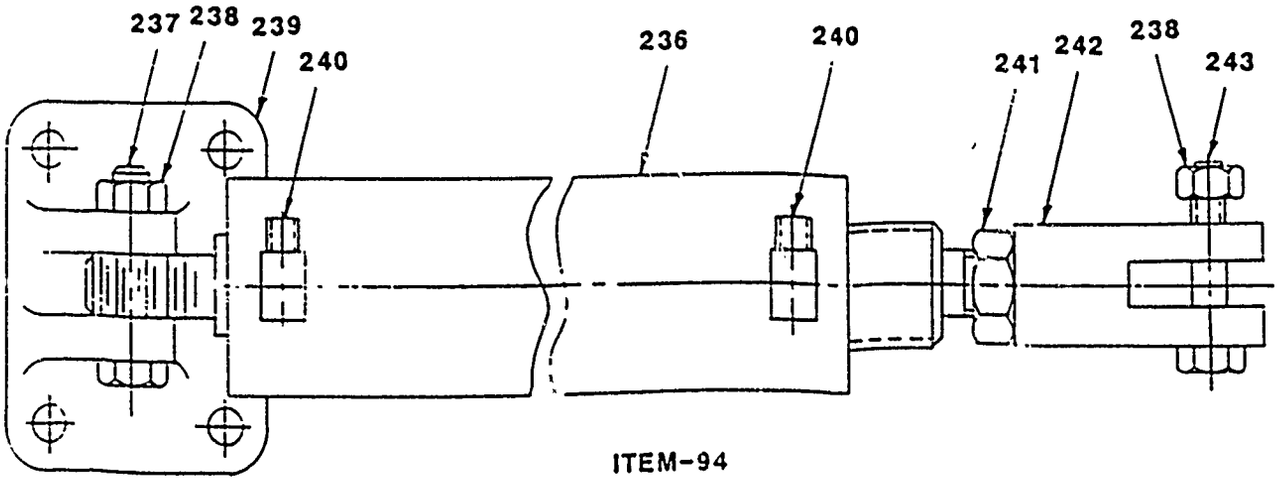


ITEM-5

ASS'Y 01445940



ITEM-94

ASS'Y 01046020

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REPLACEMENT PARTS LIST

FIG. 3

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
178	01441830	Manifold 5-Port	1
179	00971720	Solenoid 24 VDC 4-Way 3 Pos. Open Center	1
180	00934220	Solenoid 24 VDC 4-Way 3 Pos. Closed Ctr.	4
181	93353532	Scr. Soc. HD. #10-24 x 2" LG.	20
182	97512011	Bushing HX. 3/8 NPT x 1-1/4 NPT	10
183	97512014	Bushing HX. 1/2 NPT x 1/4 NPT	4
184	01006222	Adapter Str. 1/4 NPT x 7/16-20	6
185	01006225	Adapter Str. 1/4 NPT x 1/2-20	6
186	01006476	Elbow 90° 1/4 NPTF x 7/16-20	1
187	01006422	Elbow 90° 1/4 NPTM x 7/16-20	1
188	01006228	Adapter Str. 1/4 NPTM x 1/4 NPTM	1
189	01391720	Tip	1
190	01390730	Nozzle	1
191	01412220	Shaft Button	1
192	00783612	Button	1
193	01391630	Sleeve	1
194	00627911	Huva Cup	1
195	93604432	Nut 5/16-18 ESNA	1
196	93604133	Nut 3/8-16	1
197	93613633	Lockwasher 3/8	1
198	95830151	"O" Ring -151	1
199	95830239	"O" Ring -239	1
200	95830112	"O" Ring -112	1
201	93593220	Scr. Set Soc. HD. 5/16-18 x 1-1/4	1

REPLACEMENT PARTS LIST

FIG. 3

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
202	01412310	Spacer - Nozzle	1
203	95835044	"O" Ring -044	1
204	00373410	Cable - Pattern 1" #10-32 x 1/4-28	1
205	00607810	Cylinder 3/4 Bore x 1" Stroke	2
206	01006220	Fitting - Straight 1/8 NPTM x 7/16 JIC	4
207	97372001	Fitting - Elbow 1/8 NPTM x 1/8 NPTF	2
208	01128910	Bracket - Switch Mounting	2
209	01402610	Cable - Rate 1" Stroke #10-32 B.E.	1
210	01445230	Bracket - Cylinder Mount	1
211	01445830	Plate - Selector	1
212	01446110	Disk - Selector	1
213	01446210	Link - Connector	2
214	92010002	Switch - Normally Closed	2
215	93543110	Screw - Hex Head 1/4-20 x 5/8 LG	4
216	93601235	Nut - Hex #10-32	2
217	93603231	Nut - Hex Jam 1/4-28	2
218	93604131	Nut - Hex Std 1/4-20	4
219	93611635	Washer - Lock #10 Split	6
220	93613631	Washer - Lock 1/4 Split	4
221	93613731	Seal - Stato 1/4	4
222	93613734	Seal - Stato 7/16	2
223	93613837	Washer - Lock 5/8 INT	2
224	92120003	Connector - Quick 1/4 Male	4
225	93343510	Screw - Hex. Head #10-24 x 5/8 LG.	4

REPLACEMENT PARTS LIST

FIG. 3

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

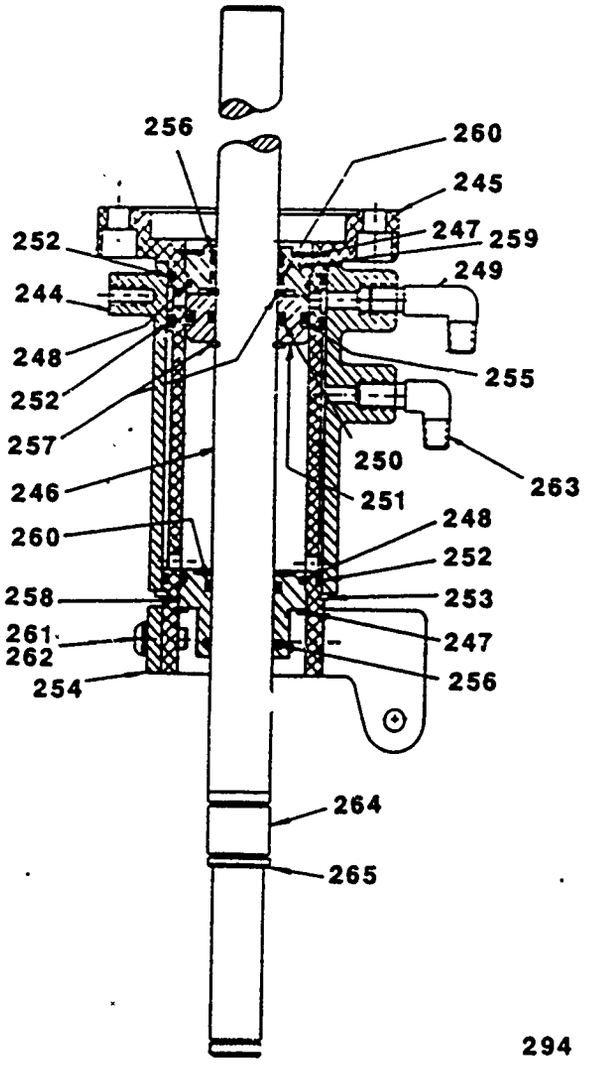
No.	Part Number	Part Name	No. Req'd.
226	93602135	Nut - Hex #10-24	4
227	93611035	Washer - Flat #10	4
228	00081210	Valve - Needle	2
229	00075810	Gage Bracket	1
230	00470910	Gage Block	1
231	97421203	Gage (Wika #213)	1
232	93313520	Scr. #10-24 x 1-1/4 RD. HD.	2
233	93611835	#10 Lockwasher	2
234	93602135	Nut Hex. #10-24	2
235	01006220	Adapter Str Aero #2021-2-4S	1
236	00098920	Cylinder 4" Stroke (Valve)	1
237	93543228	Scr. Hex. HD. 5/16-18 x 1-3/4 LG.	1
238	93604332	Nut - Lock 5/16-18	2
239	00049910	Bracket - Cylinder	1
240	01006422	Elbow 90° 1/4 NPTM x 7/16-20	2
241	93604245	Nut 1/2-13	1
242	00101610	Rod - Clevis	1
243	93543224	Cap Scr. 5/16-18 x 1-1/2 LG.	1

REPLACEMENT PARTS LIST

FIG. 4

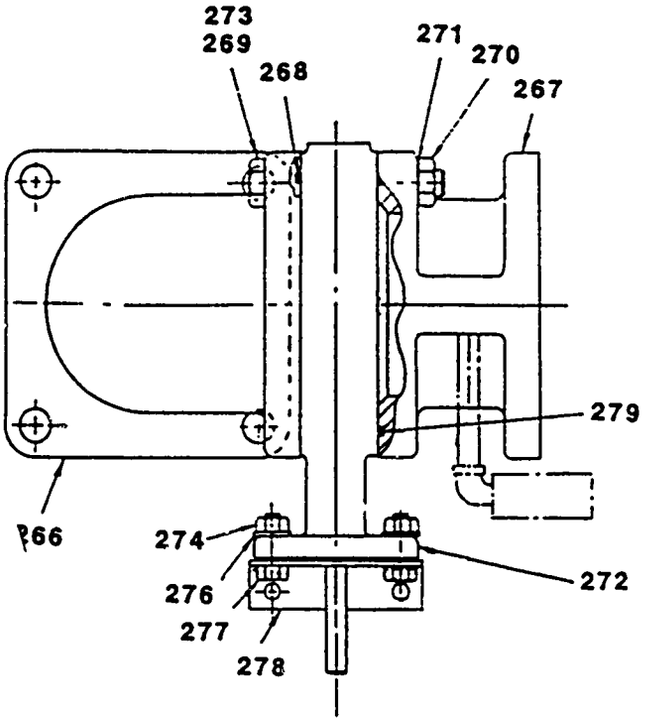
01460040

TURRET-HYD.-OSC.-400/800-N.A.-24VDC



ITEM-70

ASS'Y 01083530



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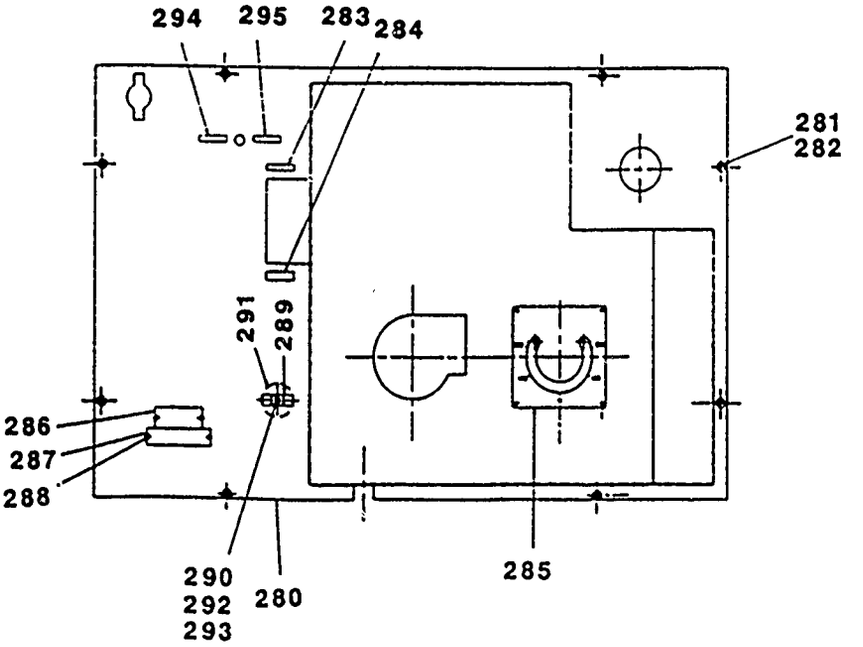

ITEM-2

ASS'Y 01461030

REPLACEMENT PARTS LIST

FIG. 4

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
244	00333730	Cylinder Body	1
245	00333830	Cylinder - Elevation	1
246	01281820	Rod, Elevation	1
247	98100181	Ret. Ring (N5000-181)	2
248	95830030	"O" Ring -030	2
249	01006470	Elbow Long 90° 1/8 NPTM x 1/2-20	1
250	95831118	"O" Ring -118 LCR	1
251	00334210	Piston	1
252	95831137	"O" Ring -137 LCR	3
253	98110225	Retaining Ring 5100-225	1
254	00333920	Control Mount	1
255	95831222	"O" Ring -222 LCR	1
256	95842107	Wiper Ring	2
257	98110087	Retaining Ring 5100-87	2
258	00743110	Cap - Cylinder End	1
259	00743510	Cap - Cylinder End	1
260	00599722	U-Packing Seal	2
261	93503108	Scr. But. HD. 1/4-20 x 1/2 LG.	4
262	93613631	Lockwasher 1/4 S.S.	4
263	01006424	Elbow 90° 1/8 NPTM x 1/2-20	1
264	01281910	Sleeve	1
265	98212075	Ring Ret. Spirolox RS-75 S.S.	1
266	00082940	Inlet Elbow	1
267	00036630	Coupling - Base To Valve	1

REPLACEMENT PARTS LIST

FIG. 4

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
268	95830353	"O" Ring -353	1
269	93544780	Mach. Screw 5/8-11 UNC x 5" LG.	3
270	93604117	Nut 5/8-11 UNC	4
271	93613847	Lockwasher 5/8"	4
272	00502030	Valve 4" Wafer	1
273	93544772	Scr. Hex. HD. 5/8-11 x 4-1/2 LG. ST. CAD	1
274	93604245	Nut 1/2-13 Jam	2
275	01265710	Nameplate Identification	1
276	93613635	Lockwasher 1/2"	2
277	93543524	Cap Screw 1/2-13 x 1-1/2" LG.	2
278	00024620	Valve Brace	1
279	95830245	"O" Ring -245	1
280	01440440	False Ceiling	1
281	99001103	#5 - 1/4 Turn Stud	8
282	99001101	Retainer #5	8
283	00065610	Nameplate Open	1
284	00065510	Nameplate Closed	1
285	01446620	Nameplate Oscillation	1
286	00064510	Nameplate Feecon	1
287	00093810	Nameplate Part No.	1
288	93163204	Scr. Self Tap #4 x 1/4	16
289	99001001	Clip	1
290	93313506	Scr. RD. HD. #10-24 x 3/8 LG.	1
291	00288210	Washer	1

REPLACEMENT PARTS LIST

FIG. 4

Unit: TURRET - HYDRAULIC OSCILLATING 400/800 N.A. 24 VDC 01460040

No.	Part Number	Part Name	No. Req'd.
292	93602135	Nut HX. #10-24	1
293	93611835	Lockwasher #10	1
294	00065810	Nameplate Valve Hydraulic	1
295	00064710	Nameplate Valve Manual	1

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LINEAR ACTUATOR DATA SHEETS

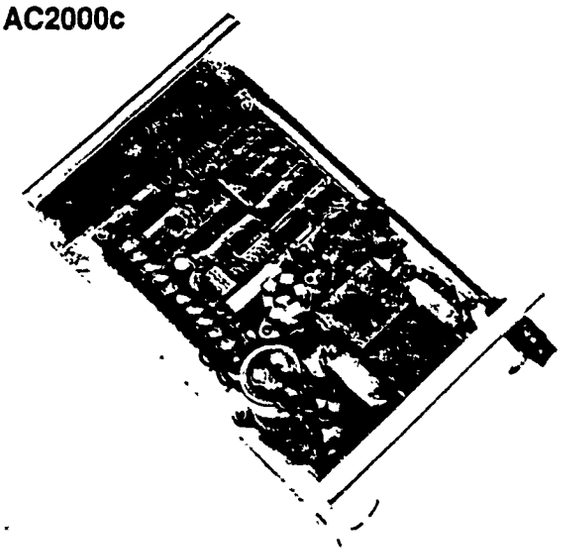
MODEL AC2000 and AC2001
ELECTRIC CYLINDER CONTROLS
INSTALLATION AND OPERATING
INSTRUCTIONS
SPECIFICATIONS AND IDENTIFICATION
TROUBLESHOOTING CHART
PARTS LIST
SUFFIX DEFINITIONS

INDUSTRIAL
DEVICES
CORPORATION

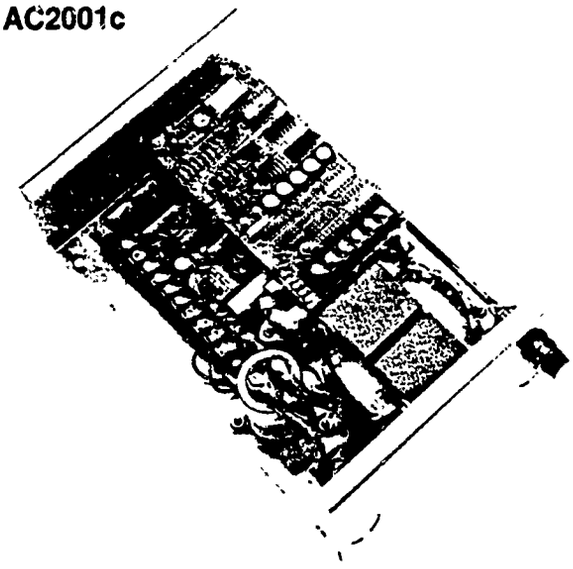
Novato, CA 94947-6284
(415) 883-3535

IDENTIFICATION

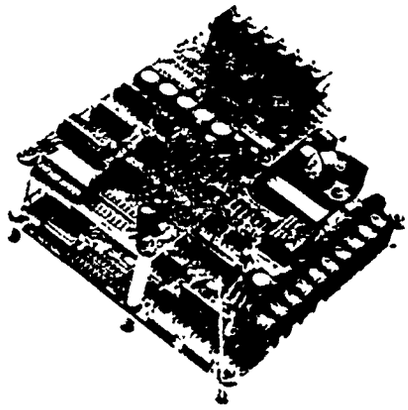
AC2000c



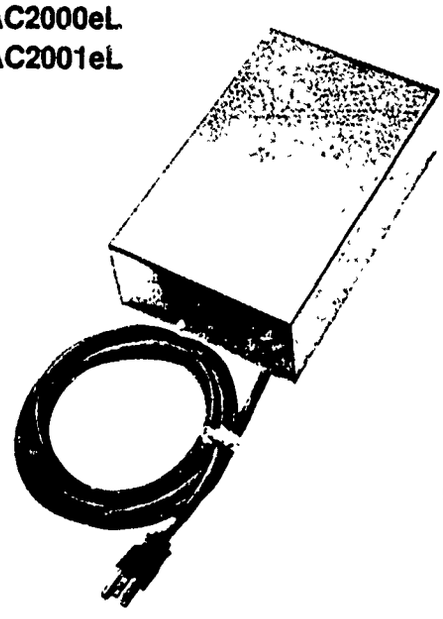
AC2001c



AC2001b



AC2000eL
AC2001eL



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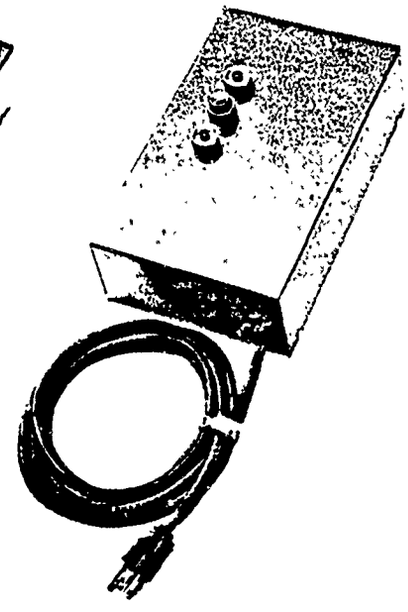


SUFFIX DEFINITIONS

b = Board only c = Chassis, power supply and board e = Enclosed chassis, power supply and board
L = Line cord p = Enclosed panel controller with push-button switches

WIRING INSTRUCTIONS: AC2000 CONTROL

A. C. INPUT - CHASSIS

1. This control is shipped from the factory connected for 115 volt AC input. To use 230 volt AC input, disconnect the jumpers which connect the transformer leads #1 to #3 and #2 to #4. Connect only jumper leads #2 to #3.
   Wire the AC input to the terminals on the transformer labeled L1 and L2. Secure a ground line to the grounding screw provided. Consistent with good wiring practice, AC lines should be separate from the low voltage DC wiring in the rest of the system.

2. **POWER SUPPLY WIRING - AC2000**. (Disregard if received wired).
   The **red wire** (24VDC) from the Power Capacitor "+" terminal is connected to position #2 on the terminal strip and the **black lead** (ground) from the capacitor "—" terminal to position #1. CAUTION - Reverse polarity will damage this circuit.

3. **MOTOR WIRING - AC2000**
   Connect motor leads to positions #3 and #4. Connect **black lead** to #3, **red** to #4. 16AWG wire is adequate for runs under 10 feet; if a longer distance between controller and motor is required, use 14AWG wire. NOTE: Units with reverse motor mount or certain gear ratios will require reversing the motor leads (terminals #3 & #4) for proper extend/retract orientation.

4. **LOGIC WIRING - AC2000**
   All logic functions utilize low-level signals and are initiated by normally open momentary contacts. Wire all logic contacts across the "Com" terminal, #5, and appropriate position as follows:

Position	Circuit Board Label	Function
6	"RTR"	RETRACT
7	"EXT"	EXTEND
8	"STOP"	STOP
9	"LS"	LIMIT SWITCH
10	"AUX"	AUXILIARY

WIRING INSTRUCTIONS: AC2001 (AC2000 with VS001)

5. ADDITIONAL LOGIC WIRING

Position	Circuit Board Label	Function
11	"LS2"	Limit Switch 2 — (speed change)
12	"COM-EXT EN"	COMMON - EXTEND ENABLE - See note below
13	"COM-RTR EN"	COMMON - RETRACT ENABLE - See note below
		NOTE: Used with LS2 to provide for **speed change** in the appropriate direction, i.e., if a limit switch is used to change speed when extending, but not when retracting, it should be wired to "COM-EXT EN" & "LS2".
14	"EXT-COMP"	EXTEND COMPLETE OUTPUT
15	"RTR-COMP"	RETRACT COMPLETE OUTPUT
16	"GND"	GROUND - additional ground

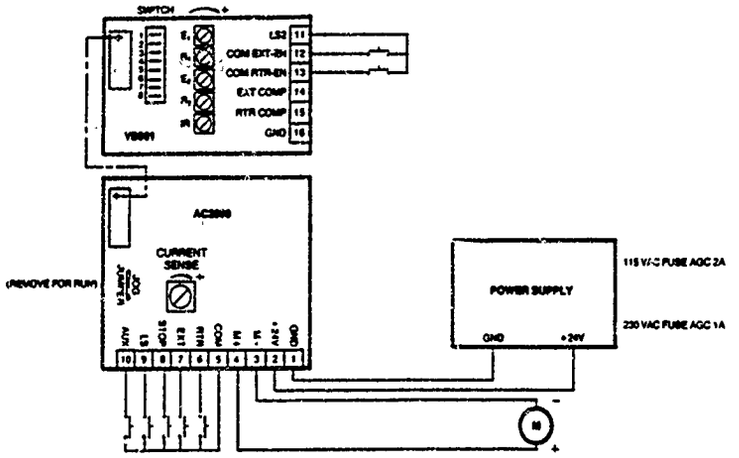
6. ADJUSTMENTS - Speed Potentiometers

- E_1 INITIAL SPEED EXTEND — Turn clockwise to increase speed
- R_1 INITIAL SPEED RETRACT — Turn clockwise to increase speed
- E_2 SECOND SPEED EXTEND — Turn clockwise to increase speed
- R_2 SECOND SPEED RETRACT — Turn clockwise to increase speed
- IR IR COMPENSATION — Turn counterclockwise to increase gain

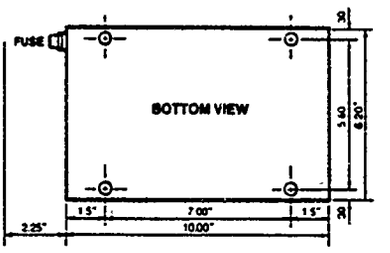
7. DIP SWITCH POSITIONS

1 = LS STOP
2 = LS AUTO-RETRACT
3 = LS AUTO-EXTEND
4 = LS STOP IN RETRACT DIRECTION ONLY
5 = LS STOP IN EXTEND DIRECTION ONLY
6 = CURRENT LIMIT: AUTO-RETRACT
7 = CURRENT LIMIT: AUTO-EXTEND
8 = SPARE

AC 2001 CONNECTION DIAGRAM



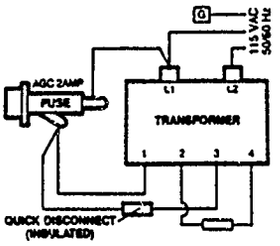
MOUNTING DIMENSIONS



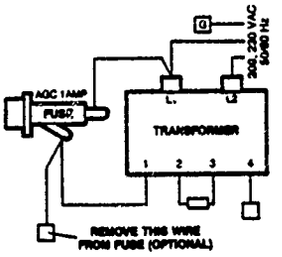
NOTE:
FUSE REQUIRES CLEARANCE FOR REMOVAL.

TRANSFORMER HOOKUP

115 VAC



208, 230 VAC



AC2001c - CONVERSION FROM AC2000c

(Connection of an VS001b to an AC2000c, disregard if received assembled)

VS001b Parts List

Qty.	Part #	Description
1	VS001b	Variable Speed circuit board
4	AC-2014-13	#6-32x2" Flat head machine screw
4	AC-2014-12	1¼" Nylon Standoff for a #6 screw

ASSEMBLY INSTRUCTIONS

1. Check that all of the parts are accounted for.
2. Remove the four back mounting screws on the AC2000 board; two are along the far back edge (side opposite terminal strip) and two are in the middle.
3. Install the four 2-inch long screws through these positions making sure to go through the ⅜ inch standoffs located between the chassis and AC2000 board.
4. Place the 1¼ inch standoffs over these screws; position the VS001 board and install nuts to secure.
5. Connect the ribbon cable from the VS001 board into the AC2000 socket so that the cable makes an "S" turn and protrudes under the VS001. Align position number 1 on the cable with position number 1 on the socket.

SPECIFICATIONS

A. MECHANICAL

Dimensions	AC2000b	VS001b	AC2001b	DC2000* CHASSIS	DC2000* MOUNTING
Length	5.5"	5.5"	5.5"	11.0"	7.0"
Width	5.0"	3.0"	5.0"	6.5"	5.6"
Height	1.2"	0.9"	2.2"	2.9"	—
Ambient Temperature Range					
Operating	0°C to 50°C		(32°F to 122°F)		
Storage	-40°C to 85°C		(-40°F to 185°F)		

B. ELECTRICAL

Power Requirements: DC2000: 105 - 120VAC 50/60 Hz FUSE AGC 2A
208 - 240VAC 50/60 Hz FUSE AGC 1A
AC2000b: +22 to 30VDC @ 10A Max.

Input Signals: EXTEND, RETRACT, STOP, LS, AUXILIARY
High level, open circuited +8.25VDC Max.
Low level, current sinking 0 to .8VDC @11ma Max.

Input Signal: LS2
High level, open circuited +8.25VDC Max.
Low level, current sinking 0 to .8VDC @1.0ma Max.

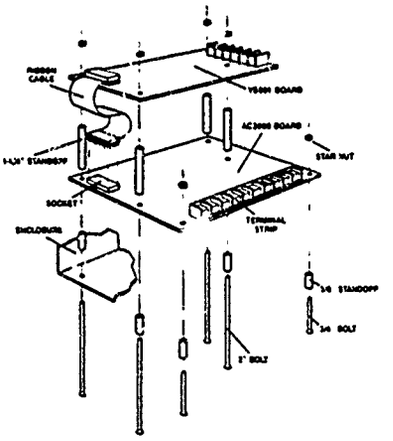
Output Signal: COM EXT-EN, COM RTR-EN, EXT COMP, RTR COMP
High level, open circuited +8.25VDC Max.; .400ma Max.
Low level, current sinking .5VDC Max.; 150ma Max.

Output Signal: M+, M-
High level Input Voltage - 2VDC Min., 10A Max.
Low level .5VDC @ 10A Max.

C. INPUT SWITCHING

Input Signal: EXTEND, RETRACT, STOP, LS, AUXILIARY
Low level, pulse width (latched input) 5ms Min.
Delay between inputs (time to go from extend to retract or vice versa) 5ms Min.

*A DC2000 is the chassis power supply only



OPERATING INSTRUCTIONS - AC2000 & AC2001

ELECTRIC CYLINDER CONTROL

The AC2000 series electric cylinder control provides all the power, logic and solid state switching functions required to drive an Industrial Devices Model 15D electric cylinder. The AC2000 is the basic electric cylinder control providing motor direction switching, automatic overload protection and dynamic braking. A second board, part number VS001, can be added to provide additional functions to the control. *An AC2000 used in conjunction with a VS001 is designated as an AC20[illegible].*

AC2000

The AC2000 has five logic function inputs: EXTEND, RETRACT, STOP, LIMIT SWITCH, and AUXILIARY. Each of these inputs, when grounded, activates that function - logic low true. (A common ground post, terminal #5, is provided for this purpose.) The inputs are optically coupled for transient protection and noise immunity. Typical devices used to activate the inputs are: a normally open momentary switch, a relay (form A or C), or an open collector sinking transistor.

MODES OF OPERATION

The AC2000 can be operated in a RUN or JOG mode. A removable jumper is supplied on the circuit board to provide for operation in the jog mode. NOTE: The control is shipped from the factory with this jumper installed on one pin of the JOG position — (not connected, RUN mode). To enable the JOG mode — place the jumper across both pins.

JOG:

In the jog mode the cylinder moves *only* while the extend or retract input is maintained. When the signal is released, the cylinder will stop. During jog movement, it will *also* stop when the "stop" or "limit switch" inputs are activated. To restart, the "extend" or "retract" inputs must be released and reactivated.

RUN:

In the run mode the "extend", "retract", and "auxiliary" inputs need only to be activated momentarily to latch their operation. The cylinder will then run continuously until another input is activated or until the unit is stopped. Minimum duration of signal is 5 milliseconds.

LOGIC COMMANDS

All logic functions are initiated by grounding the input terminals as described above. These are low-level signals, 8 volts at 11 milliamperes; light wire and low contact ratings may be used. The control circuitry is designed to ignore contact bounce and transient signals. All logic contacts connect across the "Com" terminal, #5, and the appropriate function as follows:

EXTEND:

Contact causes cylinder to extend until it receives a new signal or is stopped due to a current overload such as a mechanical stop (e.g., end of stroke). See "Current/Overload Sensing" below.

RETRACT:

Same as above but opposite direction. NOTE: Applying a "retract" signal while the cylinder is extending, or an "extend" signal while retracting, will cause the unit to stop and immediately start in the opposite direction. If both "extend" and "retract" signals are given simultaneously, the electric cylinder will stop and will not restart until both signals are released and one is reinitiated.

STOP:

An emergency stop control function, this causes an immediate stop. The control will not accept another signal while this condition is maintained.

LIMIT SWITCH:

A one-shot function; immediately stops the cylinder yet permits other inputs to operate.

AUXILIARY:

Used to resume operation. If the cylinder has been stopped, this input will restart in the same direction as it was previously traveling.

CURRENT/OVERLOAD SENSING

The single potentiometer in the lower middle of the circuit board sets the current sense threshold. Clockwise rotation of this pot increases the thrust level at which the control will automatically cause the unit to stop. Too low a setting will cause the unit to stop immediately after it starts; too high a setting may break the machine linkage or cause the fuse to blow.

If the cylinder is stopped due to current overload, the input to that direction is disabled, e.g., if the cylinder is extending and reaches the end of stroke and stops due to current overload, any further activations to the extend input are ignored.

If functional considerations require continued motion after current sense stop, this feature can be disabled—consult factory.

OPERATING INSTRUCTIONS: AC 2001 CONTROL

AC2001 (AC2000 with VS001)

The VS001 circuit board adds the following functions to the AC2000: 1) variable speed: two independent speed adjustments for each direction, and 2) additional automatic logic functions, including limit switch direction mask, limit switch input to auto-retract or auto-extend, and auto-extend/auto-retract due to current overload.

VARIABLE SPEED

Four speed potentiometers provide four independent speed adjustments, two in each direction. The speed adjustments allow for a 15:1 reduction from the base speed (maximum rated no-load speed for cylinder). Full clockwise rotation is maximum speed.

- E1: Sets the first speed used in the extend direction.
- R1: Sets the first speed used in the retract direction.
- E2: Allows for a second speed in the extend direction only. The logic is activated by grounding the LS2 input (terminal #11) while extending. The LS2 input is located on the VS001 terminal strip. See "Common-Extend Enable" below.
- R2: Same as above but in the retract direction only. See "Common-Retract Enable" below.
- IR: This fifth pot is provided to smooth the motor action at low speeds. It is normally set in the full clockwise position. If significant changes in load during the cycle cause excessive speed fluctuation, turn counterclockwise to increase the control's sensitivity to speed change. Adjustment is also needed when the current sense feature is used while running at very slow speeds. In this case, the IR pot should be slowly rotated counterclockwise until the current sense circuit operates.

DIRECTION CONDITIONAL LOGIC

COMMON-EXTEND ENABLE:

It is used in conjunction with the LS2 input to initiate a speed change in the extend direction only. Additionally, this directional "common" can be used to enable a limit switch in only the *extend* direction, or to signal other controls that the actuator is running in the extend direction. This is accomplished via a sinking transistor output which is grounded only when the control is in the extend direction.

COMMON-RETRACT ENABLE:

Same as "Common-Extend Enable" but in the *retract* direction.

OUTPUT SIGNALS

EXTEND COMPLETE:

An output used to signal other electric cylinders or other devices that the unit has stopped. This is a sinking transistor output that will go low once stopped and stay low until the unit is restarted in *either* direction.

RETRACT COMPLETE:

Same as "Extend Complete" but in the *retract* direction.

PROGRAMMABLE FUNCTIONS

A variety of complex motions can be obtained by the use of selected stopping and auto-return functions. An eight-position dip switch is provided to select these actions when they are required. The normal state for the dip switch is in the open position. Closing the appropriate switch enables that function. Each dip switch position is defined as follows:

Position	Function
1	Sets the normal *stop function* to the limit switch circuitry on the AC2000 board.
2	Sets the limit switch circuitry to *auto-retract* instead of stop (DO NOT enable position 4 when using this input).
3	Sets the limit switch circuitry to *auto-extend* instead of stop (DO NOT enable position 5 when using this input).
4	Sets the limit switch circuitry to operate *only in retract direction* (to be used with position 1).
5	Sets the limit switch circuitry to operate *only in extend direction* (to be used with position 1).
6	Enables *auto-retract* when a *current overload* exists in the extend direction.
7	Enables *auto-extend* when a *current overload* exists in the retract direction.
8	Spare.

TROUBLESHOOTING CHART

SYMPTOM	CAUSE	REMEDY
ACTUATOR DOES NOT MOVE	Power not on	Check AC voltage
	Fuse blown	Replace Fuse 115VAC: AGC 2A 230VAC: AGC 1A
	No DC power at AC2000	Check DC voltage at Terminals #1 and #2. Power supply bad unless #1 = GND, #2 = 22-30VDC
	Speed setting too low (AC2001 Only)	Increase Speed Pots
	Inputs continuously grounded	Check for ground on Terminals #6, 7, 8, and 10 - remove ground
	No motor power	Be sure that a Run signal has been given, then check for voltage between motor terminals #3 & #4. No voltage - contact factory
	Open circuit between AC2000 & motor	Check wiring to motor leads
ACTUATOR LUNGES FORWARD AND STOPS	Current sense pot too low	Increase current sense pot setting
	Jog plug installed	Remove jog plug for Run applications
MOTOR MOMENTARILY HUMS WITHOUT ACTUATOR MOVING*	Mechanical bind or jamming causing overload	Check for side load binding; Max. 10 lbs. at Output Bearing
	Thrust tube is over torqued deforming Drive nut	Loosen thrust tube and tighten hand tight
	Drive nut jammed against thrust bearing due to thrust tube not being seated against drive nut flange	Contact factory

*NOTES: 1. If Control turns motor on and then off due to current sense overload, the control is working properly and the problem is mechanical.

2. To check for overload — Install a 0-10 AMP Ammeter in series with the motor and read current while running. Maximum dynamic current should be less than 4.5 AMP with no load applied to the actuator and 8 AMP at full load.

PARTS LIST

Description	Part #	Description	Part #
1. AC2000b	AC2000b	9. Jog Plug	AC-2010-26
2. VS001b (includes mounting hardware)	VS001b	10. Capacitor Holder (Nylon)	999-529
3. Transformer	999-528	11. Fuse Holder	999-509
4. Capacitor 40V 11000uF	999-509	12. On-off Switch (pL version only)	999-548
5. Bridge Rectifier	999-510	13. Neon Light (pL version only)	999-549
6. Fuse AGC 2A (115V operation)	999-532	14. ⅜" Nylon Spacer	999-527
7. Fuse AGC 1A (230V operation)	999-547	15. 1¼" Nylon Spacer	AC-2014-12
8. Line Cord	999-534		

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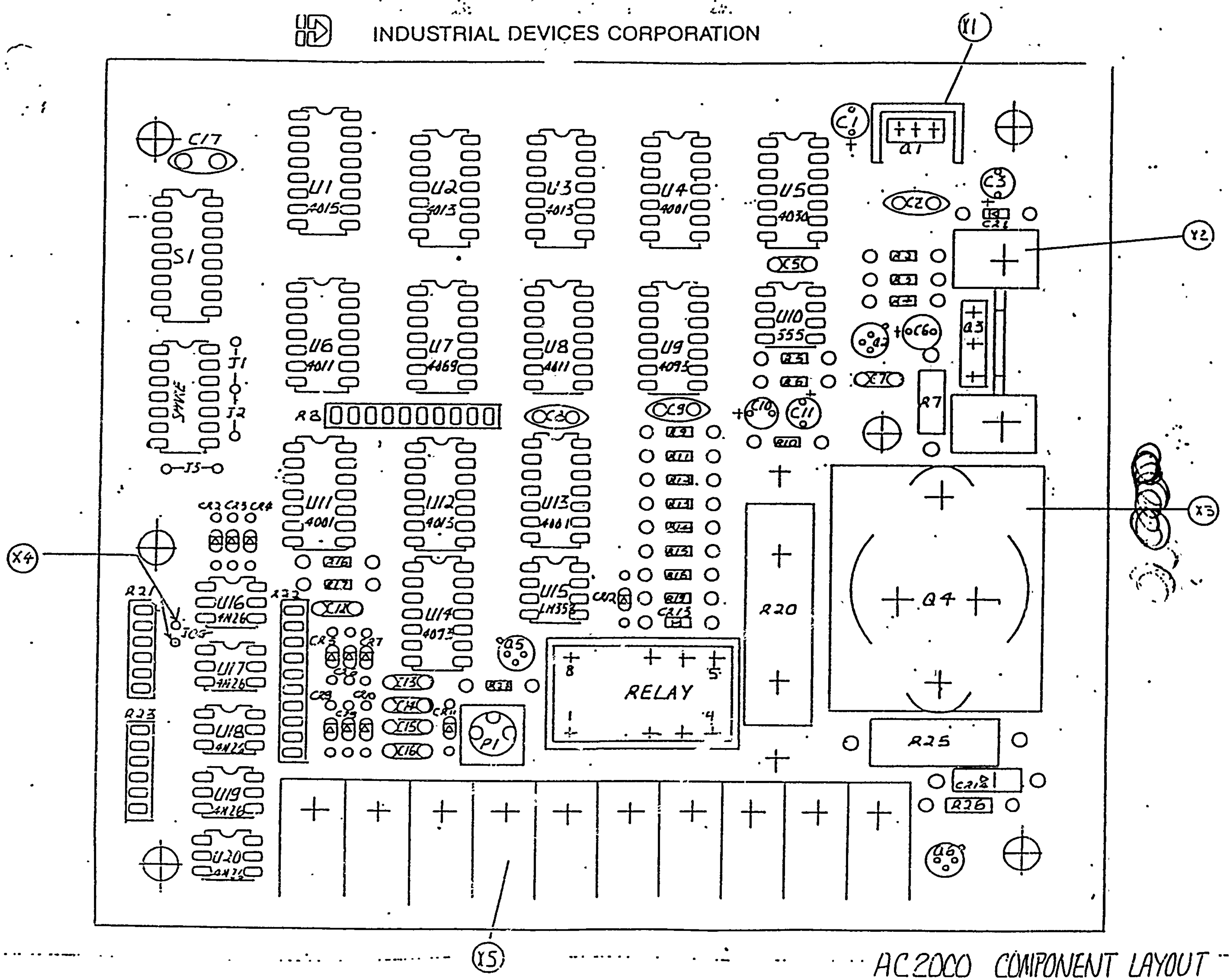

AC2000 COMPONENT LAYOUT

DWG. NO.	SH	REV.

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED

IC'S

U1	4015
2	4013
3	4013
4	4001
5	4030
6	4011
7	4069
8	4011
9	4093
10	NE555
11	4001
12	4013
13	4001
14	4093
15	LM358
16	4N26
17	4N26
18	4N26
19	4N26
20	4N26

TRANSISTORS

Q1	LM7812
2	2N2222A
3	TIP 35A
4	2N6285
5	2N2222A
6	2N2222A

CAPACITORS

C1	10 MF 16V
2	.1 MF
3	100 MF 35V
4	NOT USED
5	.01 MF
6	1 MF 16V
7	.01 MF
8	.1 MF
9	.1 MF
10	2.2 MF 16V
11	1 MF 16V
12	.01 MF
13	.01 MF
14	.01 MF
15	.01 MF
16	.01 MF
17	.1 MF

POTENTIOMETER

R27 10K POT

RELAY

8 PIN 24VDC
8 AMP
AMERICAN ZETTLER
AZ-732-560-2

SOCKET

16 PIN SOCKET

RESISTORS

R1	NOT USED
2	200K
3	4.7K
4	1 K
5	100K
6	27K
7	100Ω 2W
8	47K (10 PIN SIP)
9	200K
10	4.7K
11	100K
12	820K
13	200K
14	22K
15	10K
16	2.2K
17	100K
18	51K
19	10K
20	.05Ω 7W
21	10K (6 PIN SIP)
22	220K (10 PIN SIP)
23	1.2K (6 PIN SIP)
24	4.7K
25	680Ω 2W
26	680 Ω

DIODES

CR1	1N4001
2	1N914
3	1N914
4	1N914
5	1N914
6	1N914
7	1N914
8	1N914
9	1N914
10	1N914
11	1N914
12	1N914
13	1N4003
14	MR822
	(OR EQUIV.)

MISC.

X1. HEATSINK AAVID 5771B W/4-40 X 5/16" PAN HEAD AND 4-40 KEP NUT.

X2. HEATSINK AAVID 60130-010B W/4-40 X 5/16" PAN HEAD. AND 4-40 KEP NUT.

X3. DUAL HEASINK ASSEMBLY. AAVID EG 5203B W/4-40 FEMALE STUD AAVID 5791B AND 4-40 X 5/16" PAN HEAD.

X4. CAGE JACK MIDLAND ROSS 450-3703-01-06-00

X5. 10 POSITIONS TERMINAL STRIP.

NOTE: UNLESS OTHERWISE SPECIFIED:

1. RESISTORS VALUE IN OHMS AND 1/4 WATT.

QTY PER	FSCM NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION

PARTS LIST

NEXT ASSY	USED ON	
APPLICATION	DO NOT SCALE DRAWING	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±

MATERIAL

FINISH

CONTRACT NO.

APPROVALS		DATE
DRAWN	SON LAM	3-20-85
CHECKED	Son Lam	3-20-85
ISSUED	H Parris	3-20-85

INDUSTRIAL DEVICES CORPORATION
NOVATO, CALIFORNIA 94947-6264

AC 2000 COMPONENT LIST (VCC = 12V)

SIZE	FSCM NO.	DWG. NO.	REV.
B		AC-B2014	F

SCALE | SHEET 1 OF 1

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INDUSTRIAL DEVICES CORPORATION
35 PAMARON WAY / NOVATO, CA 94947-6284

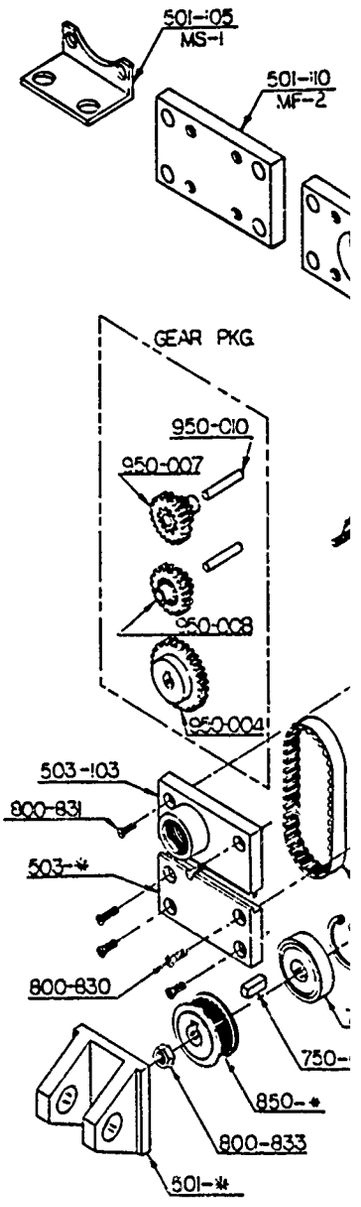
15D Series Electric Cylinders

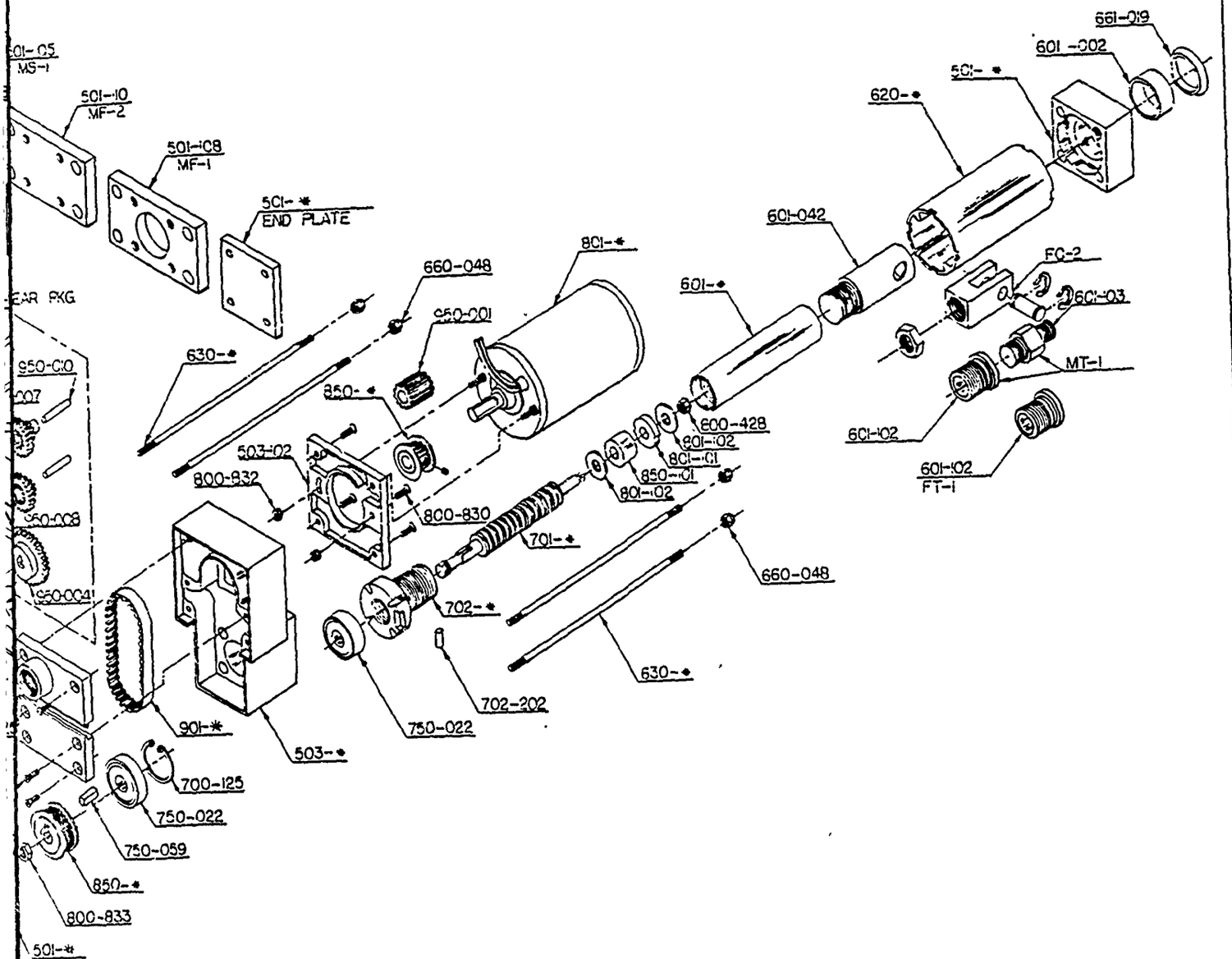
PART NUMBER:	DESCRIPTION
501-102	Clevis Cap - Double Leg
501-104	Clevis Cap - Double Leg Geared
501-105	MS-1 Side End Angle
501-106	End Plate
501-107	End Plate - Geared
501-108	MF-1 Mounting Plate
501-110	MF-2 Mounting Plate
501-103	Rod End Housing
501-203	Rod End Housing Assembly
501-303	Rod End Housing Assembly - MS4
501-403	Rod End Housing Assembly - MFS
503-102	Motor Support Plate - 15D Series
503-103	Terminal Cover Plate - Upper
503-203	Terminal Cover Plate - Lower
503-213	Terminal Cover Plate - Lower - Geared
503-204	Bearing Housing - Geared
503-404	Bearing Housing - MS4
503-504	Bearing Housing - MS4 - Geared
503-704	Bearing Housing - 15D/23S Series
601-002	Rod End Sleeve Bearing
601-042	FE-2 Rod End
601-102	Rod End Bushing
601-103	NFPA Male Fitting
610-102	2" Stroke Thrust Tube
610-104	4" Stroke Thrust Tube
610-106	6" Stroke Thrust Tube
610-108	8" Stroke Thrust Tube
610-112	12" Stroke Thrust Tube
610-118	18" Stroke Thrust Tube
620-102	2" Stroke Guide Cylinder
620-104	4" Stroke Guide Cylinder
620-106	6" Stroke Guide Cylinder
620-108	8" Stroke Guide Cylinder
620-112	12" Stroke Guide Cylinder
620-118	18" Stroke Guide Cylinder
630-102	2" Stroke Tie Rod-MP
630-104	4" Stroke Tie Rod-MP
630-106	6" Stroke Tie Rod-MP
630-108	8" Stroke Tie Rod-MP
630-112	12" Stroke Tie Rod-MP
630-118	18" Stroke Tie Rod-MP
630-202	2" Stroke Tie Rod-MSMF
630-204	4" Stroke Tie Rod-MSMF
630-206	6" Stroke Tie Rod-MSMF
630-208	8" Stroke Tie Rod-MSMF
630-212	12" Stroke Tie Rod-MSMF
630 218	18" Stroke Tie Rod-MSMF
630-302	2" Stroke Tie Rod-MX
630-304	4" Stroke Tie Rod-MX
630-306	6" Stroke Tie Rod-MX
630-308	8" Stroke Tie Rod-MX
630-312	12" Stroke Tie Rod-MX
630-318	18" Stroke Tie Rod-MX
660-048	Tie Rod Nut
661-019	Wiper Ring

PART NUMBER:	DESCRIPTION
700-125	Bearing Retaining Ring
701-202	2" Stroke Lead Screw - 15D Series
701-204	4" Stroke Lead Screw - 15D Series
701-206	6" Stroke Lead Screw - 15D Series
701-208	8" Stroke Lead Screw - 15D Series
701-212	12" Stroke Lead Screw - 15D Series
701-218	18" Stroke Lead Screw - 15D Series
702-001	Drive Nut - 15D Series
702-011	Drive Nut - 15D Series - MFS
702-021	Drive Nut - 15D Series - FS
702-031	Drive Nut - 15D Series - Linear Pot.
702-041	Drive Nut - 15D Series - MFS-Linear Pot.
702-051	Drive Nut - 15D Series - FS-Linear Pot.
702-202	Drive Nut Magnet
750-022	Radial Thrust Bearing
750-059	Shaft Key
800-428	Left Hand Nut
800-830	8-32 PH FH Screw
800-831	8-32 SL FH Screw
800-832	8-32 Loc Nut
800-833	7/16-20 Retaining Nut
801-001	24VDC Motor
801-002	24VDC Motor w/Pin Gear
801-101	Rod End Bearing
801-102	SS Retaining Washer
850-101	Elastomeric Spring

Belt Drives

Model 15D-06050-	
850-110	15XL Motor Pulley
850-102	15XL Driven Pulley
901-101	Drive Belt
Model 15D-04075-	
850-112	12XL Motor Pulley
850-107	18XL Driven Pulley
901-101	Drive Belt
Model 15D-03100-	
850-111	10XL Motor Pulley
850-106	20XL Driven Pulley
901-101	Drive Belt
Model 15D-02180-	
850-103	18MXL Motor Pulley Assembly
850-105	60 MXL Driven Pulley
901-102	Drive Belt
Model 15D-004800-	
950-001	Pinion Gear-Motor
950-004	Spur Gear - Driven
950-007	Spur Gear-1-Intermediate Assembly
950-008	Spur Gear-2-Intermediate Assembly
950-010	Bearing Shaft





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INDUSTRIAL DEVICES CORPORATION / 35 PAMARON WAY / NOVATO, CA 94947 / 415 883-3533

ANALOG POSITION CONTROL

AP001

The AP001 control, used in conjunction with the AC2000 control, enables a 15D series actuator installed with a linear potentiometer to be positionally controlled by a 0 to 5 volt signal. At 0 volts the actuator is at full retract; at 5 volts the actuator is a full extend.

The AP001 automatically decelerates to a slow speed prior to stopping to minimize overshoot, thereby maintaining approximately the same stopping point when approaching from either direction.

The AP001 allows adjustment to (1) the amount of distance before deceleration begins, (2) the sensitivity hysteresis surrounding the stopping point, (3) the maximum speed (4) the slow speed rate, (5) the IR (current compensation) and (6) two bias potentiometers.

This control operates best when the actuator is under one half of its rated load. This is because the AC2000 stops the actuator during a stall condition regardless of what the AP001 commands it to do and requires a direction change to clear the stall and resume motion.

THEORY OF OPERATION

The linear potentiometer inside the actuator (LP0-1) is connected to the AP001 on terminals #11, #12, and #13 (see wiring instructions). The potentiometer is energized with 5 volts DC and produces a voltage division output proportional to its stroke displacement. For example, at full extend the voltage will be 5 volts, and at one half extension the voltage will be 2.5 volts.

The AP001 compares the linear potentiometer voltage with the position reference voltage fed in by an external source or by connecting a potentiometer to the input terminals #16, #17, and #18 (see wiring instructions) and produces a plus or minus differential voltage proportional to the difference.

If the actuator is at 4 volts and the reference is at 2 volts then the AP001 signals the AC2000 board to retract the actuator until the voltages are the same. The actuator begins retracting at full speed and then automatically decelerates to a slower speed as it approaches the stopping point.

SET-UP AND ADJUSTMENTS

NOTE: THE AC2000 MUST BE IN JOG MODE FOR PROPER OPERATION

There are five potentiometers which allow the AP001 to be adjusted for maximum performance and/or preference for a given application.

DECEL POT - Clockwise rotation sets the maximum distance to begin deceleration prior to stopping, setting a low differential gain. Counter clockwise rotation reduces the deceleration distance setting a higher differential gain. Full counter clockwise rotation may cause unstable operation. (excessive differential input gain) causing overshoot.

SENSITIVITY POT - This pot sets the amount of input voltage difference required before movement is made. With large sensitivity gain, very minute voltage changes cause the actuator to move. Likewise, with low sensitivity gain the input voltage difference must be larger before the actuator will move. Clockwise rotation sets the minimum sensitivity gain; turn counter clockwise to increase the position sensitivity gain.

FOR EXAMPLE - When the DECEL POT is adjusted for a larger deceleration distance, it also produces a larger differential offset voltage null for which no movement occurs (low sensitivity). That is, the differential offset voltage between the two inputs which causes no movement is increased. Increasing the sensitivity gain reduces this differential offset allowing more accurate positioning.

When the DECEL POT is adjusted for a small deceleration distance the sensitivity is also increased. Therefore the SENSITIVITY POT need not be set for as high a gain. It is not advisable to have both the DECEL and SENSITIVITY pots near their full counter clockwise rotation, for too much gain on both pots may cause unstable oscillatory operation.

MAX SPEED LIMIT POT - Counter clockwise rotation reduces the maximum speed at which the actuator will travel.

SLOW SPEED RATE POT - This pot sets the slow speed at which the actuator makes its final move into position. Counter clockwise rotation reduces the final speed. Too slow a speed may cause the actuator to take excessive time to reach position. Too high a speed causes jumpy type motion when making short incremental moves.

IR COMPENSATION POT - (Current regulation compensation) Counter clockwise rotation increases the power the actuator has at slow speeds when heavily loaded. The normal position is at full clockwise rotation.

BIAS(+) AND BIAS(-) - These two pots, BIAS(+), labeled R11, and BIAS (-) labeled R12, enable the operator to limit the voltage adjustment on the position reference potentiometer. This in turn limits the maximum and minimum travel distances. When these pots are turned fully clockwise they are shorted out and full voltage is output to the reference pot. Counter clockwise rotation reduces the output voltage.

LED INDICATORS

There are two indicators used to show if the actuator is stopped.

GREEN - The GREEN LED indicates the actuator is stopped at the proper location. This light should be in a steady state and not blinking. If the light is blinking, reduce the sensitivity gain by turning the SENSITIVITY POT clockwise.

RED - The RED LED which indicates the actuator has stalled in a particular direction. If this LED is on, it will be necessary to reverse the direction to clear the stall condition.

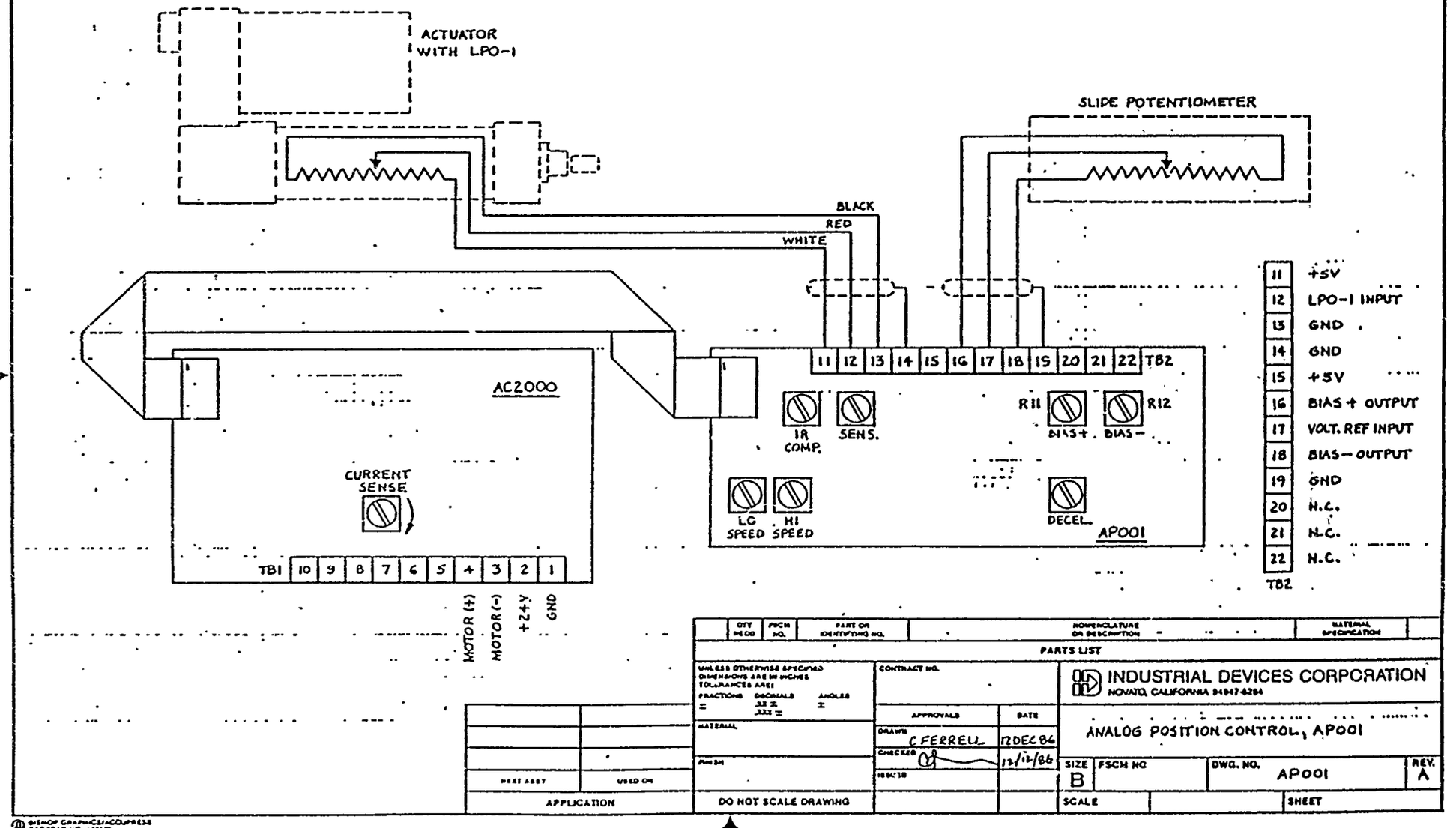
The stall may have occured in one of two ways: first, by an overload in which case it will be necessary to reduce the load on the actuator, or secondly by a rapid increase in speed in the same direction after having been moving at a slow speed. This rapid change in speed, from slow to fast, in the same direction causes an inrush of current to the motor for which there is no current masking. If the actuator has stopped prior to the fast speed, the AC2000 masks the current inrush and ignores the overload so no stall occurs.

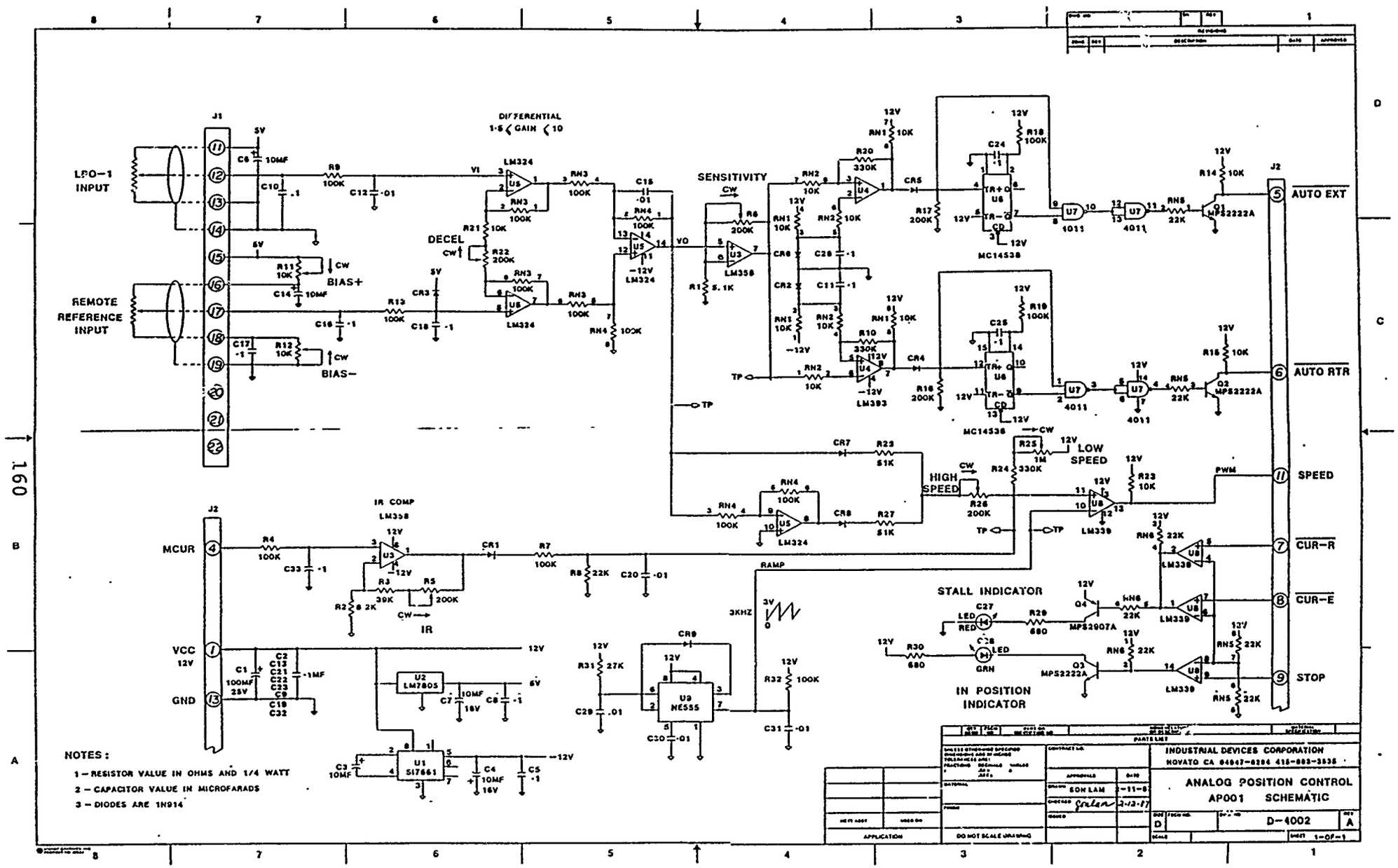
INDUSTRIAL DEVICES CORPORATION / 35 PAMARON WAY / NOVATO, CA 94947-6284 / 415 883-3535

MODIFICATION 400
FOR ANALOG POSITION CONTROL, AC2002

Modification 400 adds two outputs and one input to the Analog Position board, AP001. The outputs are used to indicate when the position is found and if a stall or current overload has occured. The input is used to allow movement only when desired.

TERMINAL	DESCRIPTION	
20	Stall	- a sinking transistor output which goes to ground only if a stall has occurred. To regain movement, a reference input change forcing the actuator to move in the other direction is required. During normal operation the output is at a voltage level of 11VDC (pulled up by a 10K ohm resistor). Maximum sinking current is 50ma.
21	Position	- a sinking transistor output which goes to ground only when the position is found. When out of position, that is when the input reference voltage does not agree with the actuator's LPO-1 voltage, the output is at a voltage level of 11VDC (pulled up by a 10K ohm resistor). Maximum sinking current is 50ma.
22	Enable	- logic low input, when the input is grounded the control is enabled to move the actuator to the reference position. When the input is not grounded, the control is not allowed to move even if the reference input is different from the actuator's LPO-1.




LPO-1 INPUT
REMOTE REFERENCE INPUT
BIAS+
BIAS-
DECEL
SENSITIVITY
DIFFERENTIAL
1<GAIN<10
LM324
LM358
LM393
MC14538
4011
LM339
MPS2222A
MPS2907A
AUTO EXT
AUTO RTR
SPEED
CUR-R
CUR-E
STOP
LOW SPEED
HIGH SPEED
PWM
RAMP
3KHZ
IR COMP
IR
MCUR
VCC
GND
STALL INDICATOR
IN POSITION INDICATOR
U1 SI7661
U2 LM7805
U9 NE555
NOTES:
1 - RESISTOR VALUE IN OHMS AND 1/4 WATT
2 - CAPACITOR VALUE IN MICROFARADS
3 - DIODES ARE 1N914
INDUSTRIAL DEVICES CORPORATION
NOVATO CA 94947-6284 415-883-3535
ANALOG POSITION CONTROL
AP001 SCHEMATIC
D-4002
A
SHEET 1 OF 1

ADDENDUM TO AC2001 OPERATING INSTRUCTIONS

The VS001 multifunction control has been replaced with the VS001A to incorporate additional features. The AC2000 basic controller board has been modified to accommodate some of the changes.

A time delay option is available with the designation of VS001AT.

All AC2001 controls will now incorporate the VS001A board. When the time delay functions are included, the control is designated as AC2003.

To allow for higher cycle rates and increased actuator performance in certain applications, a heavy duty power supply option is now available. It utilizes a larger transformer and provides greater heat dissipation capabilities. These units are designated AC2020 and may be used in conjunction with any of the standard controls.The heavy duty power supply contains thermal protection which will interrupt power if excessive temperatures are encountered. This will automatically reset when the unit has cooled to normal operating temperatures.

AC2000/AC2020 - basic control
AC2001/AC2021 - basic control with variable speed, programmable functions and outputs
AC2002/AC2022 - basic control with analog positioning control. Used with cylinders equipped with LPO-1 option.
AC2003/AC2023 - AC2001 with time delay functions

AC2000 BOARD CHANGES:

The Auxiliary input (terminal 10) is not used unless a VS001A is installed. Previously it was used to provide a resume function. With the VS001A installed this terminal acts as a second limit switch input similar to terminal 9. It is a one-shot stop function which when selected by the dip switches on SW1 can act as a one-shot extend, one-shot retract or trigger to start the optional timer. See SW1 Dip Switch selection table.

VS001A BOARD CHANGES:

The difference between the old VS001 and the new VS001A is in the use of the programmable dip switches. If you previously were using an AC2001 and a) all the dip switches were turned off and b) nothing was wired to terminals 14, 15, or 16, the new AC2001 may be installed without modifying your set-up.

Terminal 11, 12 and **13** function as before but terminal 11 is now labeled SP2 instead of LS2 to better indicate its function - Second Speed Change. Whenever terminal 11 is grounded the logic selects the actuator speed to be that set on the E2 or R2 potentiometers. This speed remains set even if the ground on terminal 11 is removed. This is cleared once the actuator is stopped. Upon starting, speeds E1 and R1 are in effect until terminal 11 is grounded.

Terminal 12, Common-Extend Enable, is a ground output which is present only during the extend cycle. To enable a limit switch to be seen only in the extend direction, wire the ground side to this terminal. For example, if you want a limit switch to change the speed of the actuator when it is passed in the extend direction and not when passed in the retract direction, wire the limit switch to terminals 11 and 12. If the limit switch is to change the speed when passed from both directions, wire it to terminals 11 and 5.

Terminal 13, Common-Retract Enable, same as terminal 12 but in the retract direction.

Terminal 14, Extend Complete, is a sinking transistor output used to signal other devices that the unit has stopped. This output will be triggered by stopping on either LS1 (terminal 9) OR a current overload in the extend direction. It will not be turned on by either the Stop input (terminal 8) or the new AUX limit switch input (terminal 10). Dip switch #5 on SW1 selects which trigger will be used. On the old VS001, this output was turned on any time the actuator was stopped in the extend direction.

Terminal 15, Retract Complete, same as terminal 14 but in the retract direction. Dip switch #6 on SW1 selects which trigger will be used.

Terminal 16, Time Delay Output Pulse. This output only functions when the time delay option is installed. It is a sinking transistor pulse which is selected to go low either at the end of the time delay (connect W3) or during the time delay (connect W2). On the old VS001 this terminal was grounded. When using the output pulse at the end of the time delay the pulse width can be varied by adjusting pot P6. (approx. 50ms to 2 sec.) The time delay period can be varied by adjusting pot P7. (approx. 20ms to 20 sec.)

AC2003: (AC2000 with a VS001AT, time delay option)

The time delay option has a variety of functions programmed by the dip switches on SW2. It can cause an automatic extend or retract at the end of the time delay, be selected to be triggered by LS1 (terminal 9) or AUX (terminal 10) and/or the current overload signals and be enabled to operate only in a particular direction. In addition, a sinking transistor output is provided to interface the external logic (terminal 16). See SW2 Dip Switch selection table.

**** OVER ****

DIP SWITCH SELECTION TABLES FOR VS001A BOARD AND VS001AT BOARD (TIME DELAY OPTION)

SW1 DIP SWITCH SELECTION TABLE: STANDARD LIMIT SWITCH FUNCTIONS

SWITCH #	FUNCTION
1	ON : ONE - SHOT RETRACT ON LS1 (terminal 9) OFF : ONE - SHOT STOP ON LS1
2	ON : ONE - SHOT EXTEND ON LS1 (terminal 9) OFF : ONE - SHOT STOP ON LS1
3	ON : ONE - SHOT RETRACT ON AUX (terminal 10) OFF : ONE - SHOT STOP ON AUX
4	ON : ONE - SHOT EXTENDED ON AUX (terminal 10) OFF : ONE - SHOT STOP ON AUX
5	EXTEND COMPLETE OUTPUT (terminal 14) TRIGGERED BY: ON : CURRENT OVERLOAD OFF : LS1 (terminal 9)
6	RETRACT COMPLETE OUTPUT (terminal 15) TRIGGERED BY: ON : CURRENT OVERLOAD OFF : LS1 (terminal 9)
7	ON : AFTER CURRENT SENSE OVERLOAD AUTO RETRACT OFF : AFTER CURRENT SENSE OVERLOAD STOP
8	ON : AFTER CURRENT SENSE OVERLOAD AUTO EXTEND OFF : AFTER CURRENT SENSE OVERLOAD STOP

NOTES:

1 - SWITCHES 1 AND 2 SHOULD NOT BE TURNED ON AT THE SAME TIME
2 - SWITCHES 3 AND 4 SHOULD NOT BE TURNED ON AT THE SAME TIME

SW2 DIP SWITCH SELECTION TABLE: OPTIONAL TIME DELAY FUNCTIONS

SWITCH #	FUNCTION
1	ON : AFTER TIME DELAY AUTO EXTEND OFF : AFTER TIME DELAY AUTO STOP
2	ON : AFTER TIME DELAY AUTO RETRACT OFF : AFTER TIME DELAY AUTO STOP
3	ON : TIME DELAY TRIGGERED BY LS1 (terminal 9) OFF : TIME DELAY NOT TRIGGERED BY LS1
4	ON : TIME DELAY TRIGGERED BY AUX (terminal 10) OFF : TIME DELAY NOT TRIGGERED BY AUX
5	ON : TIME DELAY TRIGGERED BY EXT DIR CUR OVERLOAD OFF : TIME DELAY NOT TRIGGERED BY EXT DIR CUR OVERLOAD
6	ON : TIME DELAY TRIGGERED BY RTR DIR CUR OVERLOAD OFF : TIME DELAY NOT TRIGGERED BY RTR DIR CUR OVERLOAD
7	ON : TIME DELAY ONLY ON EXTEND DIRECTION OFF : TIME DELAY ENABLED
8	ON : TIME DELAY ONLY ON RETRACT DIRECTION OFF : TIME DELAY ENABLED

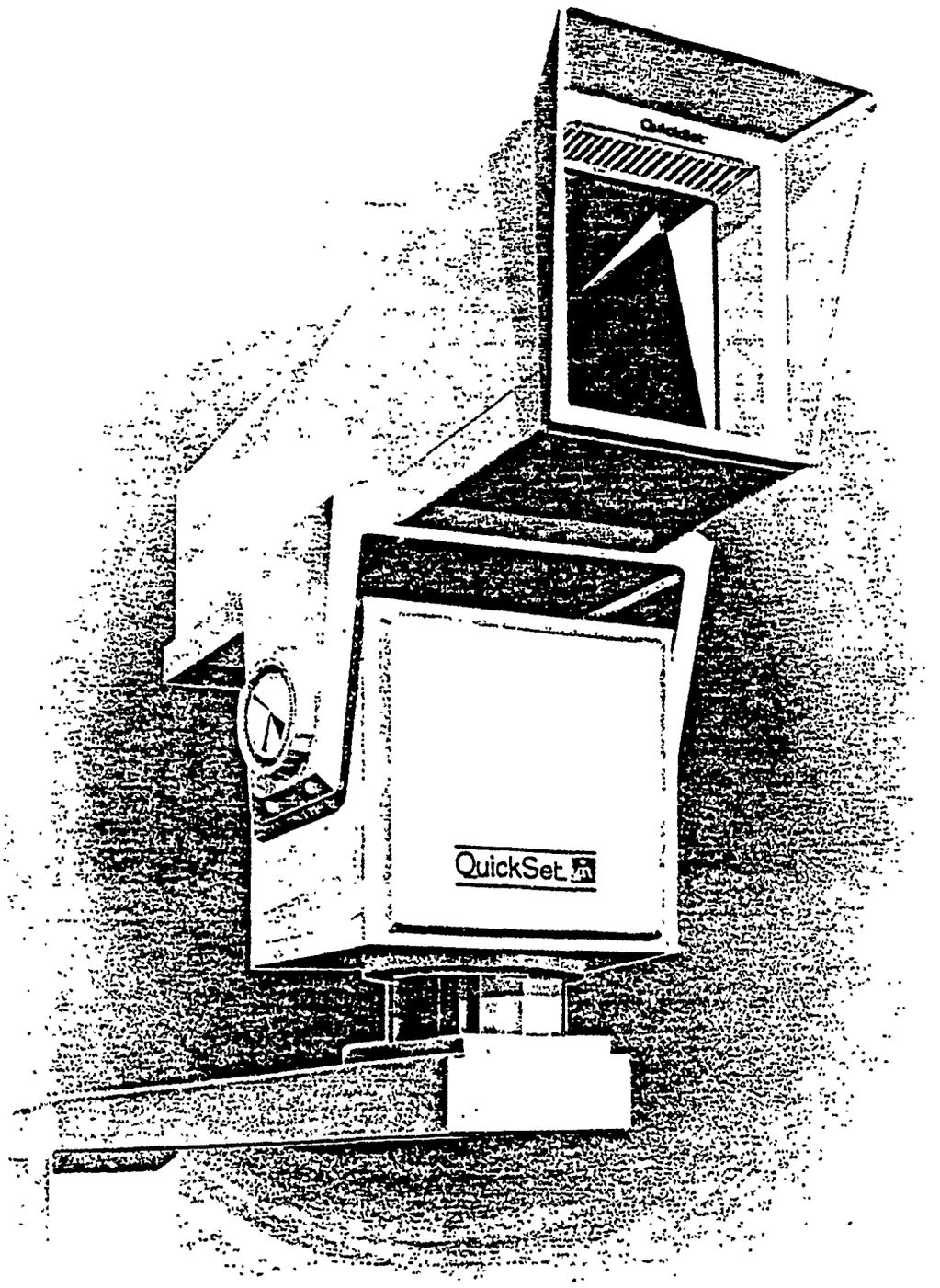
NOTES: PERTAINING TO DIP SWITCHES ON SW2

1 - THE TIME DELAY AUTO RETURN FEATURES WILL NOT OPERATE WITH THE JOG PLUG INSERTED.
2 - SWITCHES 1 AND 2 SHOULD NOT BE TURNED ON AT THE SAME TIME UNLESS W1 IS REMOVED
3 - SWITCHES 1 AND 5 SHOULD NOT BE TURNED ON AT THE SAME TIME
4 - SWITCHES 2 AND 6 SHOULD NOT BE TURNED ON AT THE SAME TIME
5 - SWITCHES 7 AND 8 SHOULD NOT BE TURNED ON AT THE SAME TIME
6 - WHEN USING AUTO RETURN AFTER TIME DELAY MAKE SURE THE SAME FUNCTION IS NOT SET ON SW1 DIP SWITCHES
7 - TO TIME DELAY ON BOTH ENDS,
    - REMOVE W1, TURN ON POSITIONS 1 AND 2 ON SW2 AND TURN POT P6 FULLY COUNTERCLOCKWISE

QuickSet

Section 1

Integral CCTV Camera Positioning, Protection and Mounting System



SECTION I General Information

A. Scope:

This manual provides information for installation, adjustment, maintenance and repair of the QPT-30 AC Pan/Tilts. The information is limited to what is considered practical for field repair and maintenance without requiring special tools or special techniques.

CAUTION: READ THIS MANUAL COMPLETELY BEFORE CONNECTING POWER TO THE UNIT. INJURY TO PERSONS OR UNIT CAN OCCUR IF THE DEVICE IS NOT PROPERLY USED.

B. Purpose of Equipment:

This ruggedly constructed, heavy-duty, all-weather environmental pan/tilt is designed to remotely position a CCTV camera and housing, or other instrumentation, to any degree of azimuth from 0° to 340° or elevation from 90° above to 90° below the horizon.

C. Description of Equipment:

Units are constructed of aluminum, steel, and engineering resins. Dimensions of the pan/tilt are 12½" high x 6½"deep x 11½" wide and weighs 18.59 pounds. Exterior and interior are painted. All unpainted steel components have a corrosion resistant finish.

Access to the unit interior is provided by a front and a rear cover. Each cover is retained by four captivated screws.

D. Specifications:

See Chart A.

SECTION II Installation

A. General:

To achieve optimum results from this unit, proper installation procedures should be followed; primarily these have to do with unit location and setting limit stops. These items are reviewed in the following paragraphs.

B. Unpack and Inspect:

Carefully unpack the unit and examine for signs of physical damage, particularly dented or broken parts, damage to wire harness or distortion of tilt table or body cover. If any are observed, notify the freight carrier immediately for claim handling.

Check the box contents for (1) Pan/Tilt unit, (1) mating connector and (1) manual. Retain packing box if future shipping or storage is expected.

Chart A
Specifications

All Pan/Tilts

Weight Capacity ..... 30 lbs (13.6 k)

Pan Specifications

Rotation	0°–340° (370° Special Order)
Torque	12 lb-ft (1150 gm-cm)
Speed	8°/sec (±1°)
Duty Cycle	Continuous
Motor	Permanent Split Capacitor
Motor Protection	Impedance Protected
Drive System	Chain/Worm
Backlash	Zero Adjustable
Bearings	Torrington Needle
Limit Switches	Internal – Adjustable
Power	24V – 1.2A, 115V – 0.25A, 220V – 0.13A

Tilt Specifications

Rotation	±90°
Torque	30 lb-ft (2877 gm-cm)
Speed	3°/sec (±½°)
Duty Cycle	Intermittant
Motor	Permanent Split Capacitor
Motor Protection	Impedance Protected
Drive Systems	Chain/Worm
Backlash	Zero Adjustable
Bearings	Engineered Resins
Limit Switches	Internal – Adjustable
Power	24V – 1.2A, 115V – 0.25A, 220V – 0.13A

General Specifications

Dimensions – See Drawings

Weight

Wall Bracket	7.116 lb	(3.2 k)
Pan/Tilt	19.9 lb	(9.0 k)
Housing	5.8 lb	(2.6 k)
Total	32.8 lb	(14.8 k)

Weather – Environment

Pan/Tilts – Gasketing and sealed against water and dust.

Housing – Gasketed and baffled against water. Insect proof, air intake filtered. Dust tight sealing available – special order

Ambient Temperature

Auto scan duty +5°F (–15°C) to +113°F (45°C)
Intermittant duty +5°F (–15°C) to +131°F (55°C)

Exterior Finish – Baked on enamel, almond color.

C. Installation Procedures – Mechanical:

1. Location Site.

Select a mounting location that will provide the desired maximum viewing angles without permitting the pan and tilt or camera housing to come in contact with, or strike, any objects in their sweep paths. Adjustable limit switches are provided to limit the degree of travel in both pan and tilt. The pan travel can be narrowed from the maximum of 340° to any lesser sweep; the tilt action from 90° above and below the horizon to anything less.

2. Mounting.

The mounting base (see Figure 1) is pre-drilled with four each ⅜" diameter holes on a 4⅜" diameter bolt circle in a 4½" square base. The mounting attitude may be in any plane. Fasten the base to a stable platform. We recommend 5/16" stainless steel bolts and nuts to be used. Consideration of wind loading factors on the camera housing and the pan and tilt is important when calculating how solid the mounting platform need be and the strength required in the mounting screws.

3. Wall Bracket Installation (Model QWBM-18, Code 7-17500-3)

a. Wall or Similar Flat Vertical Surface

After determining desired location (with consideration for clearances required for pan and tilt, housing, accessories, etc.), use template provided (part number 202517703-7) to locate mounting screw centers.

Screws with large slotted heads for mounting are provided (1/4-20UNC-2A). (A 6mm screw may be substituted.) The material of the wall mounted to, and means of providing female threads will determine if a substitute screw should be used. We highly recommend the use of a screw with a slotted head as it will be much more convenient to tighten.

Insert screws into wall, leaving approximately a 3/16" (5mm) loosness. Install bracket on screws and pull downward so screws are in the narrow slot of the keyhole.

Remove plug buttons from front of bracket to provide access for screw driver for tightening screws.

b. Outside Corner of Building or Pole

Outside corner adapter – Model QWBMOC, Code 7-17530-0 should be used. [Pole diamaters from 6.0" to 8.0" (150mm to 200mm) can conveniently be accommodated with this bracket.]

Position adapter as required to locate mounting holes. Secure adapter suitable with ¼" (6mm) screws.

Secure wall bracket to adapter with ¼" (6mm) screws and nuts.

c. Inside Corner at Intersecting Walls

Inside corner adapter – Model QWBMIC, Code 7-17525-0 should be used.

Position adapter as required to locate mounting holes. Secure adapter with suitable ¼" (6mm) screws.

Secure wall bracket to adapter with ¼" (6mm) screws and nuts.

4. Internal Access.

To remove either pan/tilt cover, loosen four (4) captivated Phillips head screws. **NOTE:** The screw in the lower left corner of each cover is longer than the other three so that the cover can be rotated about this screw and remain captivated while providing access to pan/tilt.

5. Setting of Pan and Tilt Limit Stops.

(1) With a large screwdriver (a good fit minimizes damage to the slot) turn the tilt worm shaft "C1" until the desired "Up" position is attained.

(2) Rotate the "Up" limit ring "B3" (use a screwdriver blade in the slots around the periphery) until its associated switch "S3" is activated; the tension ring will provide enough friction to keep the limit ring in place during normal operations, until you readjust it.

(3) Repeat steps 1 and 2 to set the "Down" limit ring "B4".

Pan –

The pan limit stops are set similarly to the tilt stops. Turn the pan worm shaft "C2" to select the desired position. The botton pan limit ring "B1" is the right (clockwise head rotation) limit adjustment. The second ring up, "B2" is the left (counterclockwise) adjustment.

NOTE: If your pan and tilt unit also has the optional "Auto Scan", it is normal practice to set the right and left limit stops for the maximum angle that can be achieved without hitting some obstruction.

Auto Scan –

Auto scan is used to limit automatic scanning to an important area inside the limits just set. At any time, the operator can view the areas between that covered by auto scan and the ultimate limit stops by panning there manually. When control is switched back to auto scan, the unit will automatically return to the preselected automatic scanning area.

The auto scan switch "S5" is located in front, in the area with the drive chains, and is actuated by the scan cam "E" located between this switch and the pan limit rings. This cam is in turn actuated by the two limit rings "B5" and "B6".

NOTE: Both auto scan limits *MUST BE SET INSIDE* the previously set limit stops.

To Adjust Auto Scan –

(1) Rotate the unit clockwise to the right by turning the pan worm shaft counterclockwise until the desired right (clockwise) scan limit position is attained.

(2) Rotate scan cam "E" in a counterclockwise direction against its stop, thus actuating the auto scan switch "S5".

(3) Rotate the top auto scan limit ring "B6" counterclockwise until scan cam "E" moves clockwise enough to open the auto scan switch "S5"; its tension ring will insure that this limit ring stays in place until you readjust it.

(4) To set the left limit, first rotate the unit by turning the worm shaft clockwise until the desired position is attained. The scan cam should remain stationary in its clockwise position until it is tripped by the manual rotation of the left auto scan limit ring "B5" during Step 5.

(5) Rotate auto scan limit ring "B5" (second from top) in a clockwise direction until scan cam "E" moves counterclockwise and actuates the auto scan switch "S5". As before, the tension ring will provide enough friction to keep the limit ring in place during normal operations, until you readjust it.

NOTE: There are stops on the two auto scan limit rings that make it impossible to set them in any position where the cam will be driven in both directions at the same time. It is important that this safety feature not be overridden.

D. Installation Procedures – Electrical:

1. General Comments.

The interconnecting cable between the controller and pan/tilt is vitally important to the reliable operation of any motorized instrument positioning system. Selection of the type of cable, the size (AWG), the number of conductors required, grounding techniques, special consideration for wiring to the devices mounted on the pan/tilt unit, plug connections and the pan/tilt options are the topics covered in Section D.

2. Wire Selection.

Careful consideration should be given to the type of cable utilized in order to achieve long term reliability and avoid costly system modifications. The type of cable installation, such as underground or overhead, generally requires cable designed for the specific application. In addition, the wire may have to be run in conduit. Check your local electrical code. Certain pan/tilt models which operate at 24 VAC generally preclude the use of conduit.

a. Select the proper size (AWG) of the conductors.

Adequate wire size insures that sufficient voltage will appear across the pan/tilt motors which will provide the required torque to move the mechanical load. Among the many factors that influence the determination of wire size are minimum line voltage anticipated, the weight of the mechanical load, the distribution of the mechanical load, the minimum tilt angle, and the distance between the pan/tilt source and the pan/tilt unit. The pan/tilt power source is usually the controller. However, in the case of the low voltage relay box control system, the digital control system, the QCSR coaxset receiver, tone decoder receiver, etc., the pan/tilt power source is the field box. Adherence to the data provided in the wire selection tables, Table I, II and III, will insure proper operation of the pan/tilt unit when operated with the rated mechanical load and at line voltages 10% below nominal. The information in Table I refers to all pan/tilt wires, including auto scan, with the exception of the wires required for the operation of the potentiometer (azimuth elevation readout) and heater options.

The wires required for operation of the potentiometer option should be shielded and can be #24 AWG or larger for distances of up to 1000 feet (#20 AWG or larger for distances up to 2000 feet). The heater primary power is normally supplied from the power mains at the pan/tilt site. The heater power requires 110 watts, depending

upon pan/tilt model. Consult the schematic of the appropriate pan/tilt unit utilized and use wire sizes commensurate with your local electrical codes.

Wire Size AWG	220 VAC QPT 30	117 VAC QPT 30	24 VAC* QPT 30
#24	994	284	
#22	1,582	452	
#20	2,513	718	31
#18	3,997	1,142	49
#16	6,356	1,816	78
#14	10,108	2,888	124
#12	16,072	4,592	197

* If higher voltage taps are available on the controller transformer, the distance may be extended as indicated in the tables shown below. Higher voltage taps are available only on our model 7-45700-5 which is included with the QJ-24, or QJAS-24 controllers. Much greater distances are possible by using the QRB-2 relay box.

Table II

Maximum Distance versus Wire Gauge when QJ-24 or QJAS-24 Controllers are used with APT30-24:

Wire Size AWG	QPT-30 — 24 VAC 24 V. Tap	27 V. Tap	30 V. Tap
#24	12 ft.	30 ft.	61 ft.
#22	19 ft.	48 ft.	97 ft.
#20	31 ft.	77 ft.	154 ft.
#18	49 ft.	122 ft.	245 ft.
#16	78 ft.	195 ft.	389 ft.
#14	124 ft.	310 ft.	619 ft.
#12	197 ft.	492 ft.	984 ft.

The maximum distances for a given wire gauge, as indicated in Tables I and II are relatively conservative. The basis for their determination was:

1. A maximum of 5% voltage drop in the wiring,
2. Simultaneous operation of both motors, and
3. An increase in wire resistance of 14% during hot weather.

The maximum distances specified in the table above can be doubled if the following conditions are satisfied:

1. The pan/tilt mechanical load is 50% of its rated load, and
2. The tilt limit stops are set to limit maximum tilt travel to +45 degrees from horizon.

Table II can be utilized only when the controller transformer (S) has secondary voltage taps. This is only the case when the QJ-24 or QJAS-24 controllers are used. Use of a higher voltage tap increases the maximum distance for a given wire gauge (AWG).

CAUTION: When using higher voltage taps, make certain that the motor voltage as measured at the pan/tilt unit with the motor running is between 25.2 and 22.8 VAC. In order to assure long term system reliability, the motor voltage should be maintained as close to the nominal 24 VAC as possible.

The maximum distance for a given wire gauge for the 24 volt model can be dramatically extended by utilizing the RB-2 low voltage relay box system.

2. Wire Selection (Continued).

b. To determine the number of conductors required between the pan/tilt unit and its source of power (usually the joystick controller except in the case of the digital or low voltage relay box system, where it is the field box) refer to Table III.

Table III

Number of Wires Required for Pan/Tilt Units:

Pan/Tilt	Number of Conductors Required Between Pan/Tilt Unit and Its Power Source
AC Pan/Tilt Unit (no auto scan)	5
AC Pan/Tilt Unit (with auto scan)	6

In addition to the number of wires specified above, one ground wire should be connected from each pan/tilt unit to a power line ground, or earth ground, at the pan/tilt site. Adhere to the requirements of your local electrical codes.

To determine the number of wires required to operate the pan/tilt options refer to Table IV.

Table IV

Number of Wires Required for Positioner Options:

Option	Number of Wires Required
Positioner Heater	2
Potentiometer	4

The power source for the thermostatically controlled positioner heater option is normally located at the pan/tilt site. Heater power requirement is 110 watts.

The four conductors required for the potentiometer kit should be shielded form other wires running in your system. They most frequently are utilized with the azimuth elevation readout system (7-47000). Use

#24 wire for distances up to 1000 feet, or #20 AWG for distances up to 2000 feet.

Remember additional wires for housing and zoom lens functions may be required depending on your system requirements.

Operating with the Javelin Omni equipment:

If autoscan is used with the Javelin Omni equipment, remove the blue jumper wire that is connected across the 68K resistor that is in series with the autoscan output lead. This blue jumper wire is located on a three lug terminal strip which is affixed to the upper pan bearing support bracket. Please note that for all other autoscan applications (except for that with the Javelin Omni system), this jumper must be left in place (shorting out the 68K OHM resistor).

3. Connection Information.

a. **General Information:**

Several Molex type connectors are available at the base of the positioner to provide for the connection of the pan-tilt and housing functions to your system wiring. Connector bodies and contact terminals (both male and female) are provided for the connections. The plug bodies are stamped with their corresponding P or J designator as described in the tables below and the schematic diagram. Each of the wires in your cable assembly should be stripped about 3/16 inch. Make certain the proper male or female terminal is used with the plug housing. Normally the base of the positioner will have three connectors protruding: a twelve pin connector for the positioner functions (PJ-J2), a fifteen pin connector for the housing and accessory functions (P10-J10), and a nine pin connector for the zoom lens functions (PJ3-J3). Some earlier units used identical connector bodies (same number of pins) for both P2-J2 and P10-J10. In order to prevent accidental misconnection of these connectors, the connectors were either color coded differently or keyed by using a female contact at Pin 5 of P10. All other contacts in P10 are male. Please inspect P10 in your positioner before installation of J10 to determine if this keying scheme is used. Note that most units will not use this keying scheme. A Molex crimping tool (Molex part number JHTR1719C) is recommended for installation. However, if one is not available, the following procedure may be used:

1. Carefully crimp the terminal over the wire with long nose pliers in two places (one for the electrical connection over the stripped wire and the other for a strain relief function over the wire insulation).
2. Carefully apply a small amount of solder to the electrical connection at the junction of the stripped wire and contact crimp. The amount of heat applied should be just sufficient to allow solder to flow and avoid cold solder joints, but not excessive which may cause your wire insulation to melt. Note that if the proper crimping tool is used, as identified above, it is not necessary to solder this connection.

Irrespective of the method used to secure the contacts to your wiring, it is adviseable to check each connection by carefully grasping the contact pin with a pair of long nose pliers. While holding the wire with your other hand, gently pull on the contact pin. Make certain the contact pin does not pull off the wire when a reasonable amount of force is applied. Insert the contacts into the appropriate plug body. It is adviseable to have a Molex extraction tool on hand. This tool (for the Molex type 5025 series of connectors) may be ordered from Molex directly. Weather proof the connections if necessary. Make certain that your installation complies with your local electrical codes.

The wire colors indicated in the tables that follow are provided for your convenience. Use caution when using them since some substitution of different colored wires are occasionally made because of shortages.

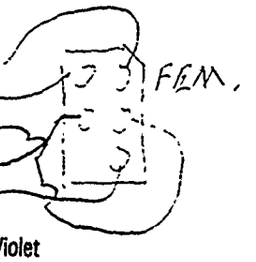
All integrally wired models utilize a 75 OHM stranded center conductor coiled video cord to route the video through the positioner. This cable is equipped with BNC type plugs. A male BNC plug is provided at the camera end of this cable. A female BNC receptacle is provided at the positioner base end of this cable.

In QPT30 integrally wired models that are not shipped with a camera housing, the wires, which are used for camera and housing functions are not terminated in any connectors or terminal block as they exit near the camera mounting platform. The schematic indicates a TB1 terminal block and a J13 plug for convenience and suggested connections. This terminal block and plug are not supplied with this model. They are usually part of the equipment the positioner will interface with (i.e., the camera housing and zoom lens).

b. **Customer Base Connection Information For All Integrally Wire Positioners Not Equipped With The Optional External Connector Module:**

All of the wires connected to P3 and P10 (except for Pins 1 and 2 of P10) are routed through the positioner and up into the camera housing. The functions listed for the P10 connector (except for Pins 1 and 2) are defined for your convenience. Since you, the customer, make the connections at both ends of these wires, you are free to redefine their functions and use them for any application your particular system requires.

1. Plug P2 (twelve contact) For Positioner Functions:



Pin #	Function	Color
1	Right	Brown
2	Left	Red
3	Up	Orange
4	Down	Yellow
5	Motor Common	Green
6	Auto Scan (Optional)	Blue
7	Chassis Ground	White/Violet
8	Ref B (+V) (CW)*	Gray
9	Ref A (–V) (CCW)*	White
10	Pan Sense*	Black
11	Tilt Sense*	White/Brown
12	Not Used	

*These connections are used only when the positioner is equipped with an optional potentiometer kit for electrically sensing the position of the pan-tilt unit.

2. Plug P10 (fifteen contact) For Housing and Accessory Functions:

Pin #	Function	Color	Housing Connection
1	Pan-Tilt Heater Hot*	Brown	None
2	Pan-Tilt Heater Common*	Red	None
3	Not Used		
4	Not Used		
5	Spare #1	Wht/Grn	TB1-8
6	Spare #2	Wht/Blu	TB1-7
7	Housing Power Hot	Violet	TB1-2
8	Housing Power Common	Wht/Gry	TB1-4
9	Camera Power Switched	White	TB1-3
10	Washer	Black	TB1-5
11	Wiper	Wht/Brn	TB1-6
12	Not Used		
13	Not Used		
14	Not Used		
15	Not Used		
	Chassis Ground**	Wht/Vio	TB1-1

*These connections are used only when the optional pan-tilt heater kit is installed in the positioner.

**The chassis ground connection to TB1-1 in the housing is made by means of the connection to Pin 7 of Plug P2.

3. Plug P3 (Nine Contact) For Zoom Lens Functions

Pin #	Function	Color	Housing Connection**
1	Lens Common	Brown	J13-1
2	Iris	Red	J13-2
3	Focus	Orange	J13-3
4	Zoom	Yellow	J13-4
5	Reference B (CW)*	Green	J13-5
6	Reference A (CWW)*	Blue	J13-6
7	Zoom Wiper	Violet	J13-7
8	Focus Wiper	Gray	J13-8
9	Iris Wiper	White	J13-9

*These connections are used only when lenses equipped with potentiometers are utilized for preset positioning applications.

**J13 is a nine pin connector located in the camera housing for connection to a zoom lens. Note: QPT30 integrally wired models that are shipped without an integral camera housing do not have this connector installed.

c. **Customer base connection information for integrally wired position equipped with the optional external connector (P15-J15) module:**

Pin #	Function
1	Pan Right
2	Pan Left
3	Tilt Up
4	Tilt Down
5	Motor Common
6	Auto Scan (Optional)
7	Chassis Ground
8	Pan-Tilt Heater Hot (Optional)
9	Reference B (+V) (CCW) For Positioner Pot Kit (Optional)
10	Reference A (–V) (CW) For Positioner Pot Kit (Optional)
11	Pan Sense for Pot Kit (Optional)
12	Tilt Sense for Pot Kit (Optional)
13	Pan-Tilt Heater Comm n (Optional)
14	Wiper*

15 Spare #1*
16 Spare #2*
17 Housing Power Hot*
18 Housing Power Common*
19 Camera Power Switched*
20 Washer*
21 Lens Common
22 Iris
23 Focus
24 Zoom
25 Reference B (CW) for Lens Pot Kit if Used
26 Reference A (CCW) for Lens Pot Kit if Used
27 Zoom Wiper for Lens Potentiometer Kit if Used
28 Focus Wiper for Lens Potentiometer Kit if Used
29 Iris Wiper for Lens Potentiometer Kit if Used

*The functions of all the wire conected to Pins 14 through 20 of P15 have been defined for your convenience. Since you, the customer, connect both ends of these wires, you are free to redefine their functions and use them for any application your particular system requires.

Video connections are made by means of a BNC connector

d. **Connection Information in Camera Housing:**

1. Terminal Board Connections:

TB1	Function	Color
1	Chassis Ground	White/Violet
2	Housing Power Hot	Violet
3	Camera Power Switched	White
4	Housing Power Common	White/Gray
5	Washer	Black
6	Wiper	White/Brown
7	Spare #2	White/Blue
8	Spare #1	White/Green

2. Housing Lens Plug Connections (Nine Contact P13-J13):

Pin #	Function	Color
1	Lens Common	Brown
2	Iris	Red
3	Focus	Orange
4	Zoom	Yellow
5	Reference B (CW)*	
6	Reference A (CCW)*	
7	Zoom Wiper*	Violet
8	Focus Wiper*	Gray
9	Iris Wiper*	White

*These connections are used only when lenses equipped with potentiometers are utilized for preset positioning applications.

A. Mechanical:

The pan/tilt sections move when the appropriate internal motors are energized, driving worm gear sets that rotate the shafts on which the pan section and the tilt section are mounted.

Both pan and tilt sections gearing consists of an interally lubricated engineering resin single lead worm wheel meshed with a dissimilar resin "Zytel".

Elevation and azimuth movement limits are determined by tripper arms activating "make or break" switches, causing instant de-energizing of the motors.

The motors utilized in the AC pan/tilt units are permanent split capacitor motors with internal friction brakes. Each motor has two windings of equal impedance. A non-polar capacitor is connected between one side of each of these windings. This side of each winding is designated the hot side. The other two wires of each winding are connected together. This side is designated as the common side. The motor direction or rotation is controlled simply by applying an AC voltage to the appropriate hot side of one winding or the other with respect to the common. The capacitor is utilized to provide additional starting torque in the proper direction.

When the pan/tilt unit is near its center of rotation, neither limit switch is activated. Continuity exists between the C and the NC contacts of the limit switches. If AC power is applied to pin 1 of J1 with respect to the common pin 5 of J1, the pan/tilt unit will move to the right until limit switch S1 is activated. The continuity between the C and the NC contacts of S1 is lost. As a result, the motor stops rotating since the voltage has been removed from the hot side of the right winding. The pan/tilt unit cannot be moved any further to the right. It can only be moved to the left by applying AC power to pin 2 of J1 with respect to pin 8 of J1 of the pan/tilt plug. Movement of the pan/tilt unit just a few degrees to the left will cause the continuity between the C and the NC contacts of S1 to be re-established. This will allow the pan/tilt unit to be moved in either direction. Switches S2, S3, and S4 provide the limiting action for the left, up and down functions respectively.

In the auto scan mode, power is continuously applied to either the left or right motor input leads via the contacts on switch S5. Whenever auto scan operation is desired, an AC voltage is applied to the common terminal of switch S5 by means of pin 6 of J1. Auto scan switching is accomplished by utilizing a mechanical latching system that maintains the position of a momentary switch (S5). Toggling of the switch occurs at each auto scan limit. Provisions have been made to allow the auto scan limit trippers to continue traveling in the same direction, even after the auto scan switch toggles to its other stable state. This allows for sector scan operation. Even though the operator may manually move the pan/tilt unit out of the auto scan sector, the auto scan switch (S5) in the pan/tilt unit will always be in the correct position to move the pan/tilt back in the proper direction when auto scan operation is resumed.

SECTION IV Adjustments:

A. Backlash:

Backlash is defined as unwanted movement in the pan or tilt sections. This "play" develops as a result of normal wear and is easily corrected. Backlash can develop in two areas:

1. Excessive center distance between worm and worm gear, or
2. Axial movement of the worm.

B. Interior Access:

Stop the unit with the tilt head in the horizontal position. Open the covers and consult Figure 1.

C. Pan Section Backlash Adjust:

1. Test for Backlash.

Test for backlash by gripping the tilt table and manually trying to rotate the table left and right. Free play should be between 1/64" and 1/32". If movement is excessive, inspect to determine if:

(1) The worm and worm shaft move axially, and/or
(2) Lost motion exists between the worm and worm gear.

If condition (1) is present, first check to see that lock nut "F2" on the worm shaft is tight enough to remove any play (do not tighten it more than is required to remove play); second, check to see that the entire worm carrier is securely bolted in place.

2. Adjust Clearance.

To adjust the clearance between the worm and worm gear, use the controller to rotate the unit to the tightest point (least backlash). Shut-off the power. With a 5/16" box or open end wrench, loosen slightly the four screws "G1" which secure the worm carrier. Tighten the slotted screw "H1" in the end of the adjuster wedge block which will move the worm carrier into closer contact with the worm gear. DO NOT OVER TIGHTEN! Retighten the four screws "G1". Again test for backlash. CAUTION — too tight a gear fit will significantly increase load on motor.

D. Tilt Section Backlash Adjust:

1. Test for Backlash.

Procedure for adjusting tilt backlash is identical to above procedure for pan (Section IV - C2).

E. Pan and Tilt Bearings:

The pan motion is carried on steel needle bearings with a thrust load rating many times greater than any load encountered. The radial bearing uses dissimilar engineered resins proven over many years to exhibit much better wear characteristics than metal bearings.

The tilt bearings are, again, dissimilar resins.

Bearing systems do not require additional lubrication.

SECTION V Maintenance and Repair:

A. Routine Maintenance:

Inspect the unit on a regular basis to assure the early detection and correction of any disorder before it becomes a problem.

B. Inspection Intervals:

The recommended intervals are:

Use	Inspect Every
24 Hour Auto-Scanning	2 months
12 Hour Auto-Scanning, 12 Intermittant	4 months
No Auto-Scanning, Intermittant Scanning	6 months

C. Inspection Items:

1. Exterior.

(1) **Finish** – Examine for signs of damage to the exterior paint or cover fitting integrity.

(2) **Wiring** – Examine the exterior wiring harness for signs of crimping, cracked insulation, frayed or pinched wires and loose connectors.

(3) **Mounting** – Check that the mounting bolts are securely tightened.

(4) **Other Hardware** – Check that none has come loose.

2. Interior.

(1) **Wiring** – Examine the interior wires for signs of crimping, cracked insulation, frayed or pinched wires and loose connections.

(2) **Loose hardware** – Check and tighten.

(3) **Cleanliness** – Any foreign material such as dust, dirt or chips can act as an abrasive in the gear grease and reduce gear life. Make certain to remove all foreign material.

(4) **Gear Lubrication** – Visually check the gears for worn teeth, poor alignment and chips. The worm and worm gear *should not be lubricated.* The gear is made of a material with an internal lubricant, and additional grease or oil will not improve performance.

Bearings – All bearings are self lubricating and require no further lubricating.

Motors – These are lubricated for their design life and require no added lubricant.

Chains – These should be lubricated with a low viscosity oil.

(5) **Chain Adjustment** – Slack in chains is not detrimental and does not affect backlash. Do not over-tighten them.

(6) **Backlash** – Check for unwanted movement (looseness) in either pan or tilt drives. Refer to SECTION IV, A,B,C, and D for adjustment instructions.

SECTION VI Troubleshooting:

Visual inspection of the unit while operating the pan and tilt will usually reveal if the problem is mechanical or electrical. Straightforward common-sense trouble shooting techniques should reveal the source of the trouble. Some general information to assist in your troubleshooting procedure follows:

A. Determine if the Problem is Mechanical or Electrical:

1. Remove the pan and tilt cover.
2. Activate the function at the Control Module and determine if the motor is running. If the motor is running, the problem is mechanical. Refer to A-4 below. If the motor is not running, the problem may be either mechanical or electrical.
3. Mechanically uncouple the motor by removing the chain from the sprocket. If the motor operates, the problem is most likely mechanical (binding worm gears, etc.). If the motor does not run, the problem is electrical. Refer to VI-B.
4. Mechanical problems – check for:
   (a) Loose sprockets indicating sheared pins or keyes.
   (b) Chains slipped from sprockets or broken chains.
   (c) Binding gears.

B. Electrical Problem:

The electrical control system consists of the control module, the interconnecting cable and the Pan/Tilt itself. Some systems include additional interface boxes, such as the Take Command System, the Low Voltage Relay System, or the Digital System. A malfunction in any of these components will cause a system failure. Logical troubleshooting procedures must be utilized to isolate the faulty component. It is assumed that the fault has been traced to the pan and tilt.

1. No Operation of the Motor and Fuse Does Not Blow.

a. Remove the Pan/Tilt cover.

b. Connect a meter across the motor armature.

c. Activate the function. If the meter reads the correct voltage, the problem is probably a defective motor. If there is no voltage at the motor terminals, the problem is in the cabling between the connector and the motor or the limit switches.

NOTE: (1) Pan/Tilt units that operate in the Auto Scan Mode put flexing stress on the wires. If these wires ever need to be replaced, use AWG #18 or #22 stranded wire, with NINETEEN OR MORE strands. Use the most flexible wire available.

(2) Most AC motors use a non-polar capacitor. Because of the reactive nature of the components involved, the AC voltage measured across the capacitor will usually be higher than the source voltage. This capacitor is utilized to provide high motor starting torques in the proper direction. A motor may or may not run (depending upon its mechanical load) if this capacitor is defective. If the motor does run it usually sounds noisier and less smooth. Direct substitution is the best method of isolating a faulty capacitor. Use only a non-polar capacitor of sufficient voltage and capacitance rating. The value of capacitance is critical. Too little capacitance will provide too low starting torque; too high capacitance will result in

excessive motor temperature. Make certain that this capacitor is checked before the motor is replaced.

2. No Operation of the Motor and Fuse Blows.

a. Remove the pan/tilt cover and remove the four screws securing the mail connector to the base of the pan/tilt.

b. Visually inspect the circuitry for any short circuits.

c. Disconnect the motor. Use an OHM meter to check the cabling. If no apparent problem is found, the motor could be defective. Mechanically uncouple the motor by removing the chain from its sprocket and apply power directly to the motor. If the fuse blows, the motor is probably defective.

3. The Pan/Tilt Stalls at the Limit Switch.

Check the:
(a) limit switch;
(b) connections to the motor;
(c) motor.

4. The Pan/Tilt Unit Does Not Stop When the Limit Switch is Activated.

Check the:
(a) wiring for a short across the normally closed and common contacts;
(b) limit switch.

5. The Pan/Tilt Does Not Auto Scan.

a. Put the system in the manual mode and check to see if the Pan/Tilt will move in *both* directions when the joystick is activated. If it does not, refer to VI-B-3. If the Pan/Tilt does move in *both* the left and right directions, the trouble is in the auto scan circuitry. The trouble could either be in the control unit, any field boxes if used (i.e., take command, low voltage relay box, digital receiver, etc.), or the Pan/Tilt unit itself. If the problem is isolated to the Pan/Tilt unit, proceed to steps b. and c.

b. Position the Pan/Tilt unit approximately midway between the auto scan limits and put the system in the auto scan mode. If the Pan/Tilt unit runs until it stalls at one of the limit switches, the problem may be any of the following items.

(1) An open connection between the auto scan switch and the motor winding.

(2) A defective auto scan switch.

(3) A mechanical problem in the latching mechanism which may be as simple as realignment of the auto scan switch or careful bending of the switch actuator arm.

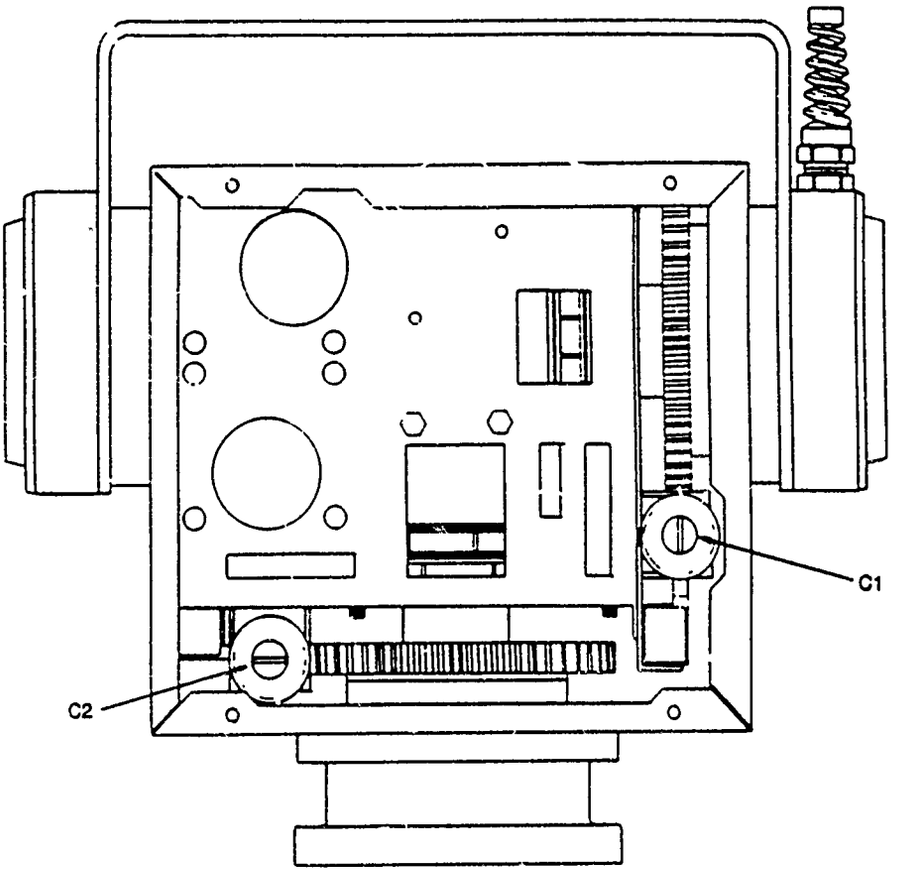
c. Position the Pan/Tilt unit approximately midway between the auto scan limits and activate the controller auto scan switch. If the unit remains stationary, the problem may be any of the following items.

(1) An open connection between the auto scan pin(s) (one wire in AC units) of the connector at the base of the pan/tilt and the auto scan switch.

(2) A defective switch.

SECTION VII Accessories:

ATP	Arctic Heater Package
P3090 58600	Potentiometer Kit



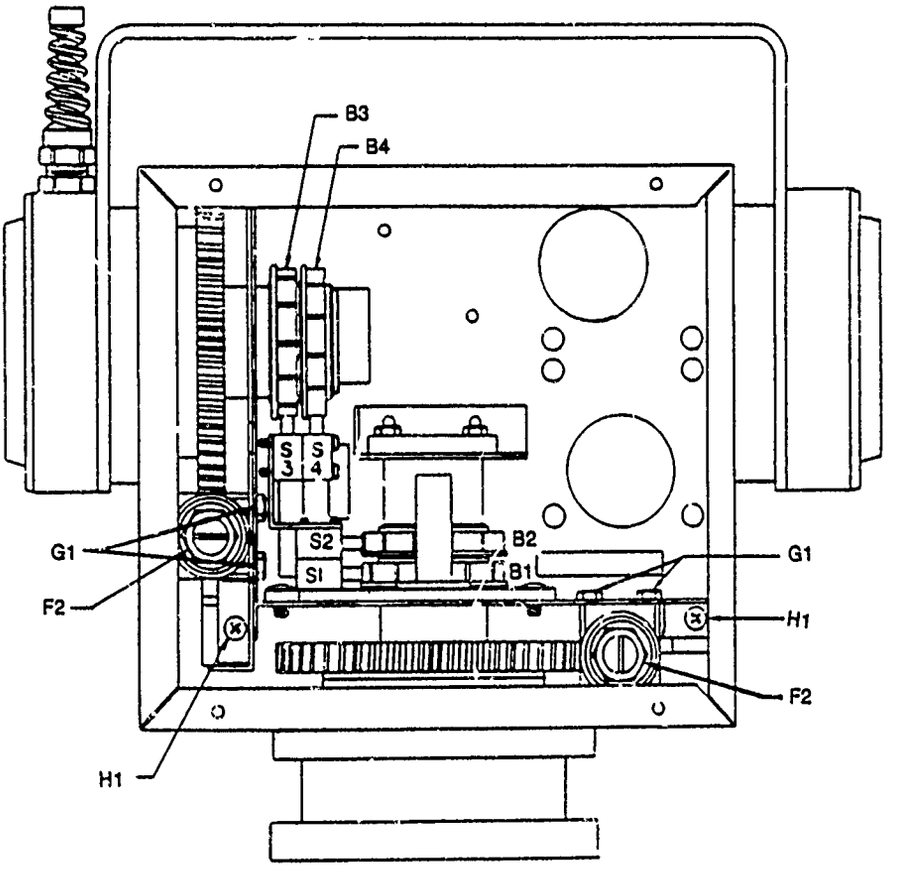
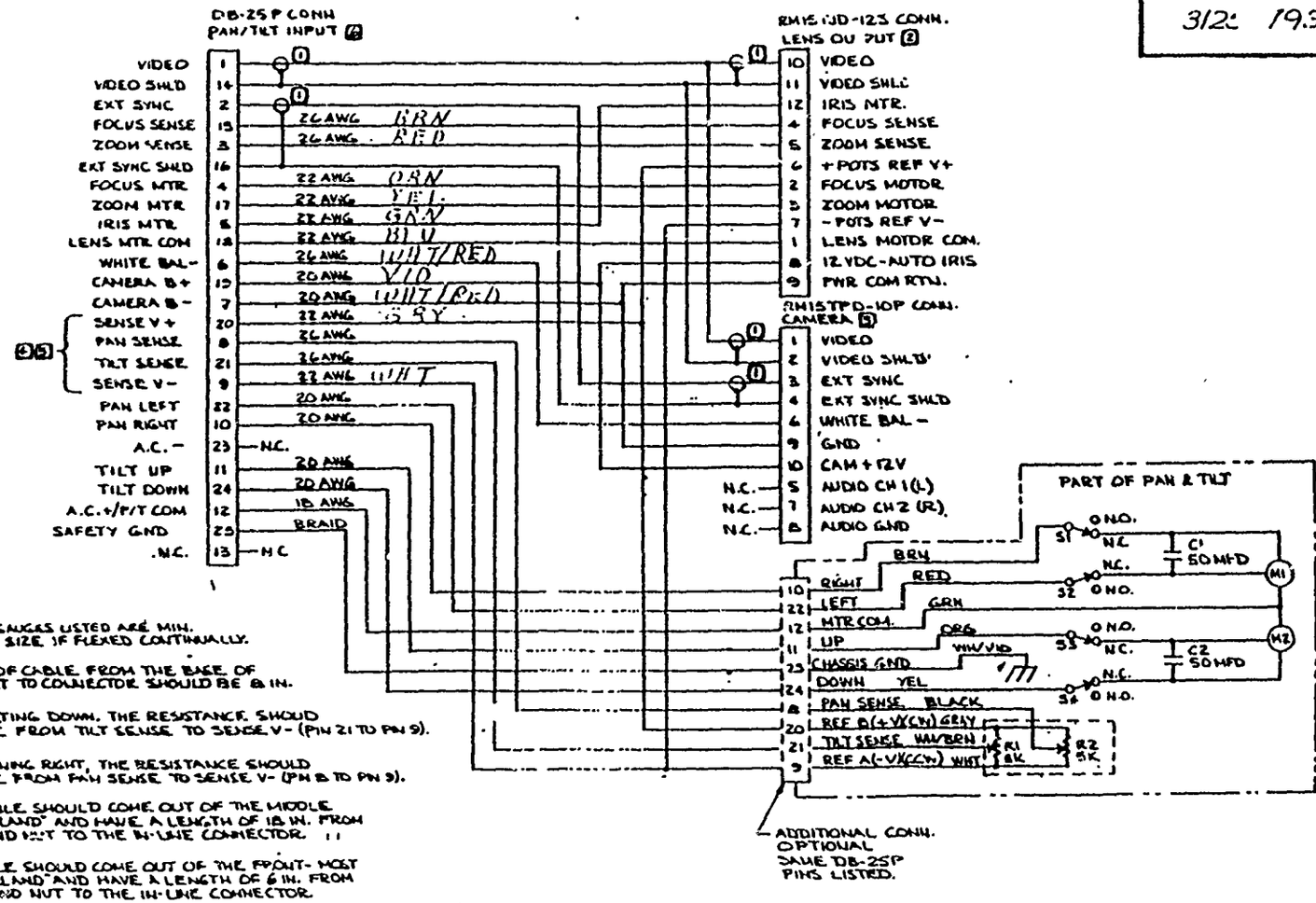


Figure 1

DWG NO 3/2: 19.35-2



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7 ALL WIRE GAUGES LISTED ARE MIN. INCREASE SIZE IF FLEXED CONTINUALLY.

6 LENGTH OF CABLE FROM THE BASE OF PAN & TILT TO CONNECTOR SHOULD BE 8 IN.

8 WHEN TILTING DOWN, THE RESISTANCE SHOULD INCREASE FROM TILT SENSE TO SENSE V- (PIN 21 TO PIN 9).

9 WHEN PANNING RIGHT, THE RESISTANCE SHOULD INCREASE FROM PAN SENSE TO SENSE V- (PIN 8 TO PIN 9).

5 THIS CABLE SHOULD COME OUT OF THE MIDDLE CABLE "GLAND" AND HAVE A LENGTH OF 18 IN. FROM THE GLAND NUT TO THE IN-LINE CONNECTOR.

4 THIS CABLE SHOULD COME OUT OF THE FRONT-MOST CABLE "GLAND" AND HAVE A LENGTH OF 6 IN. FROM THE GLAND NUT TO THE IN-LINE CONNECTOR.

1 RG-59 OR RG179U, 75 Ω COAX OR BELDEN 9221.

NOTES: UNLESS OTHERWISE SPECIFIED.

CHG.	REVISION	DATE	BY	CK.

UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS

TOLERANCE ON .X DIM. ±

TOLERANCE ON .XX DIM. ± .010

TOLERANCE ON .XXX DIM. ± .005

THREAD LENGTH DIMENSIONS ARE FOR FULL THREADS

ALL CORNERS .006/.010 R.

DO NOT SCALE DRAWING

DR	ROH	DATE 9.23.85
CK		
APP	JC	9-23-85
SCALE		

QuickSet

QuickSet Incorporated
3650 Woodhead Drive
Northbrook, Illinois 60062

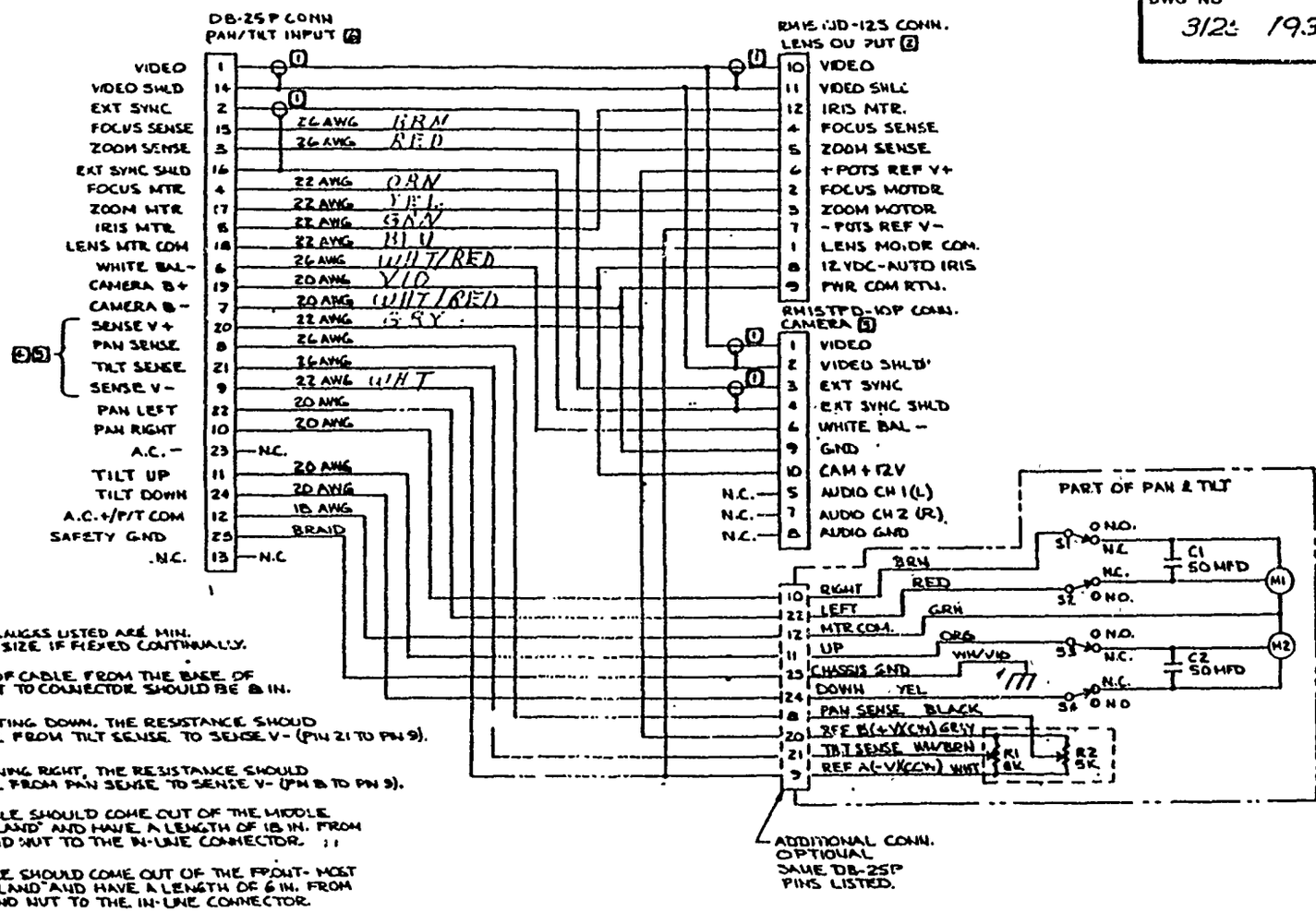
NAME SCHEMATIC FOR SBL QPT30-24VAC

FINISH

MATERIAL

DWG NO 3/2557935-2

DWG NO
3/2: 1935-2



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7 ALL WIRE GAUGES LISTED ARE MIN. INCREASE SIZE IF FLEXED CONTINUALLY.

[C] LENGTH OF CABLE FROM THE BASE OF PAN & TILT TO CONNECTOR SHOULD BE 8 IN.

[3] WHEN TILTING DOWN, THE RESISTANCE SHOULD INCREASE FROM TILT SENSE TO SENSE V- (PIN 21 TO PIN 9).

[4] WHEN PANNING RIGHT, THE RESISTANCE SHOULD INCREASE FROM PAN SENSE TO SENSE V- (PIN 8 TO PIN 9).

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NOTES: UNLESS OTHERWISE SPECIFIED.

CHG.	REVISION	DATE	BY	CK

UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS
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TOLERANCE ON .XX DIM. ± .010
TOLERANCE ON .XXX DIM. ± .005
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ALL CORNERS .006/.010 R.
DO NOT SCALE DRAWING

DR	RDM	DATE 9-23-85
CK		
APP	JC	9-23-85
SCALE		

QuickSet

QuickSet Incorporated
3650 Woodhead Drive
Northbrook, Illinois 60062

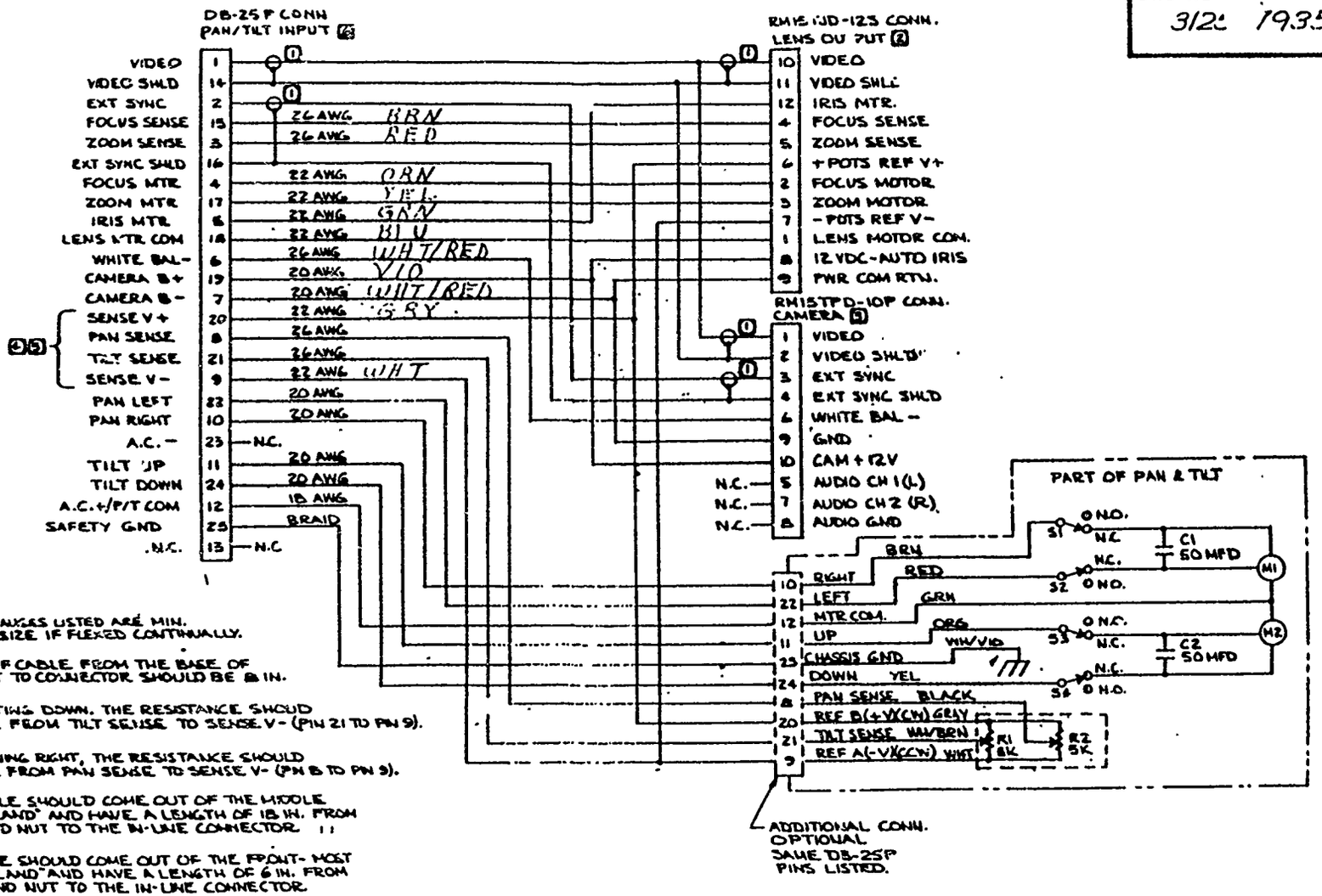
NAME SCHEMATIC FOR SBL QPT30-24VAC

FINISH

MATERIAL

DWG NO. 3/2557935-2

DWG NO 3121 1935-2



7 ALL WIRE GAUGES LISTED ARE MIN. INCREASE SIZE IF FLEXED CONTINUALLY.

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[1] RG-59 OR RG179U 75 Ω COAX OR BELDEN 9221.

NOTES: UNLESS OTHERWISE SPECIFIED.

177

CHG.	REVISION	DATE	BY	CK.

UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS
TOLERANCE ON .X DIM. ±
TOLERANCE ON .XX DIM. ± .010
TOLERANCE ON .XXX DIM. ± .005
THREAD LENGTH DIMENSIONS ARE FOR FULL THREADS
ALL CORNERS .005/.010 R.
DO NOT SCALE DRAWING

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SCALE		

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3650 Woodhead Drive
Northbrook, Illinois 60062

NAME SCHEMATIC FOR SBL QPT30-24VAC

FINISH

MATERIAL

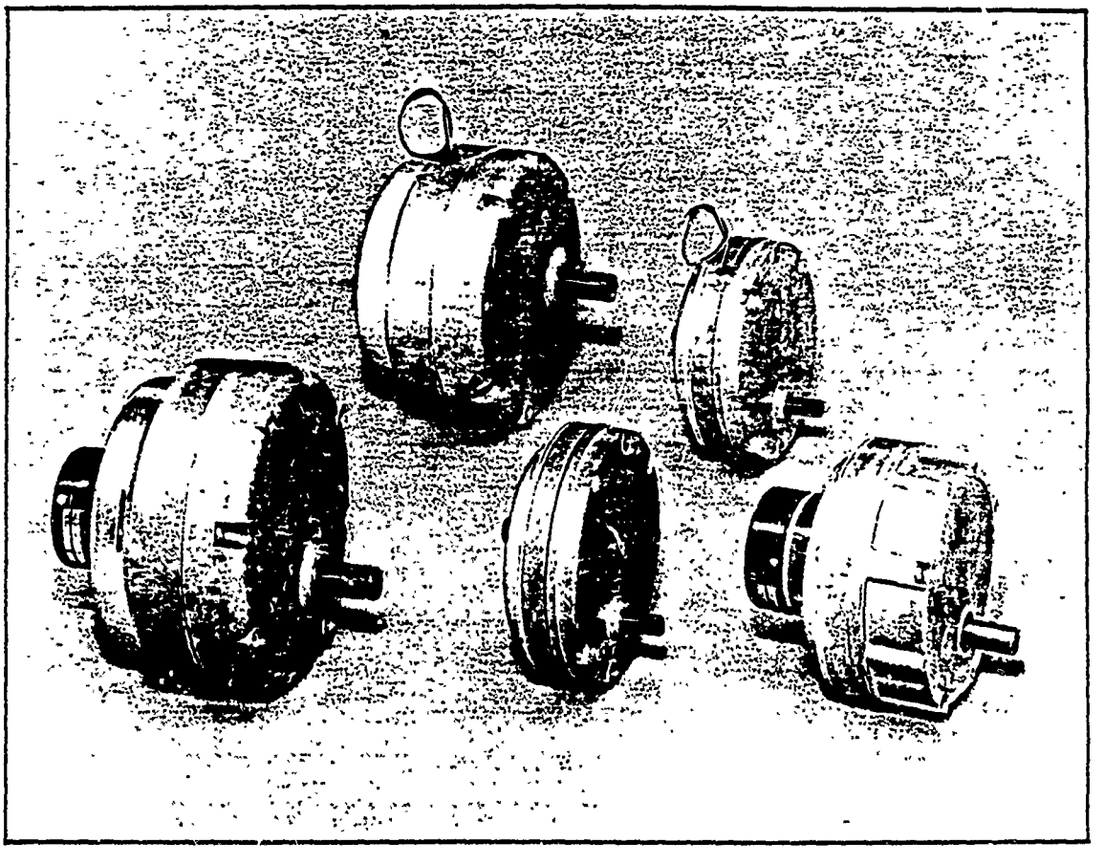
DWG NO 3/2557935-2

STEERING ACTUATOR

DATA SHEETS

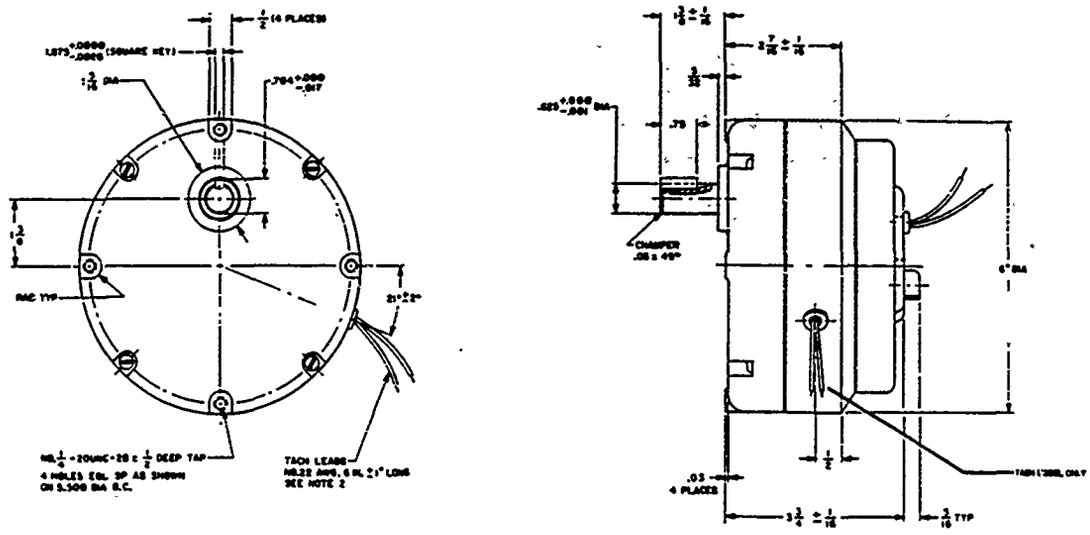
Gearmotors

Ferrite Series



FEATURES

- Flat shape — light weight
- Fast acceleration
- Zero cogging
- Smooth torque over entire speed range
- Available with PWM amplifiers, analog tachometers, and optical encoders



NOTES: See Pg. 2 & 3

U12FG dc Gearmotor						
Specifications	**Gear Ratios**					
	16.06:1	24.48:1	49.96:1	82.73:1	99.77:1	153:1
Rated Speed (RPM)[1]	189	121	60	36	30	21
Peak Torque (in.-lb)[2]	55	85	156	162	163	191
Rated Torque (in.-lb.)[3]	27	41.1	83.9	130.3	140	140
Rated Current (A)	6.3	6.3	6.3	6.3	5.9	4.1
Rated Voltage (V)[4]	20	20	20	20	19.4	17.7
Power Out (W)	61	60	60	56	50	35
Radial Load (lbs)	125	125	125	125	125	125
Thrust Load (lbs)	150	150	150	150	150	150
Weight (lbs)	5.75	5.75	5.75	5.75	5.75	5.75

U12FGT dc Gearmotor/Tach						
Specifications	**Gear Ratios**					
	16.06:1	24.48:1	49.96:1	82.73:1	99.77:1	153:1
Rated Speed (RPM)[1]	189	121	60	36	30	21
Peak Torque (in.-lb)[2]	55	85	156	162	163	191
Rated Torque (in.-lb.)[3]	24.2	36.8	75.1	116.6	140	140
Rated Current (A)	6.3	6.3	6.3	6.3	6.3	4.5
Rated Voltage (V)[4]	18	18	18	18	18	16.4
Power Out (W)	55	54	54	50	50	35
Radial Load (lbs)	125	125	125	125	125	125
Thrust Load (lbs)	150	150	150	150	150	150
Tach Output (V/KRPM)	2.1	2.1	2.1	2.1	2.1	2.1
Tach Ripple (% of V Output)	5	5	5	5	5	5
Weight	5.85	5.85	5.85	5.85	5.85	5.85

All specifications subject to change without notice.

49 Mall Drive • Commack, NY 11725-5703 • (516) 864-1000 • Telex 510-223-0007

MOTION TECHNOLOGIES
Division of Kollmorgen Corporation

4/86-MAR038A

FEBRUARY 1987
VER. 1.3
PRELIMINARY

OPERATING INSTRUCTIONS

PMI VXA SERIES

PWM SERVO AMPLIFIER WITH POWER SUPPLY

MODEL VXA-24-8

HOW TO USE THIS MANUAL

This manual is divided into several sections to help you familiarize yourself with the VXA Series amplifiers in an orderly and logical manner.

1. Introduction - Provides a general description of the amplifier and how to apply it.

2. Specifications - Describes the features of the VXA amplifier and lists the electrical and mechanical specifications.

3. Inputs and Outputs - Explains the input and output connections, adjustments and jumpers.

4. Wiring Instructions - Covers power wiring, motor connections and wiring of input signals.

5. Setup Instructions - Step-by-step procedure for powering up the amplifier and setting the adjustments.

6. Troubleshooting: A simple checkout procedure in case of difficulties to determine if the VXA is working properly.

TABLE OF CONTENTS

1.0 Introduction

The VXA is a pulse-width modulated servo amplifier specifically designed to drive PMI's low-inductance, high-performance disc armature dc servo motors. It is a compact, self-contained unit which includes its own power supply and inductor and requires only the addition of a power transformer or, optionally, a dc supply.

This unit features extensive fault protection which guards against short circuits, excess current and power supply failure. Motor protection is accomplished through the use of electronic current limiting, which is fully adjustable.

The VXA amplifier may be operated in both velocity loop and torque modes, with or without a tachometer. Mode selection is by means of jumpers on the circuit board.

The switching frequency in the VXA family is above 20 kHz, which provides inaudible operation. This high switching frequency also delivers very high bandwidth in the current loop, capable of meeting the most demanding servo applications.

Hook-up and operation is accomplished by carrying out the following steps:

1. Apply ac or dc power to the amplifier.
2. Connect the motor.
3. Connect command and feedback signals.
4. Select mode of operation.
5. Set amplifier controls to match application requirements.

2.0 System Description

2.1 Features

Modular Design

Single circuit board design which includes built-in power supply and inductors.

Four-quadrant PWM Operation

Pulse-width modulation provides bi-directional motor operation.

20 KHz Switching Frequency

High frequency switching for inaudible operation.

Extensive Fault Protection

Includes protection against:
1. short circuits
2. current limit failure
3. power supply failure

Velocity or Torque Mode Operation

Selectable by a jumper on the circuit board.

Tachometer or EMF Sensing Feedback Modes

Selectable by a jumper on the circuit board.

Adjustable Compensation
Adjustable breakpoint laglead network simplifies servo system stabilization.

Adjustable Current Limiting
Full range current adjustment gives maximum flexibility in matching the amplifier to the application.

2.2 Specifications

Input and Output Power

Input Voltage ..... 9 to 22 vac, 1 phase, 50/60 Hz
or 12 to 30 vdc

Output Voltage ..... 12 to 24 vdc, depending on input voltage
Output Current ..... 8.0 amps

Electrical Characteristics

Switching Frequency ..... >20 Khz
Form Factor 1.01

Gain (velocity mode) ..... 40 amp/mv
Gain (current mode) ..... 0.8 amp/v
Minimum input impedance ..... 100 kohms
Offset ..... adjustable to zero
Drift ..... 0.2%/°C

Bandwidth (velocity loop) ..... 500 Hz
Bandwidth (current loop) ..... 2000 Hz
Dead Band 0

Signal Input Voltage Range
- Command Signal ..... +/- 10 vdc
- Tachometer Signal ..... +/- 35 vdc

Operational Modes

1. Velocity amplifier with tachometer feedback
2. Velocity amplifier with EMF Sensing
3. Torque (current) amplifier

Adjustments

1. Offset
2. Input Gain
3. Tachometer Gain
4. Compensation
5. Current Limit
6. IR Compensation

Special Input and Outputs

1. Run Enable
2. +/- 15 vdc reference
3. LED Fault Indicator

3.0 Connections, Jumpers, Adjustments, and Indicators

Note: Refer to Figure 1 for the location of parts described below.

3.1 Terminal Connections

TB1 Power Connections

TB1 - Terminals 1 & 2	Motor Connections Terminal 1 is for (+) motor lead. Terminal 2 is for (-) motor lead.
TB1 - Terminals 3 & 4	AC Input A power transformer (9 - 22 vac) can be connected here to run the amplifier and motor.
TB2 - Terminals 5 & 6	DC Input A dc power supply (12 - 30 volts) can be connected here to run the amplifier and motor. Terminal 5 is for +DC supply Terminal 6 is for -DC supply

NOTE: Either the AC Input or the DC Input is used, depending on the power source available.

TB2 Signal Connections

TB2 Terminal 1	Current Command Input Used as the input when operating the amplifier in the torque (current) mode. Accepts a command voltage with a range of +/- 10 volts.
TB2 Terminal 2	Signal Ground This is the circuit ground.
TB2 Terminal 3	Velocity Command Input Used as the input when operating the amplifier in the velocity mode. Accepts a command voltage with a range of +/- 10 volts DC.
TB2 Terminal 4	Tachometer Input The (+) output of the tachometer is connected here. The (-) output goes to signal ground (TB2-2).
TB2 Terminal 5	-15V Reference Connected to the internal -15 volt logic supply. May be used as a voltage reference (10 ma. maximum).

TB2 Terminal 6	+15V Reference Connected to the internal +15 volt logic supply. May be used as a voltage reference (10 ma. maximum).
TB2 Terminal 7	Enable Connecting this terminal to +15 volts is required for the motor to run.

3.2 Jumper Connections

Speed/Torque (SB-2)	Selects between amplifier operation in the velocity or torque mode.
EMF/Tach (SB-1)	Selects between tachometer feedback and IR compensation (emf sensing) for speed control.

3.3 Adjustment Potentiometers

Offset	Used to set the motor speed to zero when the commanded speed is zero. This adjustment eliminates any dc offset voltage in the servo loop from either internal or external sources.
Gain	A gain adjustment for the command input. Fully CCW gives maximum gain and fully CW gives 1/10 of maximum gain.
Tach (Gain) Adjust	A gain adjustment which is used to calibrate the motor speed to the command signal. CW adjustment increases gain and decreases motor speed. CCW adjustment decreases gain and increases motor speed.
Compensation	Adjusts the transient response of the servo system to minimize overshoots and undershoots. CW rotation increases compensation.
Current Limit	Sets the maximum current that can be delivered to the motor. Fully CW = 0 and fully CCW = 8 amps.
IR Compensation	Calibrates the amplifier for operation in the emf-sensing mode. CCW adjustment increases compensation.

3.4 Indicators

LED 1	Red LED on the circuit board lights when a fault has occurred.
F1 Fuse	A 10 amp, 32 volt fast-blow fuse in the main DC supply line limits damage from shorts or component breakdowns.

4.0 Wiring Instructions

DO NOT POWER UP UNTIL ALL AMPLIFIER CONNECTIONS ARE MADE TO AVOID POSSIBLE DAMAGE TO THE AMPLIFIER, MOTOR AND YOUR EQUIPMENT.

Refer to Figure 2, System Wiring Diagram, as you go through the following procedure.

4.1 Power Wiring

All power connections are made on TB1. The VXA develops a DC bus voltage from either input option below. It is recommended that the bus voltage be matched with the motor voltage rating, so that the motor will not be driven to excessive speeds if full voltage is applied.

The bus voltage may be obtained from a DC supply, such as a battery, or an AC supply, such as step-down transformer from 115 VAC power.

AC or DC Input Power

Connect a source of either AC power or DC power, not both, to TB1 in accordance with the instructions below.

AC Option

Connect the external power transformer (9 - 22 VAC, 50/60 Hz) as shown in Figures 3 or 4. Use 16 gauge wire. Refer also to transformer Dwg. 77-10032-* in the Appendix of this manual.

(a) The secondary winding is connected to TB1 terminals 3 & 4. No polarity has to be observed.

(b) The primary winding is connected to a source of 105-125 VAC, 50/60 Hz, 1 phase (Figure 3) or 208-240 VAC, 50/60 Hz, 1 phase (Figure 4).

DC Option

Connect a DC voltage (12 - 26 vdc) to TB1 between terminals 5 & 6. Make the positive connection to terminal 5 and the negative connection to terminal 6. Use 16 gauge wire.

Motor Connections

Connect the positive (+) motor lead to TB1 terminal 1 and the negative (-) motor lead to TB1 terminal 2. Use 16 gauge or larger wire. With this wiring, the motor will rotate clockwise when the command signal on TB2 is positive.

You have now completed the connections to TB1. We will return to TB1 terminals 1 & 2 (the motor connections) later when we set current limits.

4.2 Control Signal Wiring

All control connections are made on TB2. Follow the From/To table below.

From	To
TB2 Terminal 7 (Enable)	+15 Volts (TB2-6) This connection enables the amplifier and permits the motor to run. This can be done through an external contact from a master control or by using a jumper to keep the amplifier enabled at all times.
TB2 Terminal 3 (Velocity Command Input)	Command or Controller Signal This is the normal input for commanding the amplifier in the velocity mode.
TB2 Terminal 1 (Current Command Input)	Command or Controller Signal Use this input instead of TB2-3 if you will be using the amplifier in the torque or current mode.

NOTE: Use a shielded twisted pair with the shield connected at the signal source. (22-gauge wire is OK.)

TB2 Terminal 4 (Tachometer Input)	Tachometer Positive Connection If you are using a tachometer, connect the (+) output here and the (-) output to the signal ground at TB2-2.

NOTES: 1. Use a shielded twisted pair with the shield connected to TB2-2. (22-gauge wire is OK.)
2. Tachometer voltage must not exceed +/- 35 volts.

TB2 Terminal 2 (Signal Ground)	Signal Grounds This is the return for the command and tachometer signals.

Application Note: Using the VXA as a Self-Contained Speed Controller

The VXA may be operated as a self-contained speed controller by supplying a command voltage from the wiper of a potentiometer. A 10K potentiometer with series resistance Rs can be powered from the internal +15 volt and -15 volt supplies available on the VXA. Figure 5 shows schemes for connecting the potentiometer for one-direction and two-direction speed control, with and without tachometer feedback. Use the Rs values shown below. Consult PMI for motors or tachometers with Back-EMF constants outside of ranges shown.

Rs (ohms)	Back-EMF Constant Range (V/KRPM)
33K	1 to 5 (ferrite motors)
5K	5 to 20 (alnico motors 9&12 size)

5.0 Setup Instructions

Depending on the mode you will be using, go to the appropriate section.

For	Go To
Velocity mode with tachometer	Section 5.1
Velocity mode with EMF sensing (IR Compensation)	Section 5.2
Torque (current) mode	Section 5.3

5.1 Velocity Mode With Tachometer

NOTE: FOLLOW EACH STEP SEQUENTIALLY. DO NOT APPLY POWER TO THE AMPLIFIER UNTIL INSTRUCTED TO DO SO.

STEP

V1. Check the Speed/Torque jumper SB-2 (See Figure 1)
Make sure the jumper is in the Speed position.

V2. Check the EMF/Tach jumper SB-1
Make sure the jumper is in the Tach position.

V3. Preset the adjustment potentiometers
The potentiometers should be set as follows:

Function	Setting	Pot #	Condition
Gain	Fully CW	(Pot 3)	minimum gain
Tach Adjust	Midpoint	(Pot 2)	medium gain
Compensation	3/4 CW	(Pot 5)	nearly max.
IR Comp	Not Used	(Pot 1)	--
Offset	Fully CCW	(Pot 4)	motor goes CW
Current Limit	Fully CW	(Pot 6)	min. current

Please note that the pot numbers are not sequentially marked on the circuit board but are identified on the chassis. Refer to Figure 1.

V4. Connect a jumper wire across motor terminals 1 and 2 on TB1. Use 16 or 18 gauge wire.

V5. Connect a DVM (set to 1 or 2 volt range) across resistor R1. This is the large power resistor on the edge of the circuit board.

V6. Remove command voltage at input terminals 3 and 2 of TB2.

V7. Turn on power to the amplifier.

V8. Enable the Amplifier.
For setting-up purposes, continually enable the amplifier by installing a jumper wire between TB2-6 and TB2-7.

Note: If LED fault indicator lights refer to Section 6.1 in this manual.

V9. Check and Adjust Current Limit.
Turn the Current Limit pot fully CCW to allow maximum current flow. The DVM should read about 0.8 Volts DC. This corresponds to 8 Amps which is the maximum continuous current the VXA delivers.

Adjust the Current Limit pot to the desired continuous current setting for the application. The scale factor is 0.1 volts per amp. With proper conservative motor sizing, this current setting should not exceed 80% of the continuous current rating of the motor.

Consider an example where a setting of 6.5 amps is desired. To obtain this, adjust the Current Limit Pot until you read 0.65v on the volt meter.

V10. Turn off the power
Having completed setting the continuous current, turn off the power to the amplifier.

V11. Remove the jumper between TB1 terminals 1 & 2 and see that the motor leads are properly reconnected.

V12. Remove the jumper temporarily from TB2-6. This disables the amplifier.

V13. Pre-adjust Offset
Turn the Offset pot to midpoint.

V14. Reconnect command voltage to TB2-3 and TB2-2.

V15. Restore power
Apply power to the VXA again.

V16. Safety Check Method of Enabling Motor
a. Be sure you have a zero-volt command signal or ground the Voltage Command input terminal (TB2-3).
b. Touch the enable jumper to TB2-6.

The motor will now be powered. It should be in a locked position or rotating slowly. If it runs away at high speed, immediately disable it by pulling away the jumper wire from TB2-6. Reverse the tachometer leads and try again. When you get the motor working properly, permanently reconnect the enable jumper.

V17. Adjust Offset
Set the command voltage to zero. If the motor is slowly rotating, adjust the Offset pot until it stops.

V18. Adjust motor speed
Determine the maximum command voltage that will be available. Usually it is +/- 10 vdc. When this is the voltage level being used, the Gain pot remains at minimum (fully CW). The Gain Pot has a range of 10:1 so that the VXA can handle a command signal as small as +/- 1 vdc.

Apply the maximum command voltage. The motor will run up to some speed. Determine this speed by using a hand tachometer or measuring the voltage delivered by the motor tach at TB2-4. Using the Tach Adjust Pot, set the desired motor speed (typically 3000 rpm for 10v command). CCW adjustment increases the speed of the motor (less tach gain), and CW adjustment decreases it (more tach gain).

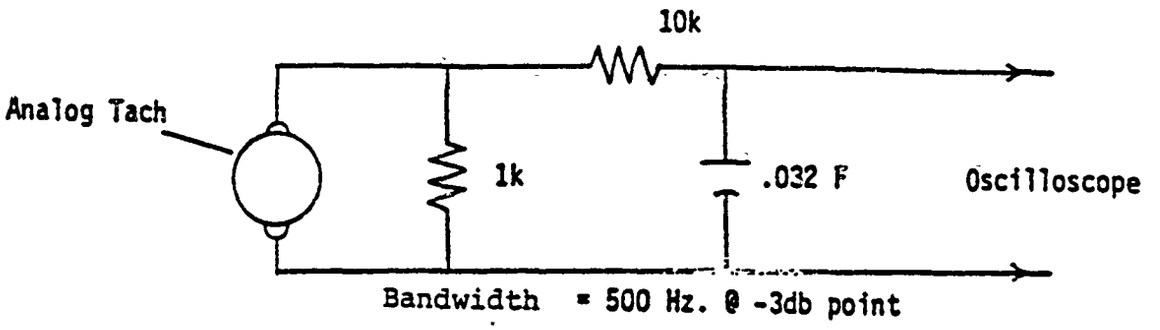
Check the speed range and tracking by applying various command levels. Also check full speed in the opposite direction by commanding a maximum negative voltage.

V19. Adjust Compensation
As a coarse adjustment, the Compensation pot may be left at the 3/4 CW position. This provides satisfactory performance in a large majority of cases. To optimize the response of the servo loop, the compensation may be fine-adjusted in accordance with the procedure below.

Fine Adjustment of Compensation
(Requires an oscilloscope and a function generator)

This procedure is used to optimize the transient response of the servo system by minimizing overshoots and undershoots. The response of the servo loop can be observed by using an oscilloscope and a function generator. Connect the oscilloscope to the tach feedback signal, which will indicate motor velocity in terms of voltage. Connect the function generator to the Velocity Command input terminal. The output of the function generator should be a low frequency square wave. The frequency must be low enough to enable the motor to reach a steady state speed. The square wave will provide a step input to the system and the tach voltage will show the response.

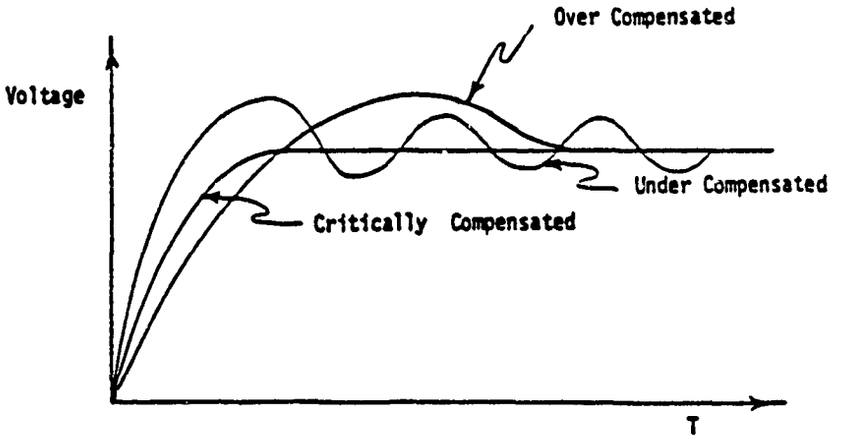
If your tachometer signal has high ripple content, the following RC filter network is recommended.



If you need a lower cut-off frequency, use a higher value for the capacitor.

The amplitude of the square wave should be adjusted to your desired operating speed. The scope should be triggered on the rising edge of the square wave. If there is a storage scope available, a single trace of the system response can be stored.

The scope should display one of the following wave shapes:



Set the compensation adjustment to obtain a critically compensated response. This will be the fastest response without overshoot. If the system is over-compensated (slow response with overshoot), turn the Compensation pot CCW. If it is under-compensated (overshoot and oscillation), turn it CW.

V20. Readjust the Offset
Apply a zero voltage command to the amplifier. If the motor is turning, adjust the Offset pot to bring it to a stop.

This concludes the adjustment and setup procedure for velocity mode applications using a tachometer.

5.2 Velocity Mode With EMF Sensing

NOTE: Follow each step sequentially. Do not apply power to the amplifier until instructed to do so.

STEP

VE1. Check the Speed/Torque jumper SB-2 (See Figure 1)
Make sure the jumper is in the Speed position.

VE2. Check the EMF/Tach jumper SB-1
Make sure the jumper is in the EMF position.

VE3. Preset the adjustment potentiometers
The potentiometers should be set as follows:

Function	Setting	Pot #	Condition
Gain	Fully CW	(Pot 3)	minimum gain
Tach Adjust	Not Used	(Pot 2)	--
Compensation	3/4 CW	(Pot 5)	nearly max.
IR Comp	Fully CW	(Pot 1)	minimum
Offset	Fully CCW	(Pot 4)	motor goes CW
Current Limit	Fully CW	(Pot 6)	min. current

Please note that the pot numbers are not sequentially marked on the circuit board but are identified on the chassis. Refer to Figure 1.

VE4. Connect a jumper wire across motor terminals 1 and 2 on TB1. Use 16 or 18 gauge wire.

VE5. Connect a DVM (set to 1 or 2 volt range) across resistor R1. This is the large power resistor on the edge of the circuit board.

VE6. Remove command voltage at input on terminals 3 and 2 of TB2.

VE7. Turn on power to the amplifier

VE8. Enable the Amplifier
For setting-up purposes, continually enable the amplifier by installing a jumper wire between TB2-6 and TB2-7.

Note: If LED fault indicator lights refer to Section 6.1 in this manual.

VE9. Check and Adjust current limit
Turn the Current Limit pot fully CCW to allow maximum current flow. The DVM should read about 0.8 vdc. This corresponds to 8 Amps which is the maximum continuous current the VXA delivers.

Adjust the Current Limit pot to the desired continuous current setting for the application. The scale factor is 0.1 volts per amp. With proper conservative motor sizing, this current setting should not exceed 80% of the continuous current rating of the motor.

Consider an example where a setting of 6.5 amps is desired. To obtain this, adjust the Current Limit pot until you read 0.65v on the volt meter.

VE10. Turn off the power
Having completed setting the continuous current, turn off the power to the amplifier.

VE11. Remove the jumper between TB1 terminals 1 & 2 and see that the motor leads are properly reconnected.

VE12. Reconnect Command Voltage and Set to Zero.
Be sure you have a zero-volt command signal or ground the Voltage Command Input Terminal (TB2-3)

VE13. Restore Power
Apply power to the VXA again.

VE14. Adjust Offset
The motor will now be powered. It should be in a locked position or rotating slowly. Adjust the Offset pot, if necessary, to stop the motor.

VE15. Test motor speed control
Apply some positive and negative command voltages. The motor should rotate clockwise and counterclockwise, respectively.

VE16. Adjust IR Comp pot
Return the motor to zero speed (zero command). Slowly turn the IR Comp pot CCW until you hear a low frequency noise from the motor (motor may also begin to rotate slowly at this point). Back off by going CW again until the noise (oscillation) stops.

Under loaded conditions, the motor may start oscillating again. In this case, repeat this adjustment.

VE17. Readjust Offset Pot.
If necessary readjust Offset pot to bring the motor to a stop.

VE18. Adjust Motor Speed
The Gain pot is used to calibrate the motor speed to the command signal. Apply the maximum command voltage you will be using (+/- 10 vdc maximum), and adjust the Gain pot until the motor is running at the desired speed.

Check the speed range and tracking by applying various command levels. Also check operation in the opposite direction by applying negative voltages.

VE19. Readjust Offset
Set the command voltage to zero. If the motor is slowly rotating, adjust the Offset pot until it stops.

VE20. Fine Tuning
To optimize performance, you may touch up adjustments of three pots:

Compensation Pot
IR Comp Pot
Offset Pot

Start by slowly turning the Compensation pot CW until you hear a high pitched noise from the motor. Then back off CCW until it stops, but no further. If you do not get the high pitched noise leave this pot fully CW.

Now readjust the IR Comp pot as in Step VE16. You may have some slight interaction with the Compensation pot. If you hear a high pitched noise readjust the Compensation pot to stop it.

With this second adjustment of the IR Comp pot you may have to readjust the Offset pot slightly to bring the motor to a stop.

You have now completed adjustments of the VXA for operation in the EMF mode. Keep in mind that this mode does not gives the same level of stiffness, stability and speed regulation as a motor/tach combination. In many applications, however, it will provide satisfactory performance.

5.3 Torque Mode

Important: Normally the torque mode should only be used with a digital positioning controller which also controls motor speed. Before applying this amplifier in the torque mode, we recommend that you contact the PMI Applications Engineering Department.

Follow each step sequentially. Do not apply power to the amplifier until instructed to do so.

STEP

T1. Check the Speed/Torque Jumper SB-2 (See Figure 1)
Make sure the jumper is in the Torque position. This disables both the tach and emf-sensing sections of the VXA circuitry.

T2. Preset the adjustment potentiometers
The potentiometers should be set as follows:

Function	Setting	Pot #	Condition
Gain	Not Used	(Pot 3)	--
Tach Adjust	Not Used	(Pot 2)	--
Compensation	Not Used	(Pot 5)	--
IR Comp	Not Used	(Pot 1)	--
Offset	Not Used	(Pot 4)	--
Current Limit	Fully CW	(Pot 6)	min. current

Please note that the pot numbers are not sequentially marked on the circuit board but are identified on the chassis. Refer to Figure 1.

T3. Connect a jumper wire across motor terminals 1 and 2 on TB1. Use 16 or 18 gauge wire.

T4. Connect a DVM (set to 1 or 2 volt range) across resistor R1. This is the large power resistor on the edge of the circuit board.

T5. Apply a command signal of 10 volts (See Figure 2)
The command signal is connected between TB2-1 (I. Comm) and TB2-2 (ground).

T6. Turn on power to the amplifier

T7. Enable the Amplifier
For setting-up purposes, continually enable the amplifier by installing a jumper wire between TB2-6 and TB2-7.

Note: If LED fault indicator lights refer to Section 6.1 in this manual.

T8. Check Current and Current Command
With the 10 vdc input command, check for maximum current delivery by turning the Current Limit pot fully CCW. You should read 0.8 volts dc on the DVM, which corresponds to 8 amps.

Leaving the Current Limit Pot fully CCW, check the current command function by applying various voltage levels to the I Comm. terminal and observing the reading on the DVM. The relationship of current to command voltage is fixed at 0.8 amps per volt. Therefore a 1 volt command will produce 0.8 amps, 2 volts gives 1,6 amps etc.

Change the polarity of the command voltage and check for a reversal of current flow.

T9. Adjust current limit
Reapply 10 volts to the I. Comm input. The DVM will read 0.8 volts. Adjust the Current Limit pot to the desired continuous current setting for the application. The scale factor on the DVM is 0.1 volts per amp. With proper conservative motor sizing, the application should not require more than 80% of the continuous current rating of the motor.

Consider an example where a setting of 6.5 amps is required. To obtain this, adjust the Current Limit pot until you read 0.65v on the DVM.

T10. Turn off the power
Having completed setting the continuous current, turn off the power to the amplifier.

T11. Remove the jumper between TB1 terminals 1 & 2 and see that the motor leads are properly reconnected.

T12. Restore Power
Apply power to the VXA again. With zero command the motor will be locked in position. As command voltage is applied, the torque of the motor will vary accordingly.

This concludes the adjustment and setup procedure for torque mode applications.

6.0 Troubleshooting

When problems occur in servo systems any of the components can be suspected. Listed below is a quick-check procedure to follow if you think the problem is with the VXA. The intent and scope of this procedure is to establish whether the VXA amplifier is functioning properly or not.

It is recommended that you go through these quick checks before consulting the PMI. If you determine that the amplifier is faulty we recommend that you return it to the factory for repair.

6.1 If LED Indicator Goes On During Set-Up Procedure.

The LED fault indicator can go on if the Current Limit pot is not set at minimum (fully CW) in any of the Set-Up Procedures: 5.1, 5.2, or 5.3.

If the light goes on when you enable the amplifier, remove the enable jumper, check that the Current Limit pot is set at minimum and re-enable.

6.2 Quick-Check Procedure

1. Remove power from amplifier.

2. Check and/or replace 10 Amp fuse F1.

3. Remove all signal inputs to amplifier.

4. Remove motor leads and put jumper across TB1-1 and TB1-2. Use 16 gauge wire.

5. Put the SB-2 Speed/Torque jumper on the circuit board to Speed mode.

6. Turn the Offset pot fully CCW.

7. Turn the Current Limit pot fully CW (minimum current).

8. Apply power to the VXA, either from the AC step-down transformer or the DC source.

9. Check Fault Indicators.
   A. If fuse blows the VXA has shorted components.
   B. If the fault LED lights the VXA has bad components.

10. If the fault indicators are OK, make the following measurements with the DVM:

    A. Input Power Voltage
       A1. If using an AC input, check across TB1-3 and TB1-4 for proper AC voltage.
       A2. If using a DC input, check across TB1-5 and TB1-6 for proper voltage and polarity.

B. Logic Voltages
   B1. Check for +15 VDC between TB2-5 and ground.
   B2. Check for -15 VDC between TB2-6 and ground.

11. If above voltages are OK connect the DVM across R1 power resistor (see Figure 1).

12. Enable the amplifier by putting a jumper from TB2-7 to TB2-6.

13. Turn the Current Limit pot fully CCW to allow maximum current. The DVM should read 0.8 VDC.

14. Turn the Offset pot fully CW. The DVM should now read -0.8 VDC.

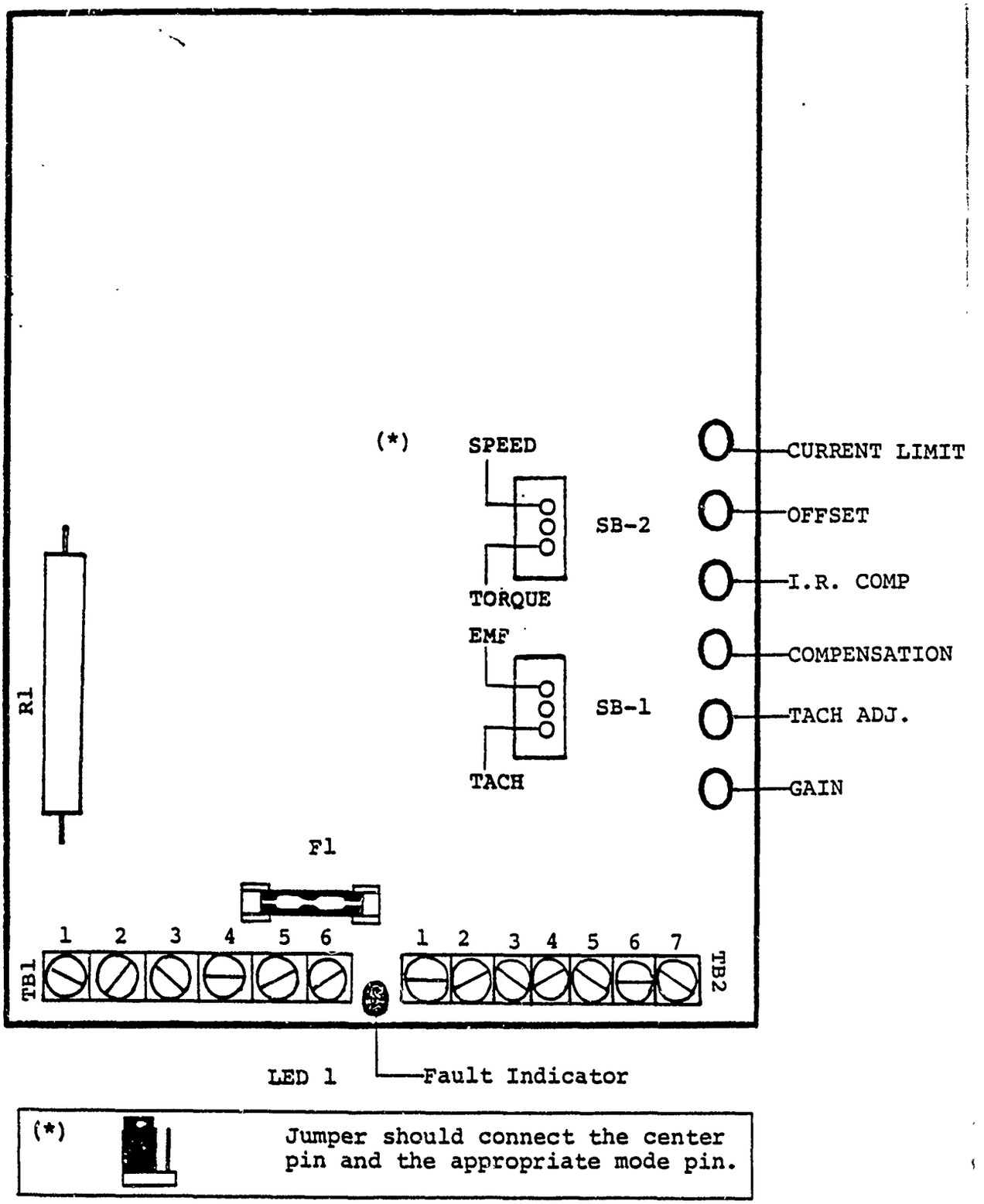
15. Check Bus Voltage. With maximum current flowing check for proper bus voltage by measuring across fuse F1 and ground (TB2-2).

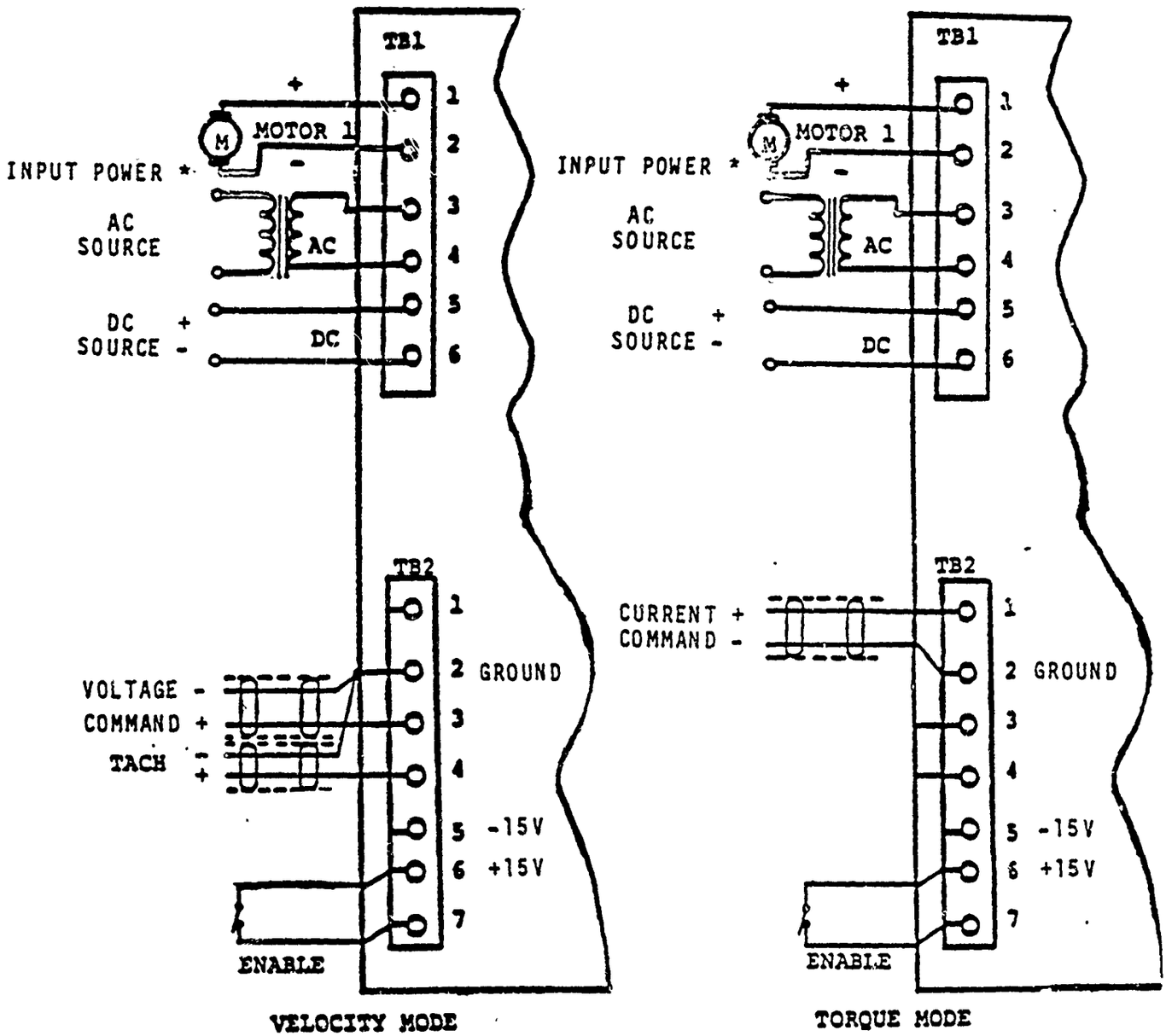
If the VXA passes all of the above checks it is operating properly.

APPENDIX

FIG. 1

CONNECTORS, ADJUSTMENTS, & JUMPERS





*Input power may be AC or DC, but NOT both. When using AC power, isolation transformer must be used.

FIG. 2

WIRING DIAGRAMS

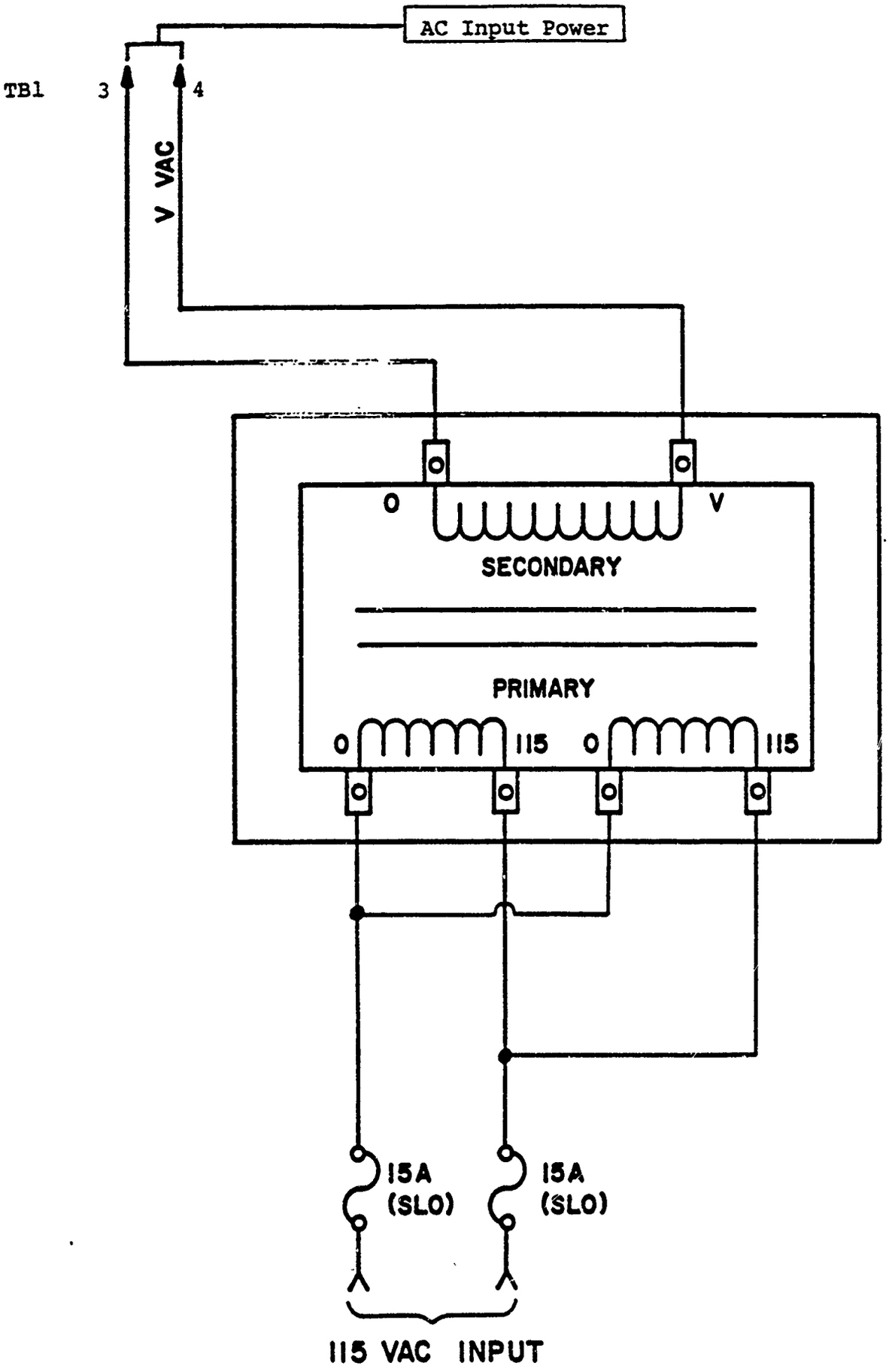


FIG. 3

105 - 125 VAC 50/60 HZ LINE INPUT

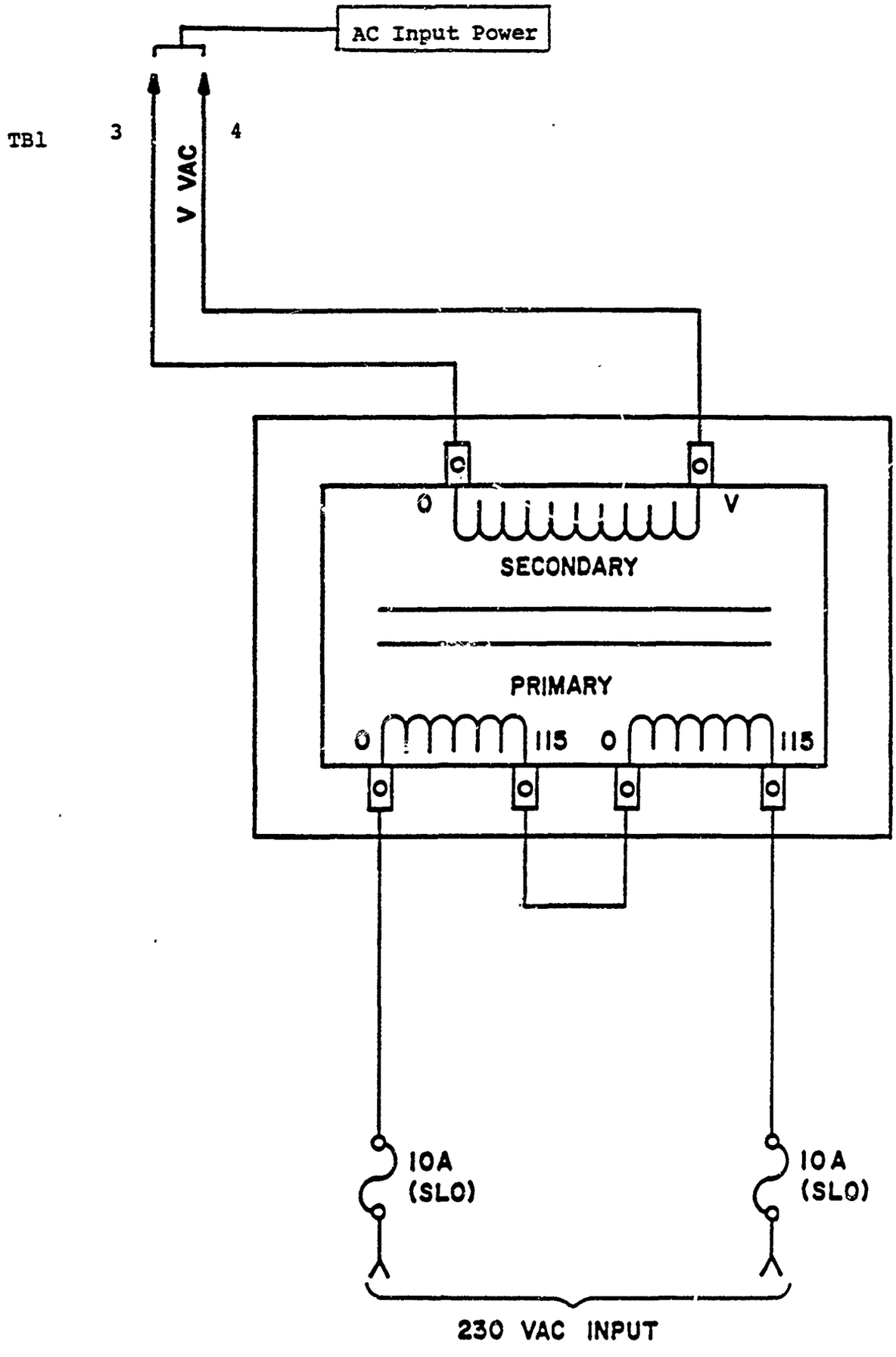
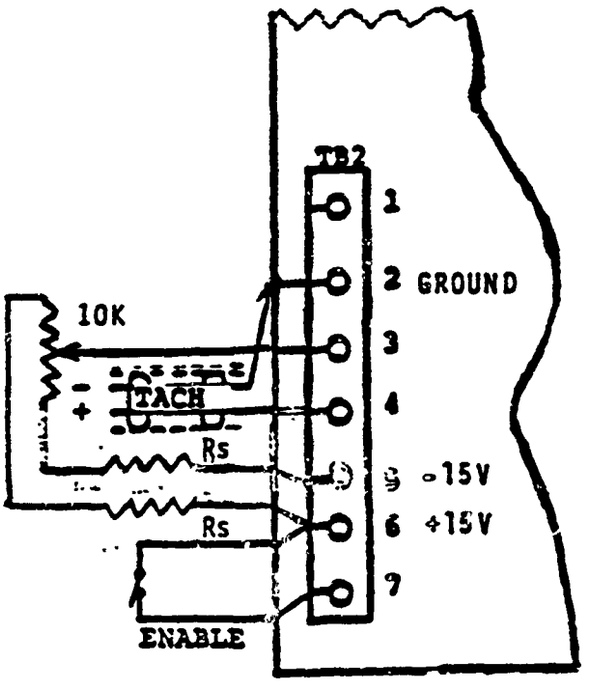
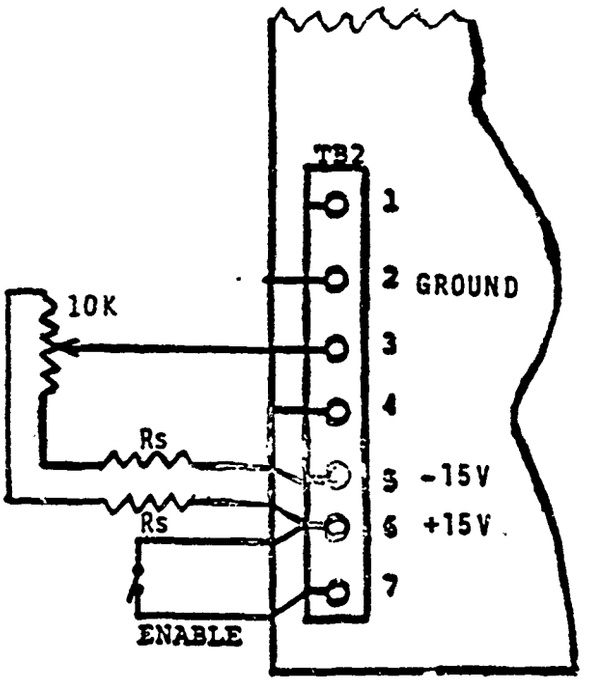


FIG. 4

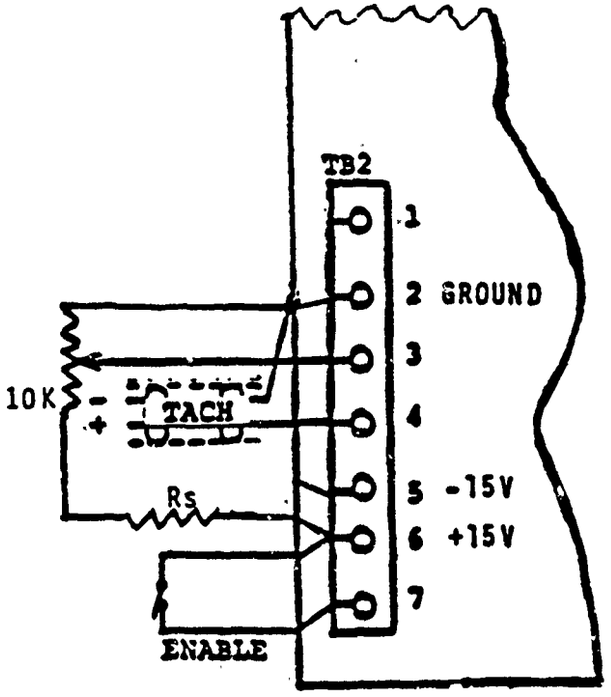
240 VAC 50/60 HZ LINE INPUT



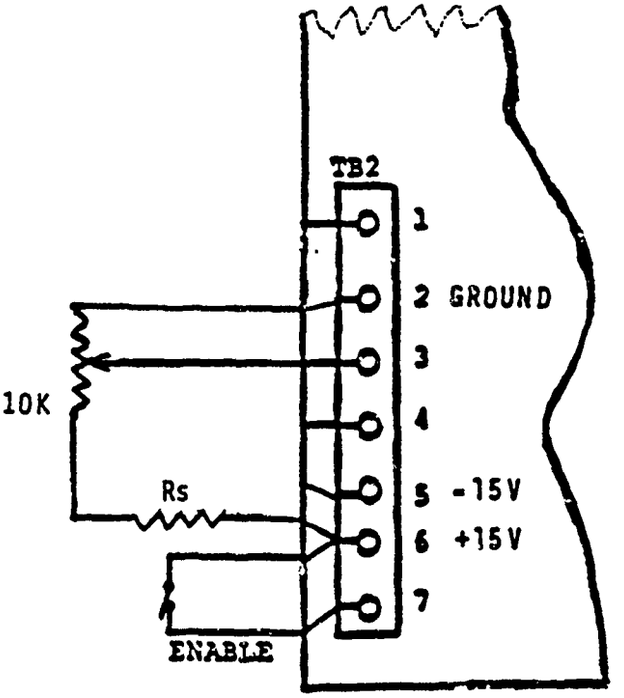
A. 2-direction control
Tachometer Feedback



B. 2-direction control
EMF Sensing



C. 1-direction control
Tachometer Feedback



D. 1-direction control
EMF Sensing

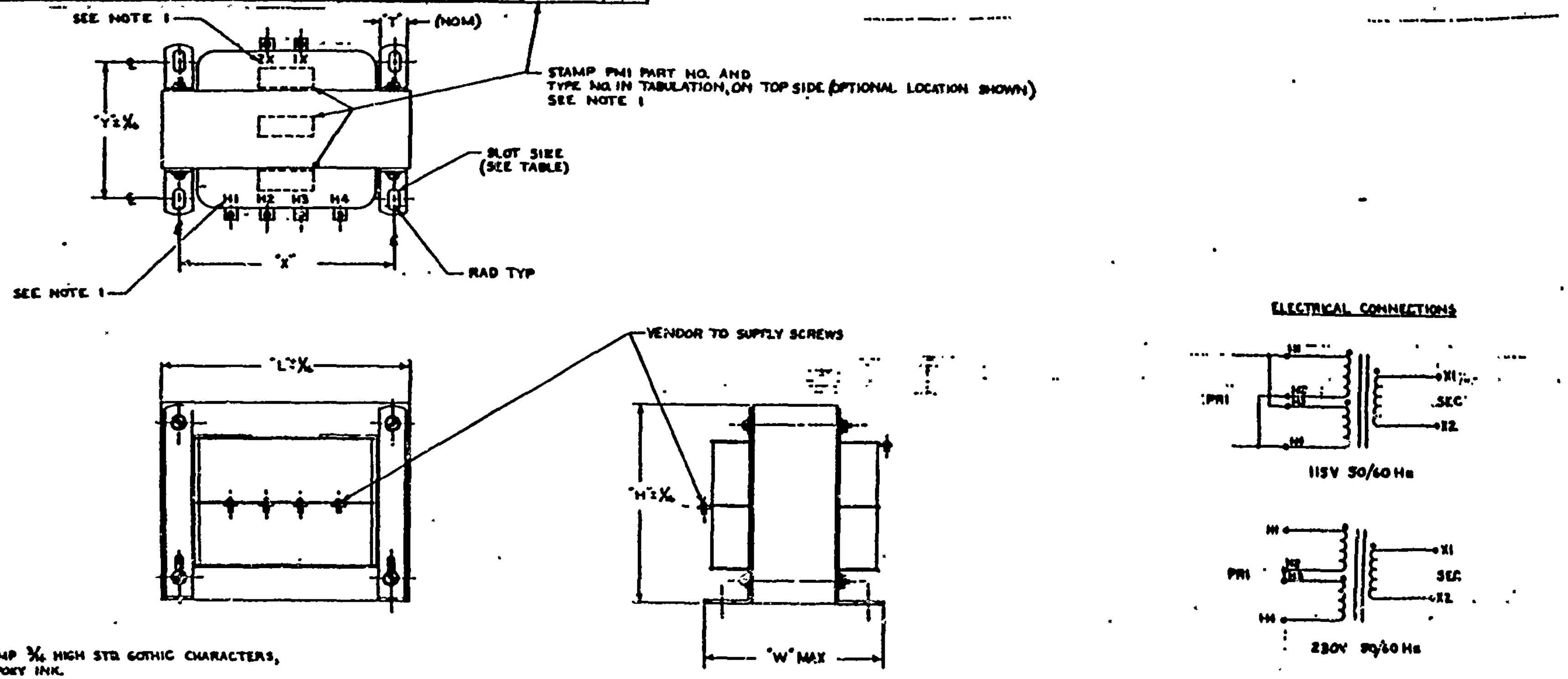
Rs = 33K for Ferrite motors, 5K for Alnico motors. Also see text.

FIG. 5

Schemes for Controlling Speed with a Potentiometer

A	RLSE FOR PROD, ECN 6976	
B	ADDED -009 TO -012 TO TAB. CHNGD NOTE 3, ECN NO 6915	

DASH NO	"L" DIM	"W" DIM	"H" DIM	"X" DIM	"Y" DIM	"T" DIM	SLOT SIZE	PRIMARY	[illegible]	[illegible]	TYPE NO	[illegible]
-001	4 5/8	3 1/4	3 3/16	3 1/16	2 7/8	3/8	7/32 x 3/8	115/230VAC, 50/60Hz	16V, 12A	#6-32	T-20-8	NO.8
-002	4 5/8	3 3/16	3 3/8	3 1/4	2 1/2	3/8	7/32 x 3/8	115/230VAC, 50/60Hz	20V, 12A	#8-32	T-26-8	NO.8
-003	4 5/8	3 1/4	3 3/16	3 5/16	2 3/8	3/8	7/32 x 3/8	115/230VAC, 50/60Hz	36V, 5.5A	#6-32	T-48-4	NO.8
-004	4 1/2	3 3/8	3 3/16	3 1/4	2 1/2	3/8	7/32 x 3/8	115/230VAC, 50/60Hz	56V, 5.4A	#8-32	T-75-4	NO.8
-005	5 1/4	4 3/8	4 3/8	4 3/8	3 3/8	3/8	9/32 x 9/16	115/230VAC, 50/60Hz	80V, 9A	#8-32	T-110-6	1/4
-006	4 5/8	3 1/2	3 3/8	3 3/8	2 3/8	3/8	7/32 x 3/8	115/230VAC, 50/60Hz	115V, 2.6A	#8-32	T-160-2	NO.8
-007	5 1/4	4 3/8	4 3/8	4 3/8	3 3/8	3/8	9/32 x 9/32	115/230VAC, 50/60Hz	115V, 6.5A	#8-32	T-160-4	1/4
-008	6 3/8	4 3/8	5 1/16	5 1/4	3 1/4	1/2	9/32 x 1/4	115/230VAC, 50/60Hz	115V, 9A	#8-32	T-160-6	1/4
-009	4 5/8	4 1/4	3 3/8	3 3/8	3 1/2	3/8	7/32 x 3/8	115/230VAC, 50/60Hz	20V, 24A	#8-32	T-26-16	NO.8
-010	4 5/8	4 1/4	3 3/8	3 3/8	3 1/2	3/8	7/32 x 3/8	115/230VAC, 50/60Hz	36V, 12A	#8-32	T-48-8	NO.8
-011	7 3/8	5 3/8	6 1/4	6 3/8	3 3/8	3/8	9/32 x 9/16	115/230VAC, 50/60Hz	80V, 18A	#8-32	T-110-12	1/4
-012	7 3/8	5 3/8	6 3/8	6 3/4	3 3/8	3/8	9/32 x 9/16	115/230VAC, 50/60Hz	115V, 13A	#8-32	T-160-8	1/4



NOTES:
1. STENCIL OR RUBBER STAMP 3/16 HIGH STD GOTHIC CHARACTERS, USING CONTRASTING EPOXY INK.
2. FOR PURCHASE INFORMATION SEE QVL 77.
3. TOP SIDE OF TERMINAL AND HOLE THREADS SHALL BE FREE OF SOLDER AND VARNISH.

DO NOT SCALE DRAWING — WORK TO DIMENSIONS SHOWN

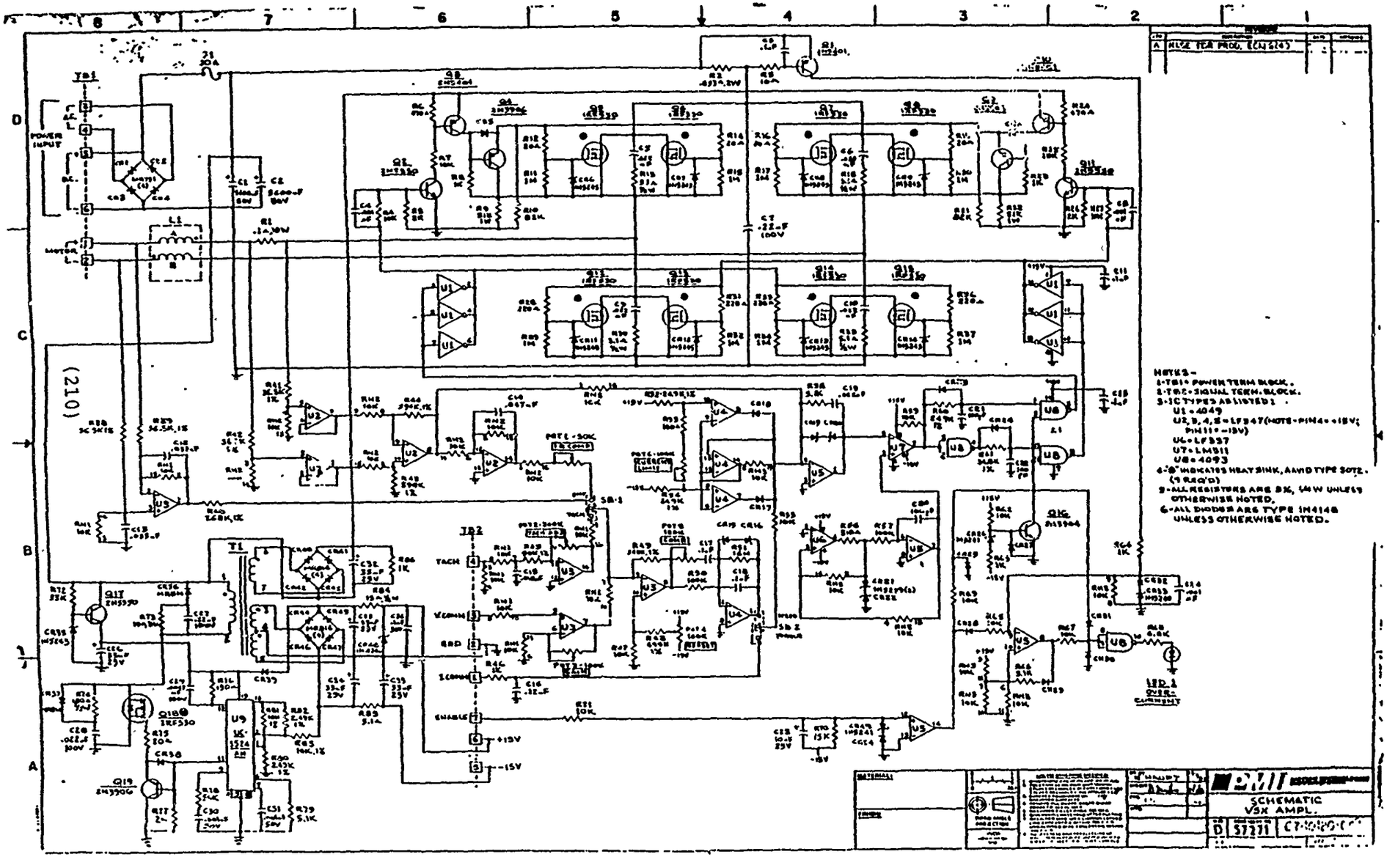
FINISH: BLACK PAINT AND/OR VARNISH IMPREG

PURCHASED PART DRAWING

TRANSFORMER - SCREW LUG TERMINALS

D 37272 77-10032-*

SCALE NONE — SHEET 1 OF 1


NOTES -
1-TB1 = POWER TERM BLOCK.
2-TB2 = SIGNAL TERM. BLOCK.
3-IC TYPES AS LISTED:
U1 = 4049
U2, 3, 4, 5 = LF347 (NOTE - PIN 4 = +15V; PIN 11 = -15V)
U6 = LF337
U7 = LM311
U8 = 4093
4-"B" INDICATES HEAT SINK, AAVID TYPE 507B. (1 REQ'D)
5-ALL RESISTORS ARE 5%, 1/4 W UNLESS OTHERWISE NOTED.
6-ALL DIODES ARE TYPE IN4148 UNLESS OTHERWISE NOTED.
SCHEMATIC
V3X AMPL.
D
51731

PRESSURE SWITCH AND

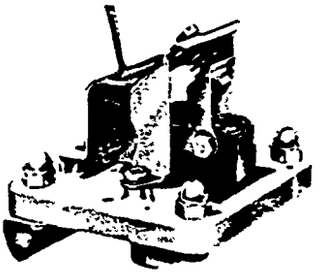
SENSOR EQUIPMENT

DATA SHEETS

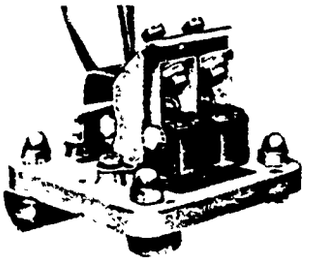
OPERATING CHARACTERISTICS • ORDERING DATA

Stripped Diaphragm Models

D1S SINGLE SETTING



D2S DUAL CONTROL



PRESSURE SWITCHES — All values given in P.S.I. (Gauge)

Proof (Test) Pressure	Adjustable Range				Approx. Actuation Value (Differential)	Wetted Material*	D1S Catalog Number	D2S Catalog Number
	Decreasing		Increasing					
	Min.	Max.	Min.	Max.				
3	.018	1.654	.064	1.7	.018 to .046	B25	D1S-H2	D2S-H2
3	.018	1.65	.068	1.7	.02 to .05	17-7PH	D1S-H2SS	D2S-H2SS
10	.03	2.89	.14	3.0	.05 to .11	B25	D1S-A3	D2S-A3
10	.03	2.85	.18	3.0	.07 to .15	17-7PH	D1S-A3SS	D2S-A3SS
60	.4	17.80	.60	18.0	.1 to .20	B25	D1S-H18	D2S-H18
60	.4	17.74	.66	18.0	.12 to .26	17-7PH	D1S-H18SS	D2S-H18SS
160	.5	77.2	3.3	80.0	1.4 to 2.8	B25	D1S-A80	D2S-A80
160	.5	76.6	3.9	80.0	1.6 to 3.4	17-7PH	D1S-A80SS	D2S-A80SS
300	1.5	144.8	6.7	150.0	2.2 to 5.2	B25	D1S-A150	D2S-A150
300	1.5	144.0	7.5	150.0	2.3 to 6.0	17-7PH	D1S-A150SS	D2S-A150SS
Approximate shipping weight lbs.							1.5	1.5

VACUUM SWITCHES — All values given in inches of mercury (Gauge)

Proof (Test) Vacuum	Proof (Test) Pressure	Adjustable Range				Approx. Actuation Value (Differential)	Wetted Material*	D1S Catalog Number	D2S Catalog Number
		Dec. Vacuum		Incr. Vacuum					
		Min.	Max.	Min.	Max.				
6	10 PSI	.06	5.8	.26	6.0	.09 to .20	B25	D1S-A3	D2S-A3
6	10 PSI	.06	5.72	.34	6.0	.14 to .28	17-7PH	D1S-A3SS	D2S-A3SS
30	60 PSI	.8	29.34	1.46	30.0	.4 to .66	B25	D1S-H18	D2S-H18
30	60 PSI	.8	29.2	1.6	30.0	.4 to .8	17-7PH	D1S-H18SS	D2S-H18SS
Approximate shipping weight lbs.								1.5	1.5

IN STOCK

*B25 Beryllium Copper, 17-7PH Stainless Steel

DETAIL DATA

ELECTRICAL CHARACTERISTICS: All models incorporate Underwriters' Laboratories, Inc. listed single pole double throw snap-action switching elements. Electrical rating (continuous inductive) 10 amps 125 or 250 volts AC, 3 amps 480 volts AC. Automatically reset by snap-action of switch. For more details and other switch classes, see pages 36-38.

ELECTRICAL CONNECTION:

Switches may be wired 'normally open' or 'normally closed' to free leads approximately 18" long.

PRESSURE (VACUUM) CONNECTION: ¼" npt internal thread. ½" npt available stainless steel only add —P2 to catalog number when ordering.

ADJUSTMENT INSTRUCTIONS

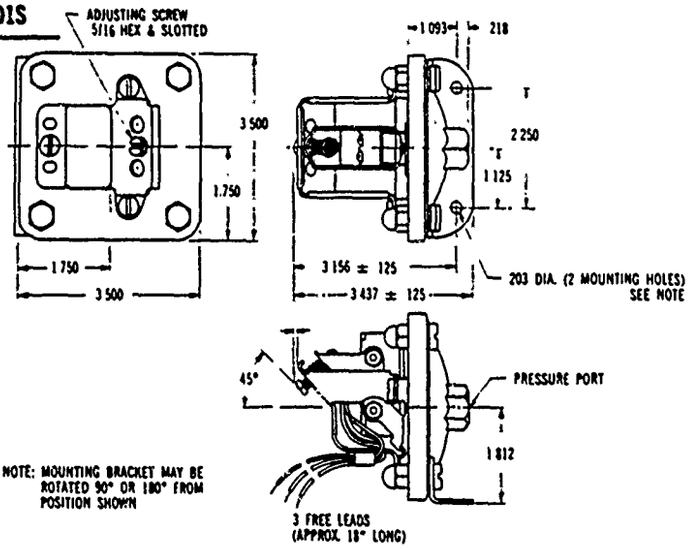
Positive Pressure: Turn adjustment screw clockwise to lower actuation point (switch setting).

Vacuum: Turn adjustment screw counterclockwise to approach atmospheric pressure.

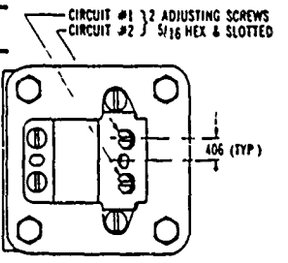
WIRE CODING — PRESSURE
Circuit #1: Common — Purple
Normally Closed — Blue
Normally Open — Red
Circuit #2: Common — Brown
Normally Closed — Orange
Normally Open — Yellow

WIRE CODING — VACUUM
Circuit #1: Common — Purple
Normally Closed — Red
Normally Open — Blue
Circuit #2: Common — Brown
Normally Closed — Yellow
Normally Open — Orange

D1S



D2S



Note: All other dimensions for D2S are the same as D1S (left).

Housed Diaphragm Models
Water-Tight Housing (NEMA 4)
Tamper-proof External Adjustment

OPERATING CHARACTERISTICS • ORDERING DATA

D1H SINGLE SETTING

D2H DUAL CONTROL

PRESSURE SWITCHES — All values given in P.S.I. (Gauge)

Proof (Test) Pressure	Adjustable Range Decreasing Min.	Adjustable Range Decreasing Max.	Adjustable Range Increasing Min.	Adjustable Range Increasing Max.	Approx. Actuation Value (Differential)	Wetted Material*	D1H Catalog Number	D2H Catalog Number
3	.018	1.654	.064	1.7	.018 to .046	B 25	D1H-H2	D2H-H2
3	.018	1.65	.068	1.7	.02 to .05	17-7PH	D1H-H2SS	D2H-H2SS
10	.03	2.89	.14	3.	.05 to .11	B 25	D1H-A3	D2H-A3
10	.03	2.85	.18	3.	.07 to .15	17-7PH	D1H-A3SS	D2H-A3SS
60	.4	17.80	.60	18.	.1 to .20	B 25	D1H-H18	D2H-H18
60	.4	17.74	.66	18.	.12 to .26	17-7PH	D1H-H18SS	D2H-H18SS
160	.5	77.2	3.3	80.	1.4 to 2.8	B 25	D1H-A80	D2H-A80
160	.5	76.6	3.9	80.	1.6 to 3.4	17-7PH	D1H-A80SS	D2H-A80SS
300	1.5	144.8	6.7	150.	2.2 to 5.2	B 25	D1H-A150	D2H-A150
300	1.5	144.	7.5	150.	2.3 to 6.0	17-7PH	D1H-A150SS	D2H-A150SS
Approximate shipping weight lbs.							1.75	1.75

VACUUM SWITCHES — All values given in inches of mercury (Gauge)

Proof (Test) Vacuum	Proof (Test) Press.	Adjustable Range Decr. Vac. Min.	Adjustable Range Decr. Vac. Max.	Adjustable Range Incr. Vac. Min.	Adjustable Range Incr. Vac. Max.	Approx. Actuation Value (Differential)	Wetted Material*	D1H Catalog Number	D2H Catalog Number
6	10 PSI	.06	5.8	.26	6.	.09 to .20	B25	D1H-A3	D2H-A3
6	10 PSI	.06	5.72	.34	6.	.14 to .28	17-7PH	D1H-A3SS	D2H-A3SS
30	60 PSI	.8	29.34	1.46	30.	.4 to .66	B25	D1H-H18	D2H-H18
30	60 PSI	.8	29.2	1.6	30.	.4 to .8	17-7PH	D1H-H18SS	D2H-H18SS
Approximate shipping weight lbs.								1.75	1.75

IN STOCK

*B 25 Beryllium Copper, 17-7PH Stainless Steel

DETAIL DATA

ELECTRICAL CHARACTERISTICS: All models incorporate Underwriters' Laboratories, Inc. listed single pole double throw snap-action switching elements. Electrical rating (continuous inductive) 10 amps 125 or 250 volts AC, 3 amps 480 volts AC. Automatically reset by snap-action of switch. For more details and other switch classes, see pages 36-38.

ELECTRICAL CONNECTION: To free leads through ½" nps conduit connector.

PRESSURE (VACUUM) CONNECTION: ¼" npt internal thread. ½" npt available stainless steel only add —P2 to catalog number when ordering.

ADJUSTMENT INSTRUCTIONS

Positive Pressure: Turn adjustment screw clockwise to lower actuation point (switch setting).

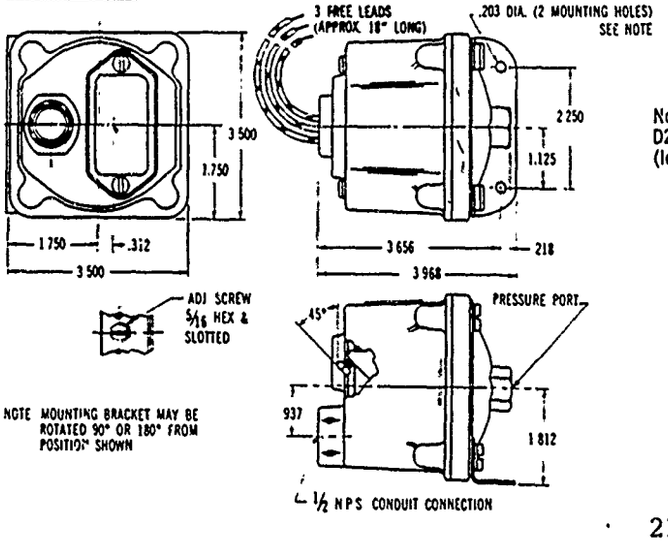
Vacuum: Turn adjustment screw counterclockwise to approach atmospheric pressure.

WIRE CODING — PRESSURE
Circuit #1: Common — Purple
Normally Closed — Blue
Normally Open — Red
Circuit #2: Common — Brown
Normally Closed — Orange
Normally Open — Yellow

WIRE CODING — VACUUM
Circuit #1: Common — Purple
Normally Closed — Red
Normally Open — Blue
Circuit #2: Common — Brown
Normally Closed — Yellow
Normally Open — Orange

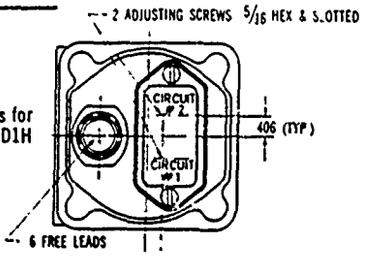
Switches Underwriters Laboratories and Factory Mutual listed for Fire Protection service request bulletin 690627.

D1H



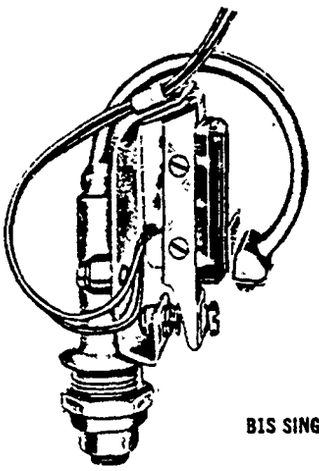
NOTE MOUNTING BRACKET MAY BE ROTATED 90° OR 180° FROM POSITION SHOWN

D2H

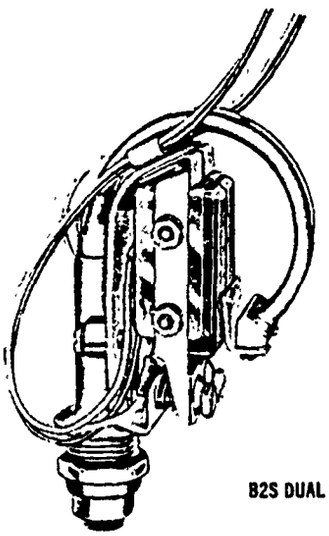


Note: All other dimensions for D2H are the same as D1H (left).

Stripped Bourdon Tube Models



B1S SINGLE SETTING



B2S DUAL CONTROL

OPERATING CHARACTERISTICS • ORDERING DATA

PRESSURE SWITCHES — All values given in P.S.I. (Gauge)

Proof (Test) Pressure	Adjustable Range Decreasing Min.	Decreasing Max.	Increasing Min.	Increasing Max.	Approx. Actuation Value (Differential)	Wetted Material*	B1S Catalog Number	B2S Catalog Number
1500	50	1180	70	1200	10 to 20	Bronze	B1S-H12	B2S-H12
1500	50	1173	77	1200	11 to 27	316	B1S-A12SS	B2S-A12SS
4000	160	3170	190	3200	15 to 30	Bronze	B1S-H32	B2S-H32
4000	160	3161	199	3200	16 to 39	316	B1S-H32SS	B2S-H32SS
6000	240	4715	325	4800	40 to 85	316	B1S-A48SS	B2S-A48SS
**8125	325	6385	440	6500	54 to 115	316	B1S-A65SS	B2S-A65SS
**15000	600	11450	1150	12000	275 to 550	316	B1S-A120SS	B2S-A120SS
**20000	600	17450	1150	18000	275 to 550	316	B1S-A180SS	B2S-A180SS
Approximate shipping weight lbs.							1.5	1.5

IN STOCK

*"Bronze" represents Phosphor Bronze Tube with SAE 88 Brass Socket
"316" represents 316 Stainless Steel Tube & Socket

**"AMINCO" female opening for ¼" OD tube connection. To change -A65SS and -A120SS switches to ¼" npt, add -P4 suffix to model number. Price addition required.

ELECTRICAL CHARACTERISTICS: All models incorporate Underwriters' Laboratories, Inc. listed single pole double throw snap-action switching elements. Electrical rating (continuous inductive) 10 amps 125 or 250 volts AC, 3 amps 480 volts AC. Automatically reset by snap-action of switch. For more details and other switch classes, see pages 37-38.

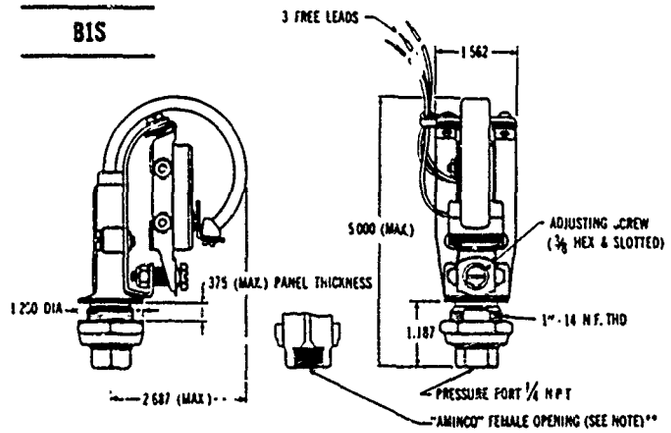
ELECTRICAL CONNECTION: Switches may be wired 'normally open' or 'normally closed' to free leads approximately 18" long.

WIRE CODING — PRESSURE
Circuit #1: Common — Purple
Normally Closed — Blue
Normally Open — Red
Circuit #2: Common — Brown
Normally Closed — Orange
Normally Open — Yellow

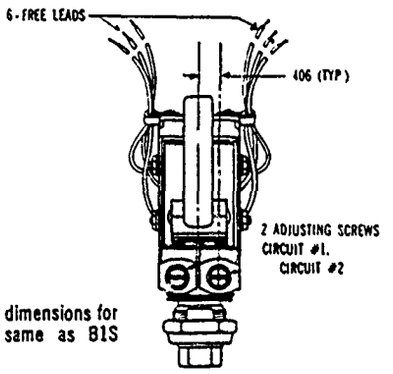
PRESSURE CONNECTION: ¼" N.P.T. internal thread, except as noted**, models with Proof Pressures above 8,000 P.S.I. have "AMINCO" female opening for ¼" O.D. tube connection.

ADJUSTMENT INSTRUCTIONS
Turn adjustment screw clockwise to lower actuation point (switch setting).

B1S



B2S

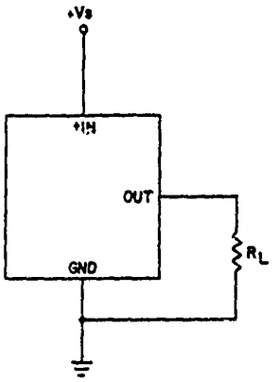


Note: All other dimensions for B2S are the same as B1S (left).

Solid State Pressure Sensors 140/160/240PC Series

ELECTRICAL CONNECTION

Voltage Excitation



NOTES

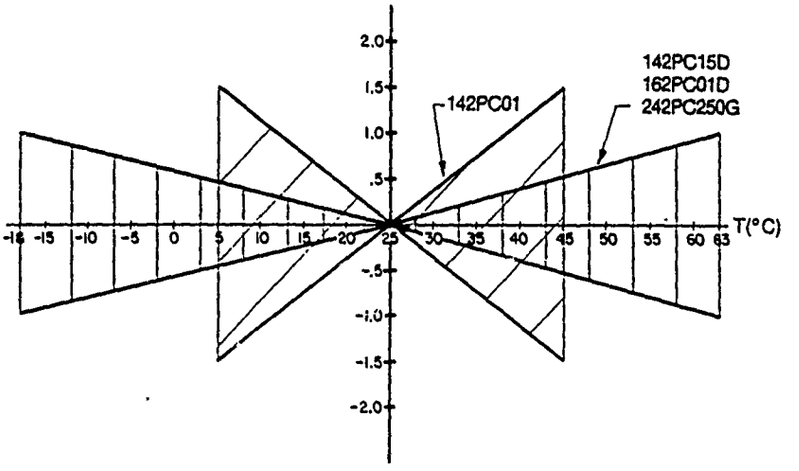
1. Terminals are labeled on the sensor.
2. Input and output share a common ground.
3. R_L must be greater than or equal to 3000 ohms.

NULL AND SENSITIVITY SHIFT

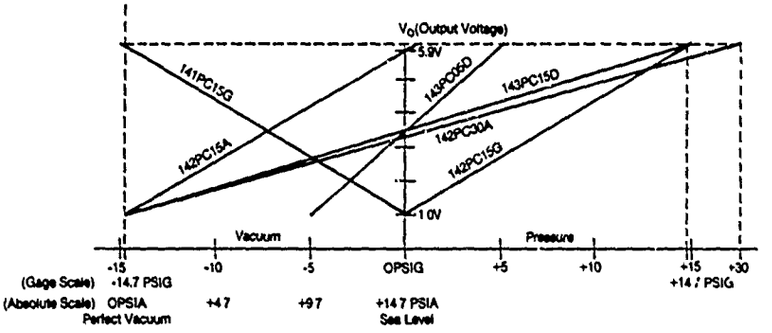
High level pressure sensors are 100% tested to insure that the maximum null and sensitivity temperature shift does not exceed the specification. The diagram below illustrates how null and sensitivity shift relates to temperature. Note that the maximum shift occurs at temperature extremes. Therefore, if a sensor is not exposed to the entire temperature range, the maximum null and sensitivity shift will actually be less than the value specified.

This diagram indicates the temperature shift pertaining to a few listings. Maximum null and sensitivity shift varies from listing to listing.

Null and Sensitivity Shift (% F.S.O.)



SCALING OF 140PC SERIES SENSORS WITH 8V EXCITATION

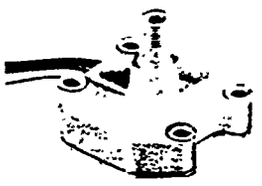


142PC15A	Absolute	V_O = 5.9V at sea level & 1.0V with -14.7 psig
142PC30A	Absolute	V_O = 6.0V at 30 psia & 1.0V with -14.7 psig
142PC15G	Gage	V_O = 1.0V at 0 psig & 5.9V at 14.7 psig
141PC15G	Vacuum Gage	V_O = 1.0V at 0 psig & 5.9V at -14.7 psig
143PC05D	Differential	V_O = 1.0V at -5 psig & 6.0V at +5 psig
143PC15D	Differential	V_O = 1.0V at -15 psig & 6.0V at +15 psig

NOTE: 141PC sensors are scaled for greater pressure on the P1 side of the chip. 142PC sensors are scaled for greater pressure on the P2 side of the chip. The exception of this is all absolute units.

Other scalings available upon request.

240PC Series Solid State Pressure Sensors



FEATURES

- Internal O-ring seals for contamination resistance
- Screw-in or flat-pack mounting
- Rugged aluminum housing

MEDIA COMPATIBILITY

Pressure media will make contact with the following: die-cast aluminum housing, O-ring seal, silicon chip sensing element, borosilicate glass, chip-to-glass tube bond* which holds silicon chip to borosilicate glass.

*Liquid medias containing some highly ionic solutions potentially could neutralize the chip-to-glass tube bond.

ORDER GUIDE - 241/242PC SERIES

PRESSURE RANGE (psi)*	
CATALOG LISTINGS Port Seal O-ring Material**	Buna-N
	Ethylene propylene
SPECIFICATIONS	Parameter
at 8.0 ± 0.01VDC Excitation	Sensitivity per psi, typ. (V)
25° C (unless otherwise noted)	Overpressure, max. (psi)
	Linearity, max.
	Best Fit Straight Line (%F.S.O.)
	Null & Sensitivity Shift (%F.S.O.)†
	25° to -18°, 25° to 63° C, max.
	25° to -40°, 25° to 85° C, typ.
	Repeatability & Hysteresis, typ. (%F.S.O.)

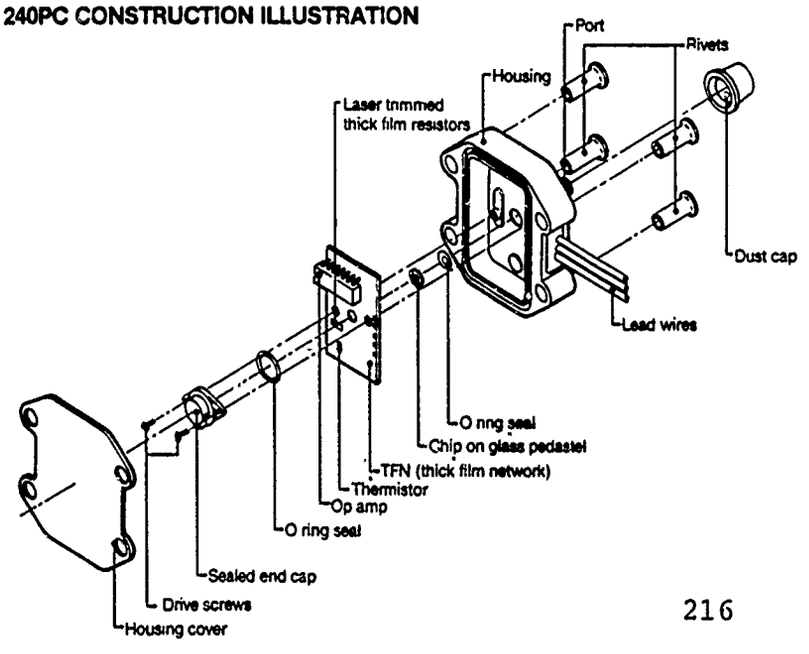
ORDER GUIDE - 243PC SERIES

PRESSURE RANGE (psi)*		
CATALOG LISTINGS Port Seal O-ring Material**	Buna-N	
	Ethylene propylene	
SPECIFICATIONS	Parameter	
at 8.0 ± 0.01VDC Excitation	Sensitivity per psi, typ. (V)	
25° C (unless otherwise noted)	Overpressure, max. (psi)	
	Linearity, max.	
	Best Fit Straight Line	P2 > P1
	(%F.S.O.)	P2 < P1
	Null & Sensitivity Shift (%F.S.O.) †	
	25° to -18°, 25° to 63° C, max.	
	25° to -40°, 25° to 85° C, typ.	
	Repeatability & Hysteresis, typ. (%F.S.O.)	

NOTE: For additional specifications, see 140/160/240PC General Specifications.

*-15 to 0 and -5 to 0 sensors are vacuum gage devices, all others are gage devices.
**Buna-N — General use; petroleum products; freon 12 and others
Ethylene propylene — Low temperature steam; phosphate esters; freon 22 and others
Other seal materials available upon request.
†Temperature Error

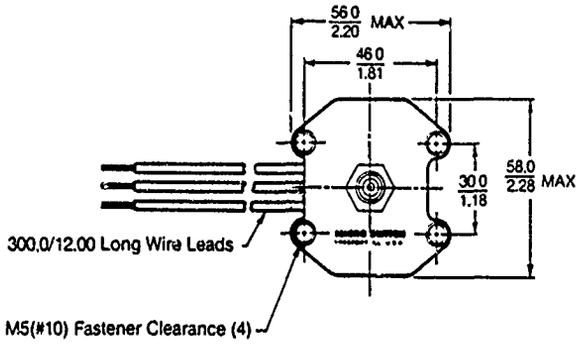
240PC CONSTRUCTION ILLUSTRATION

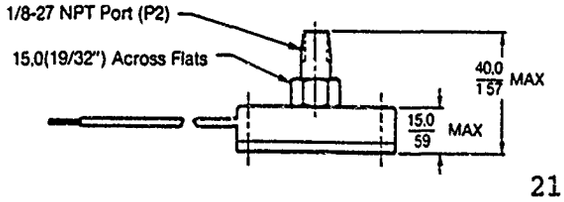


0 to -15	0 to -5	0-5	0-15	0-30	0-60	0-100	0-150	0-250
241PC15G	241PC05G	242PC05G	242PC15G	242PC30G	242PC60G	242PC100G	242PC150G	242PC250G
241PC15GS	241PC05GS	242PC05GS	242PC15GS	242PC30GS	242PC60GS	242PC100GS	242PC150GS	242PC250GS
330	1.00	1.00	.330	.167	.083	.050	.033	.020
45	20	20	45	60	120	200	300	500
±1.5	±1.5	±1.5	±1.5	±1.5	±0.5	±0.5	±0.5	±0.5
±1.0	±1.5	±1.5	±1.0	±1.0	±1.5	±1.0	±1.5	±1.0
±2.0	±3.0	±3.0	±2.0	±2.0	±3.0	±2.0	±3.0	±2.0
±0.25	±0.25	±0.25	±0.25	±0.25	±0.25	±0.25	±0.25	±0.25

±2.5	±5	±15
243PC03G	243PC05G	243PC15G
243PC03GS	243PC05GS	243PC15GS
1.00	0.50	0.177
20	30	50
±1.50	±1.50	±1.50
±0.75	±0.75	±0.75
±1.00	±1.00	±1.00
±1.50	±1.50	±1.50
±0.25	±0.25	±0.25

MOUNTING DIMENSIONS (For reference only)





Leadwires
1 - Red, Vs
2 - Black, Ground (-)
3 - Green, Output

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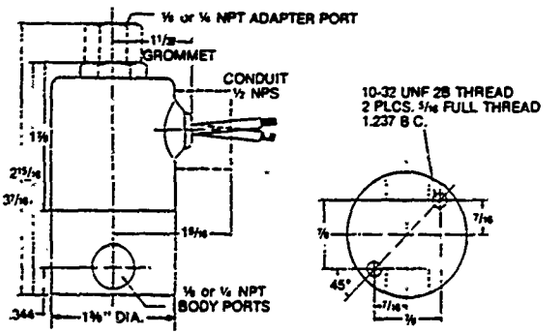
SOLENOID VALVE

DATA SHEETS

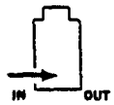
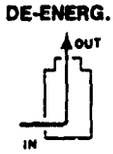
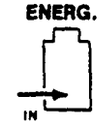
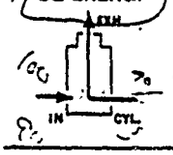
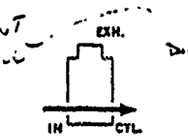
Solenoid Valves

SERIES 6 2-WAY & 3-WAY

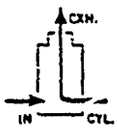
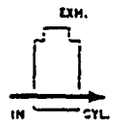
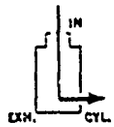
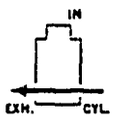
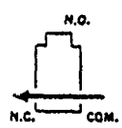
CAN ALSO GET WITH BUILT W/NEEDLE VALVE STD. OPTION



OUTLINE AND MOUNTING DIMENSIONS

TYPE	BODY PORTS N.P.T.	ORIFICE DIA. BODY	ORIFICE DIA. STOP	M.O. P.D.	Cv FACTOR BODY	Cv FACTOR STOP	VALVE NUMBER S.S. BODY GROMMET	S.S. BODY CONDUIT	BRASS BODY GROMMET	BRASS BODY CONDUIT	OPERATOR GROMMET	OPERATOR CONDUIT
2-WAY NORM. CLOSED DE-ENERG. 	1/8	1/32		1500	.020		641010	642010	641110	642110	641310	642310
	1/8	3/64		1000	.050		641011	642011	641111	642111	641311	642311
	1/8	1/16		500	.080		641012	642012	641112	642112	641312	642312
	1/8	5/64		300	.120		641013	642013	641113	642113	641313	642313
	1/8	3/32		200	.170		641014	642014	641114	642114	641314	642314
	1/8	1/8		150	.280		641015	642015	641115	642115	641315	642315
	1/8	5/32		125	.395		641016	642016	641116	642116	641316	642316
	1/8	3/16		75	.500		641017	642017	641117	642117	641317	642317
	1/8	1/4		50	.750		641018	642018	641118	642118	641318	642318
ENERG. 	1/4	1/32		1500	.020		651010	652010	651110	652110		
	1/4	3/64		1000	.050		651011	652011	651111	652111		
	1/4	1/16		500	.080		651012	652012	651112	652112		
	1/4	5/64		300	.120		651013	652013	651113	652113		
	1/4	3/32		200	.170		651014	652014	651114	652114		
	1/4	1/8		150	.280		651015	652015	651115	652115		
	1/4	5/32		125	.395		651016	652016	651116	652116		
	1/4	3/16		75	.500		651017	652017	651117	652117		
	1/4	1/4		50	.750		651018	652018	651118	652118		
2-WAY NORM. OPEN DE-ENERG. 	1/8		1/32	1000		.020	641020	642020	641120	642120	641320	642320
	1/8		3/64	800		.050	641021	642021	641121	642121	641321	642321
	1/8		1/16	400		.080	641022	642022	641122	642122	641322	642322
	1/8		5/64	300		.110	641023	642023	641123	642123	641323	642323
	1/8		3/32	200		.170	641024	642024	641124	642124	641324	642324
	1/8		1/8	100		.240	641025	642025	641125	642125	641325	642325
ENERG. 	1/4		1/32	1000		.020	651020	652020	651120	652120	651320	652320
	1/4		3/64	800		.050	651021	652021	651121	652121	651321	652321
	1/4		1/16	400		.080	651022	652022	651122	652122	651322	652322
	1/4		5/64	300		.110	651023	652023	651123	652123	651323	652323
	1/4		3/32	200		.170	651024	652024	651124	652124	651324	652324
	1/4		1/8	100		.240	651025	652025	651125	652125	651325	652325
3-WAY NORM. CLOSED FREE VENT DE-ENERG. 	1/8	1/32	1/32	400	.020	.020	641030	642030	641130	642130	641330	642330
	1/8	3/64	3/64	300	.050	.050	641031	642031	641131	642131	641331	642331
	1/8	1/16	1/16	200	.080	.080	641032	642032	641132	642132	641332	642332
	1/8	5/64	5/64	175	.120	.110	641033	642033	641133	642133	641333	642333
	1/8	3/32	3/32	150	.170	.170	641034	642034	641134	642134	641334	642334
	1/8	1/8	1/8	100	.280	.240	641035	642035	641135	642135	641335	642335
	1/8	5/32	1/8	50	.395	.240	641036	642036	641136	642136	641336	642336
	1/8	3/16	1/8	35	.500	.240	641037	642037	641137	642137	641337	642337
	1/8	1/4	1/8	VAC.	.750	.240	641038	642038	641138	642138	641338	642338
ENERG. 	1/4	1/32	1/32	400	.020	.020	651030	652030	651130	652130		
	1/4	3/64	3/64	300	.050	.050	651031	652031	651131	652131		
	1/4	1/16	1/16	200	.080	.080	651032	652032	651132	652132		
	1/4	5/64	5/64	175	.120	.120	651033	652033	651133	652133		
	1/4	3/32	3/32	150	.170	.170	651034	652034	651134	652134		
	1/4	1/8	1/8	100	.280	.240	651035	652035	651135	652135		
	1/4	5/32	1/8	50	.395	.240	651036	652036	651136	652136		
	1/4	3/16	1/8	35	.500	.240	651037	652037	651137	652137		
	1/4	1/4	1/8	VAC.	.750	.240	651038	652038	651138	652138		

SERIES 6 3-WAY

TYPE	BODY PORTS N.P.T.	ORIFICE DIA. BODY	ORIFICE DIA. STOP	M.O. P.D.	Cv FACTOR BODY	Cv FACTOR STOP	VALVE NUMBER S.S. BODY GROMMET	S.S. BODY CONDUIT	BRASS BODY GROMMET	BRASS BODY CONDUIT	OPERATOR GROMMET	OPERATOR CONDUIT
3-WAY	1/8	1/32	1/32	400	.020	.020	641040	642040	641140	642140	641340	642340
NORM. CLOSED	1/8	3/64	3/64	300	.050	.050	641041	642041	641141	642141	641341	642341
LINE CONN.	1/8	1/16	1/16	200	.080	.080	641042	642042	641142	642142	641342	642342
DE-ENERG.	1/8	5/64	5/64	175	.120	.120	641043	642043	641143	642143	641343	642343
	1/8	3/32	3/32	150	.170	.170	641044	642044	641144	642144	641344	642344
	1/8	1/8	1/8	100	.280	.240	641045	642045	641145	642145	641345	642345
	1/8	5/32	1/8	50	.395	.240	641046	642046	641146	642146	641346	642346
	1/8	3/16	1/8	35	.500	.240	641047	642047	641147	642147	641347	642347
	1/8	1/4	1/8	VAC.	.750	.240	641048	642048	641148	642148	641348	642348
	1/4	1/32	1/32	400	.020	.020	651040	652040	651140	652140	651340	652340
ENERG.	1/4	3/64	3/64	300	.050	.050	651041	652041	651141	652141	651341	652341
	1/4	1/16	1/16	200	.080	.080	651042	652042	651142	652142	651342	652342
	1/4	5/64	5/64	175	.120	.120	651043	652043	651143	652143	651343	652343
	1/4	3/32	3/32	150	.170	.170	651044	652044	651144	652144	651344	652344
	1/4	1/8	1/8	100	.280	.240	651045	652045	651145	652145	651345	652345
	1/4	5/32	1/8	50	.395	.240	651046	652046	651146	652146	651346	652346
	1/4	3/16	1/8	35	.500	.240	651047	652047	651147	652147	651347	652347
	1/4	1/4	1/8	VAC.	.750	.240	651048	652048	651148	652148	651348	652348
3-WAY	1/8	1/32	1/32	400	.020	.020	641050	642050	641150	642150	641350	642350
NORM. OPEN	1/8	3/64	3/64	250	.050	.050	641051	642051	641151	642151	641351	642351
DE-ENERG.	1/8	1/16	1/16	200	.080	.080	641052	642052	641152	642152	641352	642352
	1/8	5/64	5/64	175	.120	.120	641053	642053	641153	642153	641353	642353
	1/8	3/32	3/32	150	.170	.170	641054	642054	641154	642154	641354	642354
	1/8	1/8	1/8	100	.280	.240	641055	642055	641155	642155	641355	642355
	1/8	5/32	1/8	50	.395	.240	641056	642056	641156	642156	641356	642356
	1/8	3/16	1/8	35	.500	.240	641057	642057	641157	642157	641357	642357
	1/8	1/4	1/8	VAC.	.750	240	641058	642058	641158	642158	641358	642358
	1/4	1/32	1/32	400	.020	.020	651050	652050	651150	652150	651350	652350
ENERG.	1/4	3/64	3/64	250	.050	.050	651051	652051	651151	652151	651351	652351
	1/4	1/16	1/16	200	.080	080	651052	652052	651152	652152	651352	652352
	1/4	5/64	5/64	175	.120	.120	651053	652053	651153	652153	651353	652353
	1/4	3/32	3/32	150	.170	170	651054	652054	651154	652154	651354	652354
	1/4	1/8	1/8	100	.280	.240	651055	652055	651155	652155	651355	652355
	1/4	5/32	1/8	50	.395	.240	651056	652056	651156	652156	651356	652356
	1/4	3/16	1/8	35	.500	.240	651057	652057	651157	652157	651357	652357
	1/4	1/4	1/8	VAC.	.750	240	651058	652058	651158	652158	651358	652358
3-WAY	1/8	1/32	1/32	400	.020	.020	641060	642060	641160	642160	641360	642360
MULTI-PURPOSE	1/8	3/64	3/64	200	.050	.050	641061	642061	641161	642161	641361	642361
DE-ENERG.	1/8	1/16	1/16	175	.080	.080	641062	642062	641162	642162	641362	642362
	1/8	5/64	5/64	150	.120	.120	641063	642063	641163	642163	641363	642363
	1/8	3/32	3/32	125	.170	.170	641064	642064	641164	642164	641364	642364
	1/8	1/8	1/8	70	.280	.240	641065	642065	641165	642165	641365	642365
	1/8	5/32	1/8	40	.395	.240	641066	642066	641166	642166	641366	642366
	1/8	3/16	1/8	25	.500	.240	641067	642067	641167	642167	641367	642367
	1/8	1/4	1/8	VAC.	750	.240	641068	642068	641168	642168	641368	642368
	1/4	1/32	1/32	400	.020	020	651060	652060	651160	652160	651360	652360
ENERG.	1/4	3/64	3/64	200	.050	050	651061	652061	651161	652161	651361	652361
	1/4	1/16	1/16	175	.080	.080	651062	652062	651162	652162	651362	652362
	1/4	5/64	5/64	150	.120	.120	651063	652063	651163	652163	651363	652363
	1/4	3/32	3/32	125	.170	170	651064	652064	651164	652164	651364	652364
	1/4	1/8	1/8	70	.280	240	651065	652065	651165	652165	651365	652365
	1/4	5/32	1/8	40	.395	240	651066	652066	651166	652166	651366	652366
	1/4	3/16	1/8	25	.500	.240	651067	652067	651167	652167	651367	652367
	1/4	1/4	1/8	VAC.	750	.240	651068	652068	651168	652168	651368	652368

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VIDEO EQUIPMENT

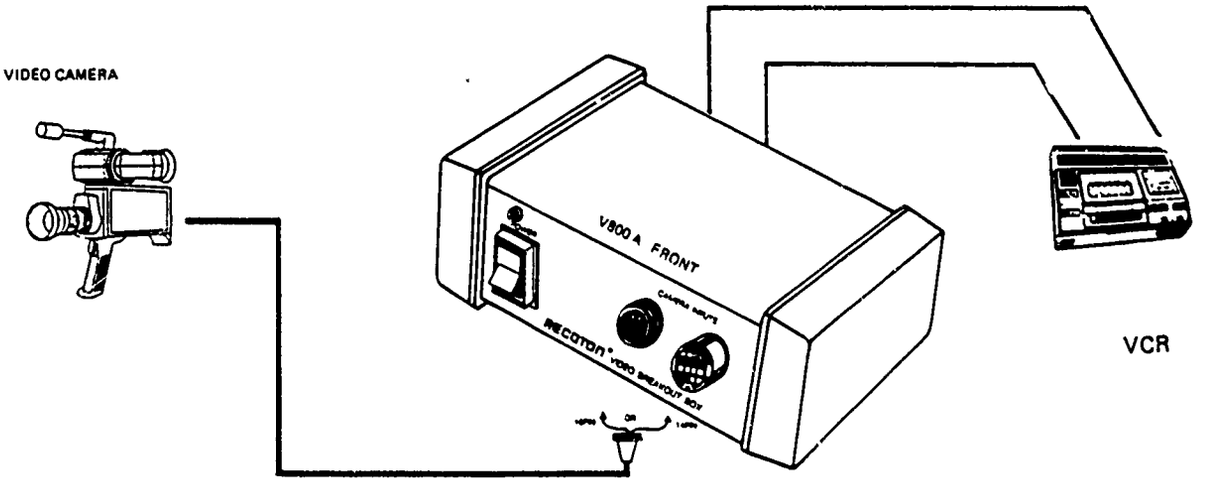
DATA SHEETS

RECOTON®

VIDEO accessories ®

THE PRODUCER SERIES™

UNIVERSAL VIDEO CAMERA BREAKOUT BOX



OWNERS MANUAL

GENERAL INFORMATION

The V800A UNIVERSAL CAMERA BREAKOUT BOX HAS been designed to allow the use of any video camera having either 10 or 14 pin connectors with any home video cassette recorder. This unique device is ideal for all types of in-home taping in situations where use of a portable VCR is either not available or not desired.

INSTALLATION

For an illustration of the following staps, see diagram on page 3

Step 1. Install 10 or 14 pin connector from video camera onto the corresponding 10 or 14 pin jack of V800A.

Step 2. Using the two RCA-RCA cables (included), connect the video ouput jack of the V800A to the video input jack of VCR, Connect the audio output jack of V800A to the audio input jack of VCR.
*For Beta VCR's, use RCA-Minl Adapter (included) for audio connections.

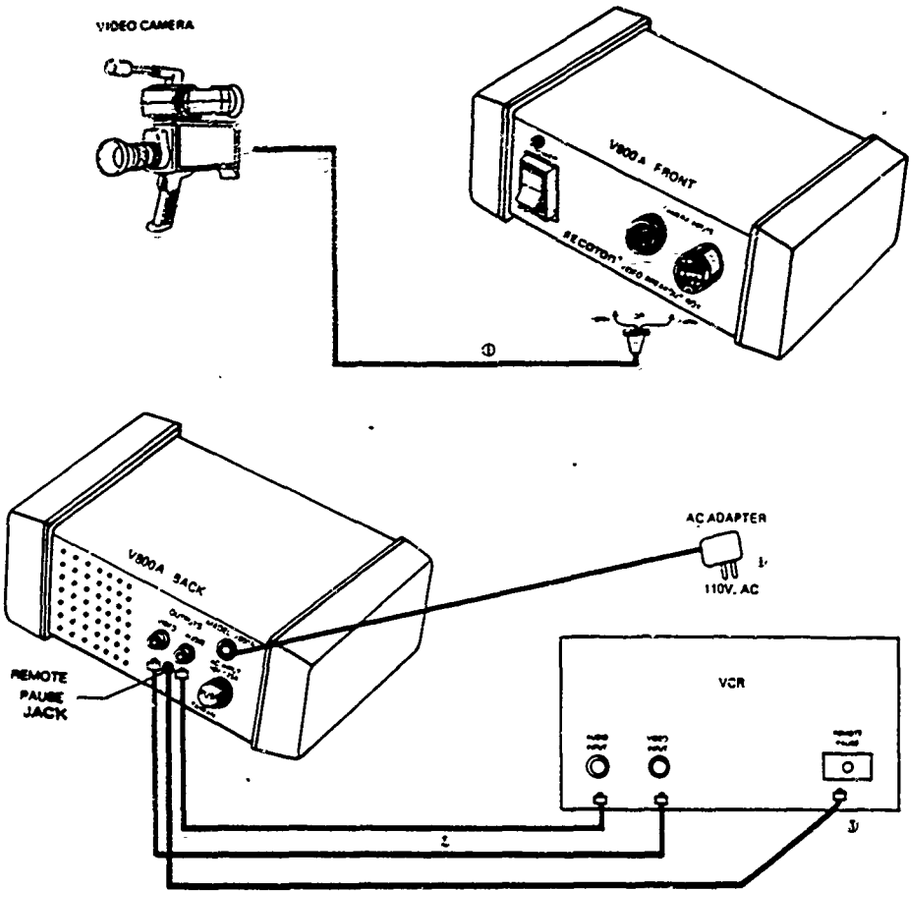
NOTE: We have included a remote pause cable which will allow you to active your VCR's pause by means of the camera trigger. This feature will operate with 10 pin camera and VHS VCR combinations only. (Follow Installation Instructions Step 3) This feature will not function with the following equipment:
10 pin camera/Beta VCR
14 pin camera/Any VCR
(Follow Installation Instructions Step 4)

Step 3. Connect the 2.5mm to 2.5mm cable (included) from the Remote Pause Jack of the V800A to the corresponding Pause Jack on your VHS recorder.

Step 4 Install your VCR remote pause control into the remote pause jack of VCR

NOTE: Since all home VCR's come with a remote pause control, we have not included this item with the V800A. If you have lost or misplaced the pause control, use Recoton Part #V327 as a replacement.

Step 5 Insert 3.5mm plug from AC adapter into the AC input jack on the rear of V800A, plug AC adapter into a 110V AC socket.



OPERATING INSTRUCTIONS

Step 1. Insert a blank video cassette into VCR, Turn VCR power on.
Step 2. Turn V800A power on.
Step 3. Press record button on video camera.
Step 4. Set remote pause control to pause, by either pressing camera remote trigger if camera and VCR are compatible or utilizing VCR's remote pause control if compatibility does not exist.
Step 5. Release pause control and begin recording.

FUSE REPLACEMENT

Should the V800A cease to operate, the probable cause will be a blown fuse. To inspect fuse, unplug AC adapter from the wall AC outlet and remove the fuse holder cap on the rear of V800A.

Visually inspect fuse, if filament is broken, replacement will be necessary.

Replace only with a 2 amp 3 ag fuse.

Caution: Failure to remove AC adapter from wall outlet when inspecting/replacing fuse can cause a severe electrical shock.

ONE YEAR LIMITED WARRANTY

Recoton Corporation (the Company) warrants to the original retail purchaser of this product that should this product or any part thereof be proven defective in material or workmanship within one year from the date of original purchase, such defects will be replaced without charge for parts or labor.

To obtain replacement within the terms of this warranty, the product should be delivered, transportation prepaid, to the Dealer where purchased or to the Company at the address shown below along with proof of date of purchase.

This warranty does not apply to any product or part thereof which has been damaged through alteration, mishandling, misuse, neglect or accident.

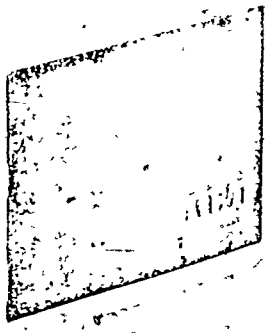
This warranty is in lieu of all other warranties, expressed or implied, and no person or representative is authorized to assume for the Company any other liability in connection with the sale of this product.

Some states do not allow limitations on how long an implied warranty lasts or the exclusion or limitation of incidental or consequential damage so the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights and you may also have other rights which vary from state to state.

RECOTON CORPORATION
46-23 Crane Street
Long Island City, N.Y. 11101

Made and Printed in Taiwan



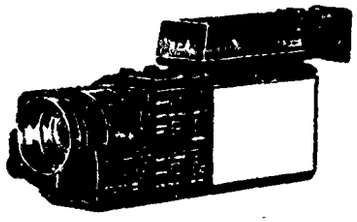
Model CLC025

SelectaVision® Color Video Camera

RCA

RCA SelectaVision®

CLC025 Color Video Camera



- ½" Saticon pickup tube
- Infrared auto focus system
- Electronic viewfinder with adjustable diopter
- Illuminated viewfinder indicator
- Remote pause control with quick review
- f1.2—6:1 lens with power zoom
- Optional titler
- Macro focus
- Constant automatic white balance
- Automatic iris
- Built-in microphone
- VHS compatibility switch
- Standby switch
- Automatic pickup tube protection
- Built-in tripod mount

½" Saticon pickup tube

Delivers a vivid color picture virtually free of smearing and "lag." The Saticon tube is sensitive enough to perform at light levels as low as 7 lux, so the camera is ideal for use indoors as well as out.

Infrared auto focus system

Sophisticated infrared triangulation system keeps moving objects in sharp focus. Automatically maintains a sharp image—even during zooms. Includes override for manual control of focus.

Electronic viewfinder

Electronic B&W viewfinder (EVF) displays exactly what will be recorded on the tape and doubles as a B&W monitor for viewing "instant replays" after taping. Adjustable diopter allows EVF focus to be changed to permit users who wear eyeglasses to remove them when operating camera.

Illuminated viewfinder indicator

Camera constantly monitors taping conditions and relays information to user via lights in the viewfinder. Indicator signals when: 1) VCR is recording; 2) VCR battery strength is low.

Remote VCR function controls

With VCR in record mode, *Pause* function is controlled with a single switch on camera's hand grip. Press to start a recording scene; press again to stop. For a quick look at the previously taped scene, press *Review* button during camera *pause mode*. *Review* feature available with RCA convertible VCRs.

f1.2 lens with 6:1 power zoom

High-speed f1.2 lens includes 6-to-1 zoom ratio and motor-driven zoom. Hand grip control lets operator zoom in for exciting close-ups or zoom out for panoramic shots. Lens will stop at desired perspective when control is released. Zoom ratios can also be manually adjusted by rotating lens ring on body of camera.

Optional titler

All RCA cameras may be used with RCA's optional character generator (Part No. CGA010), which makes titling and special effects easy. Compose up to 20 different titles and store them in title memory for later insertion in tapes. Other features include: choice of four colors and four sizes for characters; 20-page title memory; scroll up or down (variable speed); user-programmable 40-word permanent storage capacity; memory back-up; *curtain* (image is "wiped" off the screen); *window* (edges of the screen converge on the image); and calendar/stopwatch.

Macro focus

Obtain sharp images as close as ⅜" from the subject. Useful for shooting small objects without loss of detail.

Constant automatic white balance

Built-in circuitry continuously adjusts for proper color balance indoors or out. A manual color balance control is included for creating special visual effects, or for unusual lighting conditions.

Automatic iris

To assure correct exposure, camera automatically responds to available light conditions and adjusts aperture accordingly.

Built-in microphone

Records sound without need for a separate microphone. Accessory jack included for optional stereo microphone (RCA Part No. SM002), providing two-track sound when recording with a stereo VCR.

VHS compatibility switch

Adapts camera's record/pause circuitry for use with virtually all VHS-format video recorders.

Standby switch

Puts camera into power-saving standby mode during extended breaks in recording. Conserves valuable battery recording time during portable VCR use.

Automatic pickup tube protection

Special circuit shuts iris automatically to protect pickup tube when camera is in standby mode.

Built-in tripod mount

Built-in fitting accommodates standard camera tripod to provide a steady picture during recording.

SPECIFICATIONS

Signal System:
EIA standard: NTSC color

Video Output Level:
1.0V p-p composite/75 ohms

Pickup Tube:
½" striped Saticon

Lens:
f1.2—6:1 motorized zoom and macro focus to within ⅜".
Infrared Auto Focus

Minimum Required Illumination:
0.7 foot candles (7 lux)

Power Source:
12VDC

Power Consumption:
6 watts nominal

Dimensions:
H-5", W-3¹⁵/₁₆", D-10⅛"

Weight:
2.4 lbs. (approx.)
(without cable)

Specifications subject to change without notice.

This product is backed by RCA Authorized Servicenters and the RCA Service Company.

For provisions of the limited warranty on this product, see separate warranty sheet Form VR4856.

Form VR8799 Printed in U.S.A 5/85

RCA

RECEIVER	CONTROL AND INDICATOR FUNCTIONS
THUMBWHEEL	Channel frequency selection by number.
RCL/Vid	Receiver Level/Video Level, switch controls meter function.
ON/OFF	Switch turns receiver ON or OFF.
Crt. Brkr	Circuit breaker (.5A) prevents AC overload, press to reset.
Meter	Monitor receiver and video level only.
RCL/Vid	Receive level/Video Level, switch to monitor.
SYN/Alarm	Red indicates synthesizer is off frequency: (not operational with crystal frequency control.)
RCL/Normal	LED Red: With no RF input. GRN: With greater than -75 dBm RF IN.
PWR	AC/DC indicates power on, connector, Cannon KPT 06F-10-6s
Audio 1	Connector XLR, 10 dBm Line Level
Audio 2	Connector XLR, 10 dBm Line Level
Mon	Monitor, connector BNC
Video	Connector BNC
Antenna	Connector "Type N"

RF

RENTED
TV TRANSMITTER
4-87

.2W Transmitter	Control and Indicator Functions
ON/POWER (Power switch)	Switch turns transmitter ON or OFF
THUMBWHEEL	Selects channel frequency by number
PWR/LED	Power; yellow indicates transmitter ON
AFC/LED	Automatic frequency control, RED indicates transmitter is off frequency
POWER	DC, Connector (Cannon KPT06F-10-6S) Pin A N/C Pin B Video-IN Pin C Video-Mon Pin D Common Grnd, -12 VDC/Shields Pin E Audio 2 Pin F +12 VDC
AUDIO 1	Connector MB , Microphone level with AGC (Automatic Gain Control)
ANTENNA	Connector (Type"SMA")

92582

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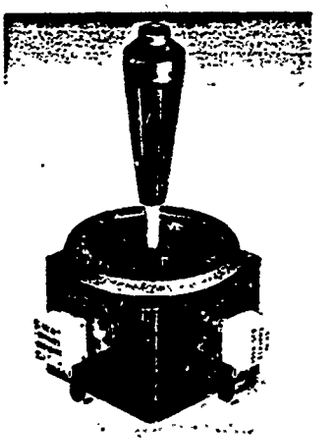
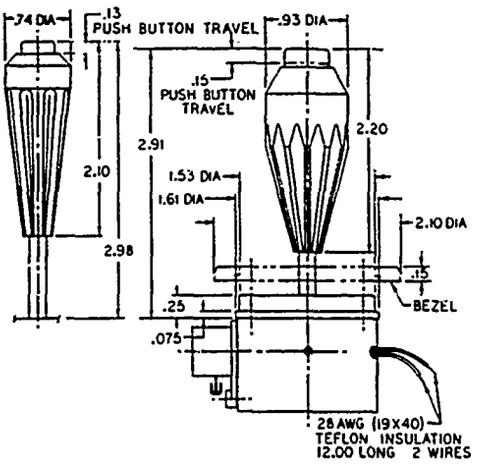
CONSOLE SWITCH

DATA SHEETS

MODEL 200 *Two-Axis with Pushbutton Joystick Assemblies*

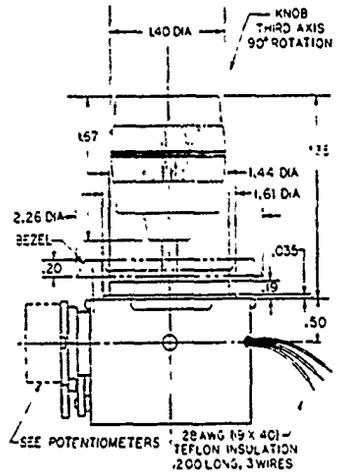
The Model 200 Joystick is a two-axis joystick with a push button switch mounted in the stick handle. The switch is a single-pole/single-throw switch. There is a choice of push-button housings: small and large. The only difference between the two other than size is the switch life cycle which is 250,000 cycles and 10,000,000 cycles for the small and large pushbutton housings respectively. The switch leads are brought through the center of the stick shaft and out the back of the housing below the mounting surface. These assemblies are provided with a two-piece textured front-mounting bezel for ease of installation. The rubber boot seal can also be used (optional). The push button and the housing both come standard black in color. Other colors are available (contact factory).

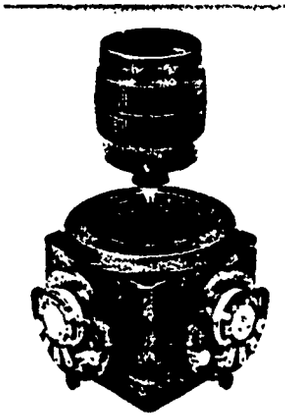




MODEL

MODEL 300B *(New Design) Three-Axis Joystick Assemblies*





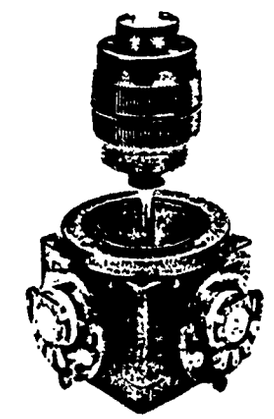
The new Model 300B is a two-axis joystick with a spring-return-to-center textured knob on the stick handle providing the third axis. A CRV-16 5k ohm, 1 watt potentiometer housed within the knob can be rated a total of 20° or 45° in each direction from design center. 4 oz. in./lbs. of torque will initiate the rotation of the knob. Three wire leads are brought through the center of the stick shaft similar to the Model 200 assemblies. A two-piece mounting bezel is provided for ease of installation, but the rubber boot seal can also be used (optional).

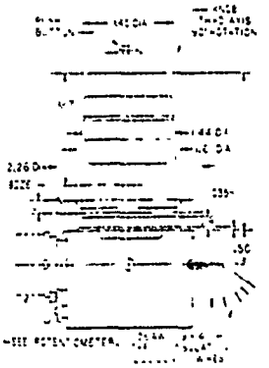
The Model 300B control knob is a double-scissor and extension-type spring action with positive stops. This concept is similar to our X, Y movement of the joystick which has proven to be trouble free.

MODEL 400

Three-Axis Joystick with Pushbutton Switch

The Model 400 is similar to the Model 300 with the addition of a pushbutton switch located on the end of the control knob. The switch provides a tactical and audio feedback. The switch is normally open, single pole/single throw, 500,000 life cycles and rated at 500 MA at 12VDC. Five wire leads are brought through the center of the stick shaft similar to the Model 200.





PLEASE NOTE:

The following optional features will vary depending on the joystick type (Standard or Miniature). See page 8 for details on availability of features and ordering information.

CONSTRUCTION

All CH Joysticks are constructed with four different combinations of plastics, which is a necessity in order to reduce friction on bearing surfaces. However, 75% of the joystick itself is for structural and environmental reasons. This is why we offer you the choice of Nylon or Minlon for these structural parts. The chart at the right will provide some of the key properties of both plastics:

Property	ASTM Test No.	Units	(0) Nylon	(1) Minlon
Tensil Strength[1]	D638	PSI	11,200	9,000
Flexural Modulus[1]	D790	PSI	175,000	600,000
Flexural Strength[1]	D790	PSI	175,000	21,500
Izod Impact Strength[1]	D256	ft.lb./in.	2.1	.7
Hardness (Rockwell)	D785	—	R108	R121
Flammability	UL94[2]	—	94V-2	94HB

Notes: Changes with Temperature and Relative Humidity, Data Based on 73°F and 50% RH.
[2]Underwriters Laboratory Test.

MOUNTING BEZELS

There are a variety of front- or rear-panel mounting bezels available all with a textured finish. A new Square Snap-on bezel (Option Q) and Round Snap-On Bezel (Option U) are also available which mount from the front, and the screws are covered up with the snap-on ring. Mounting screws are included with each unit.

Note: The Model 100 assemblies can use any of the bezels shown. Model 200, 300 and 400 assemblies are provided with split bezel (Option C) or mounting boot only (Option L).

OPTIONAL FEATURES

STANDARD JOYSTICK MOUNTING BEZELS AND MOUNTING CUTOUT DIMENSIONS

A — Round Bezel Textured (FM)

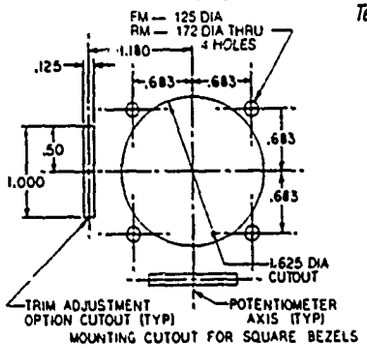
C — Split Bezel Textured (FM)

F — Square Bezel Textured (RM)

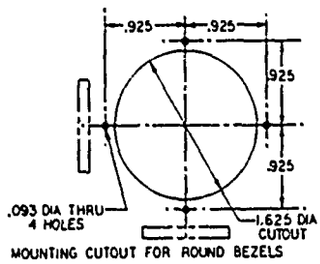
L — Rubber Boot Kit & Mounting Ring Textured (FM)

Q — Square Bezel Snap-on (FM)

Notes: (FM) Front Mount Bezel
(RM) Rear Mount Bezel



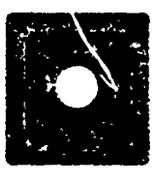
MOUNTING CUTOUT FOR SQUARE BEZELS



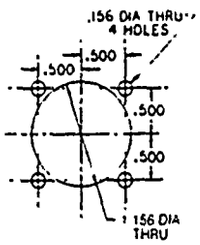
MOUNTING CUTOUT FOR ROUND BEZELS

MINIATURE JOYSTICK BEZELS AND MOUNTING CUTOUT DIMENSIONS

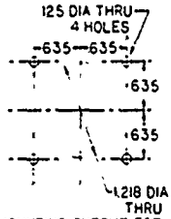
C — Split Bezel Textured (FM)



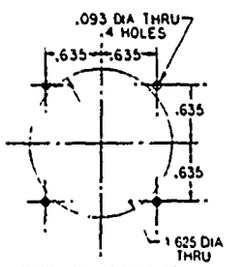
F — Square Bezel Textured (RM)



MOUNTING CUTOUT FOR SQUARE BEZELS



MOUNTING CUTOUT FOR SQ SNAP-ON BEZEL



MOUNTING CUTOUT FOR ROUND BEZELS

ORDERING INFORMATION

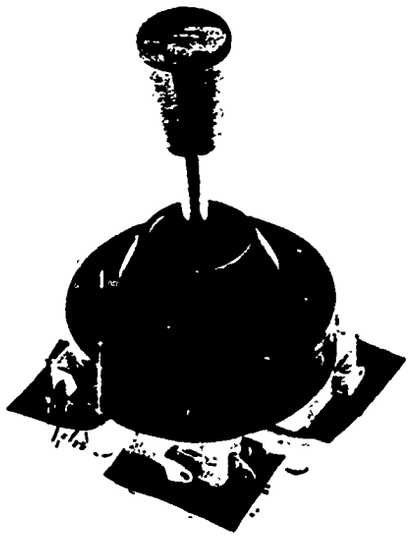
PART NUMBER DESIGNATION & FEATURE AVAILABILITY

For more information call or write:
C H PRODUCTS (619) 744-8546
1225 Stone Drive, San Marcos, CA 92069

PART NUMBER	DESCRIPTION	KEY DESIGNATION	JOYSTICK: TYPE	FEATURE AVAILABILITY											
		S	Standard	S	S	S	S								
_____	*JOYSTICK TYPE*	M	Miniature					M	M	M	M				
		C	Compact									C	C	C	C
			Model No..												
		1	100-2 Axis	100				100				100			
_____	*MODEL NUMBER*	2	200-2 Axis with pushbutton		200				200				200		
		3	300-3 Axis			300				300				300	
		4	400-3 Axis with pushbutton				400				400				400
			Optional Features:												
_____	*CONSTRUCTION*	0	Nylon Plastic	X	X	X	X					X	X	X	X
		1	Minlon	X	X	X	X	X	X	X	X				
		A	Round Cup — Textured (FM)	X											
		C	Split Bezel — Textured (FM)	X	X	X	X	X	X	X	X				
		F	Square Bezel — Textured (RM)	X				X							
_____	*MOUNTING BEZEL*	0	Computer Bezel	X								X	X	X	X
		L*	Rubber Boot Kit (FM)	X	X	X	X								
		Q	Square Bezel Snap-on (FM)	X				X							
		U	Round Bezel Snap-On (FM)	X				X							
		X	Without Bezel	X	X	X	X	X	X	X	X				
		0	Spring Centering	X	X	X	X	X	X	X	X	X	X	X	X
		1	Friction Clutch	X	X	X	X								
_____	*CENTERING*	3*	Center Detent — X Axis	X	X	X	X								
		4*	Center Detent — Y Axis	X	X	X	X								
		5*	Center Detent — Both Axis	X	X	X	X								
		6	Torque Set (Friction)	X	X	X	X	X	X	X	X				
		0	Convex Tapered (600-021)	X				X				X			
		1	Concave Tip (600-022)	X				X				X			
		2	Flat Tip (600-023)	X				X				X			
		3	Concave Tip — Long (600-024)	X				X				X			
		4	Pushbutton — Small Housing		X				X				X		
_____	*STICK HANDLE*	5	Pushbutton — Large Housing		X				X				X		
		6	Straight Tip — Short (600-020)	X				X				X			
		8	3 RD Axis — B Model			X				X				X	
		9	3 RD Axis with Pushbutton				X				X				X
		A	Straight Tip — Mid (600-019)	X				X				X			
		B	Straight Tip — Long (600-018)	X				X				X			
		C	Ball Tip (600-017)	X				X				X			
		0	With Trim	X	X	X	X					X	X	X	X
_____	*TRIM*	1	Without Trim	X	X	X	X	X	X	X	X				
		9	Unassembled	X	X	X	X	X	X	X	X				
		B	Clarostat 5K	X	X	X	X	X	X	X	X	X	X	X	X
		C	Clarostat 10K	X	X	X	X	X	X	X	X	X	X	X	X
		I	CTS 5K	X	X	X	X					X	X	X	X
		J	CTS 100K (HP100)	X	X	X	X					X	X	X	X
_____	*POTENTIOMETER*	K	CTS 100K (TRS-100)	X	X	X	X					X	X	X	X
		L	CTS 140 (HP140)	X	X	X	X					X	X	X	X
		P	NEI CRV-16 5K	X	X	X	X	X	X	X	X	X	X	X	X
		T	NEI MKIII 5K	X	X	X	X								
		U	NEI MKIII 10K	X	X	X	X								
		W	Without Pot	X	X	X	X	X	X	X	X				

NOTE:
(1) X Denotes availability of features.
(2) Customers desiring assemblies other than those listed should contact factory.
(3) Example:
S10A01B = Standard Joystick, 2-axis, Nylon Plastic, Round Bezel, Spring Centering, Stick Tip 600-021, Without Trim, 5K Clarostat Pot.

*Additional Charge (see pricing information)



Burgess

Joystick Controllers

Multi-directional, multi-pole switching assemblies consisting of Burgess Miniature or Sub-Miniature Micro Switches actuated by the manual movement of a single column. They offer positive, convenient, space-saving control in many industrial situations; suitable assemblies, for example, are available for use on machine tools and presses, fork-lift trucks, cranes and earth-moving equipment, bus doors and railway signalling. Available facilities include momentary and latch-in action, and a safeguard against accidental operation.

Ordering References

The ordering references of 40 standard assemblies are tabulated overleaf. Ordering references consist of the range symbol 'J' followed by eight digits which describe the facilities provided in the following manner:

Typical Ordering Reference: J74, 321, 213

- 1st digit: mounting plate size:
  7 = ⌀ 60 mm
- 2nd digit: number of gates
  2 = 2 gates at opposing points
  4 = 4 gates at 90° intervals
- 3rd digit: number of Micro Switches per gate
- 4th digit: type of action
  1 = Momentary
  2 = latch-in
- 5th digit: type of operation
  1 = normal
  2 = lift to operate
- 6th, 7th and 8th digit: type of Micro Switches fitted. E.g.–
  113 = Burgess VCSP
  213 = Burgess V4T7

The Range

All assemblies in the standard range conform to the same general design but differ in respect of the switching and operational facilities incorporated. The composition of each assembly is indicated in the table overleaf.

Insert Switches

Two types of Burgess Micro Switches are used in Joystick Controllers:
V4T7 – sub-miniature units. Maximum current rating 5 Amperes.
VCSP – miniature units with maximum current rating 10 Amperes.

Refer to back page for full details.

Gates

Assemblies are available with either two or four gates, into which the control column may be moved from its central 'off' position. Two gates are arranged opposite each other (i.e. North and South) and four gates are arranged at the cardinal points.

Switches per Gate

One, two or three sub-miniature Micro Switches V4T7 or one or two miniature Micro Switches VCSP may be mounted at each gate. When two or more switches are fitted they are actuated sensibly together when the control column is moved into the gate.

Action Either **momentary** or **latch-in** assemblies are available. With the former facility, the control column will remain at a gate only so long as it is held there. The latch-in facility means that the control column will remain engaged at a gate until it is manually released. In both cases, when the control column is free to move it is biased towards the central 'off' position.

Operation Choose assemblies with either **normal** or **lift** operation. With the former the control column will move without hinderance into any gate. The latter provides a safeguard against accidental operation; the control column must be lifted before it can be moved into any gate.

Sealing All units are panel sealed by virtue of a neoprene cowl and an 'O' ring under the bezel.

Joystick Controllers Schedule

V4T7 Sub-miniature

Number of Gates	Switches Per Gate	Type of Operation	Ordering References Momentary-Action	Ordering References Latch-in Action
2	1	Normal	J72, 111, 213	J72, 121, 213
		Lift	J72, 112, 213	J72, 122, 213
	2	Normal	J72, 211, 213	J72, 221, 213
		Lift	J72, 212, 213	J72, 222, 213
	3	Normal	J72, 311, 213	J72, 321, 213
		Lift	J72, 312, 213	J72, 322, 213
4	1	Normal	J74, 111, 213	J74, 121, 213
		Lift	J74, 112, 213	J74, 122, 213
	2	Normal	J74, 211, 213	J74, 221, 213
		Lift	J74, 212, 213	J74, 222, 213
	3	Normal	J74, 311, 213	J74, 321, 213
		Lift	J74, 312, 213	J74, 322, 213

VCSP Miniature

2	1	Normal	J72, 111, 113	J72, 121, 113
		Lift	J72, 112, 113	J72, 122, 113
	2	Normal	J72, 211, 113	J72, 221, 113
		Lift	J72, 212, 113	J72, 222, 113
4	1	Normal	J74, 111, 113	J74, 121, 113
		Lift	J74, 112, 113	J74, 122, 113
	2	Normal	J74, 211, 113	J74, 221, 113
		Lift	J74, 212, 113	J74, 222, 113

Construction Data The main frame moulding, which houses the mechanism and on which all the switches are mounted, is made of tough glass reinforced plastic. A plated steel control stick, capped by a substantial plastic knob, passes through a flexible cowl and internally-threaded bezel and on through an aperture in the externally-threaded mounting boss. Within the mechanism is a spherical pivot which, in conjunction with the gate moulding, defines the movement of the stick.

Other components impose a centralising action and also, if required, a latching action can be specified.

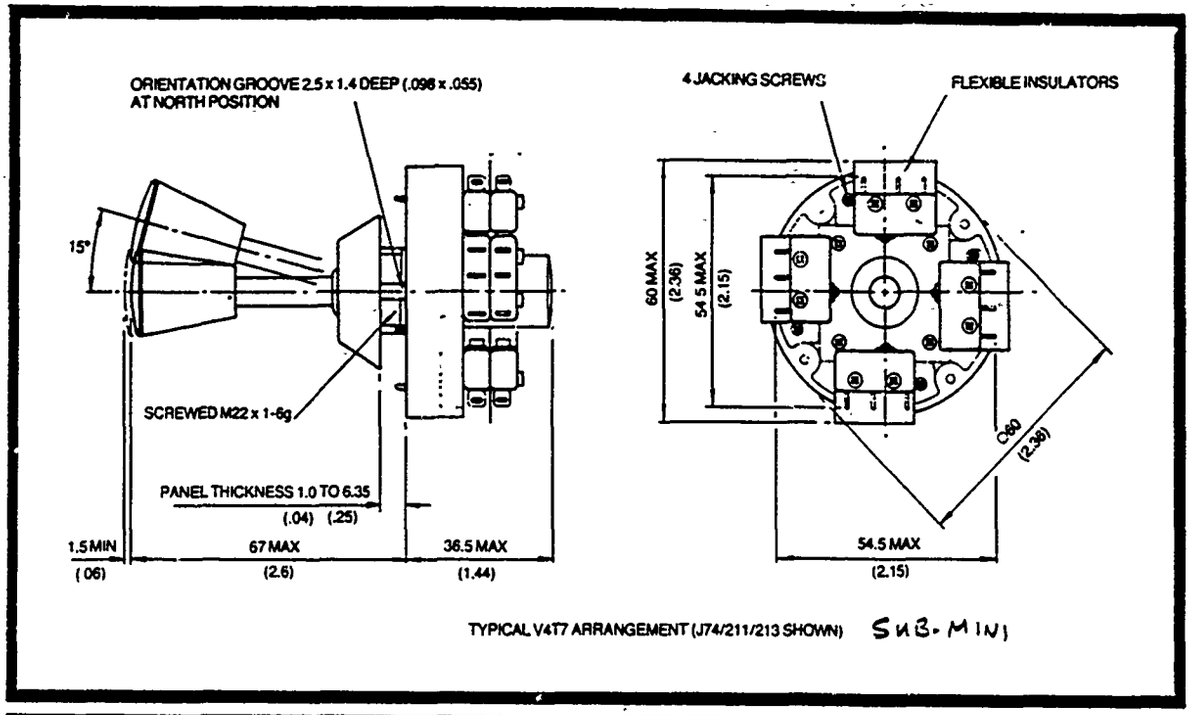
At the back of the unit, the stick is surrounded by a cylindrical actuator moulding. Movement of the stick causes the actuator to be displaced sideways, the curved outer surface of which serves to depress the switch plungers to achieve the required switching function.

Full sealing across the mounting panel is achieved by the convoluted elastomeric cowl around the stick and an 'O' ring fitted to the underside of the bezel.

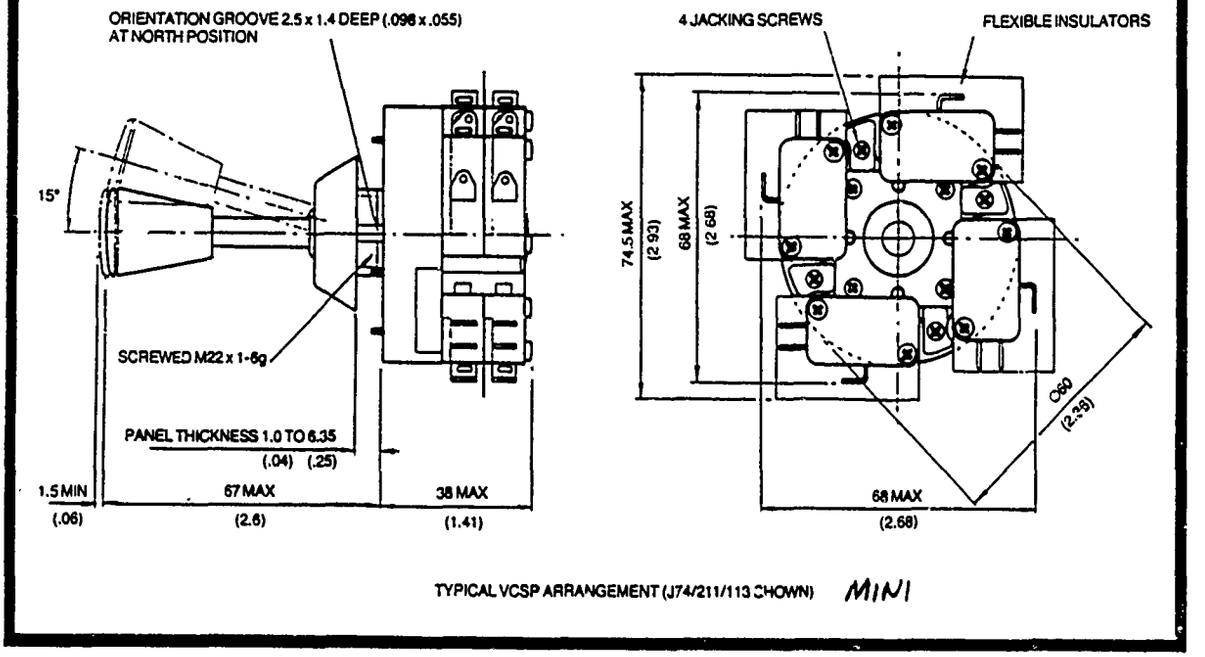
Mounting facilities are completed by four jacking screws in the main frame moulding.

Further Options Assemblies can be made available with many different options including silicone rubber cowls and 'O' rings for use at temperatures down to −50°C; one or three gates in lieu of the standard two or four; a full 'stirring action' in which no gates are provided and the control column will operate two gates simultaneously in the 45° positions. Latching action can also be specified in any of up to four directions. Furthermore, the assemblies may be fitted with a variety of insert switches including the V4S (a sealed variant of the V4T7), the E2V3S (a BASEEFA Zone 2 variant of the VCSP), the E1V3C (a BASEEFA Zone 1 variant of the VCSP) and combinations of the VCSP giving a sequenced operation at each gate.

Burgess should be consulted about these or other variants.



TYPICAL V4T7 ARRANGEMENT (J74/211/213 SHOWN) SUB-MINI



TYPICAL VCSP ARRANGEMENT (J74/211/113 SHOWN) MINI

Installation & Service Data

Mounting Recommendations

All assemblies are suitable for panel mounting and require a single hole of 22.5 mm (0.89 in) diameter. The screwed boss should be inserted through this hole from behind the panel. The bezel should be screwed onto the boss until it is finger tight. Screw in the four jacking screws, moving each one in turn a little at a time in order to maintain equal pressure. In this way they not only provide a panel thickness adjustment but they also lock the assembly to the panel in a secure fashion. Finally, the plastic knob is fitted by slipping over the control stick and pushing firmly into position.

Connections V4T7 and VCSP Micro Switches are provided with solder tag terminals, pointing outwards for easy accessibility. When soldering avoid overheating any part of the switch case or insulation.

Temperature Range Continuous working recommended limits are −10° and 70°C.

Mechanical Life . In excess of 500,000 operations.

Service Recommendations Keep reasonably clean and free of paint, especially around the Micro Switches.

Insert Switches

The two types used in the standard range of Joystick Controllers are both single-pole, changeover models exhibiting the desirable properties of a long mechanical life and snap-action even under conditions of slow plunger actuation.

V4T7 Sub-miniature switch with solder tag terminals. Environmental protection of the mechanism is generally in accordance with IEC Code IP40. Approvals include BEAB, CSA, DEMKO, NEMKO, SEMKO, SEV, U.L. and VDE – apply for details.

VCSP 'V3' miniature switch with solder tag terminals. Environmental protection of the mechanism is generally in accordance with IEC Code IP40. Approvals include BEAB, CSA, DEMKO, NEMKO, SEMKO, SEV, U.L., and VDE – apply for details.

Recommended Maximum Current Ratings

Current in Amperes
NO = Normally Open
NC = Normally Closed Terminals

V4T7 Switch SUB-MINI

Voltage	Resistive Load	Tungsten Lamp Load NC – NO	Inductive Load
AC			
125	5	0.5 0.5	5
250	5	0.5 0.5	5
DC			
Up to 15	10	3 1.5	10
30	5	3 1.5	3
50	1	0.7 0.7	1
75	0.75	0.5 0.5	0.25
125	0.5	0.4 0.4	0.06
250	0.25	0.2 0.2	0.03

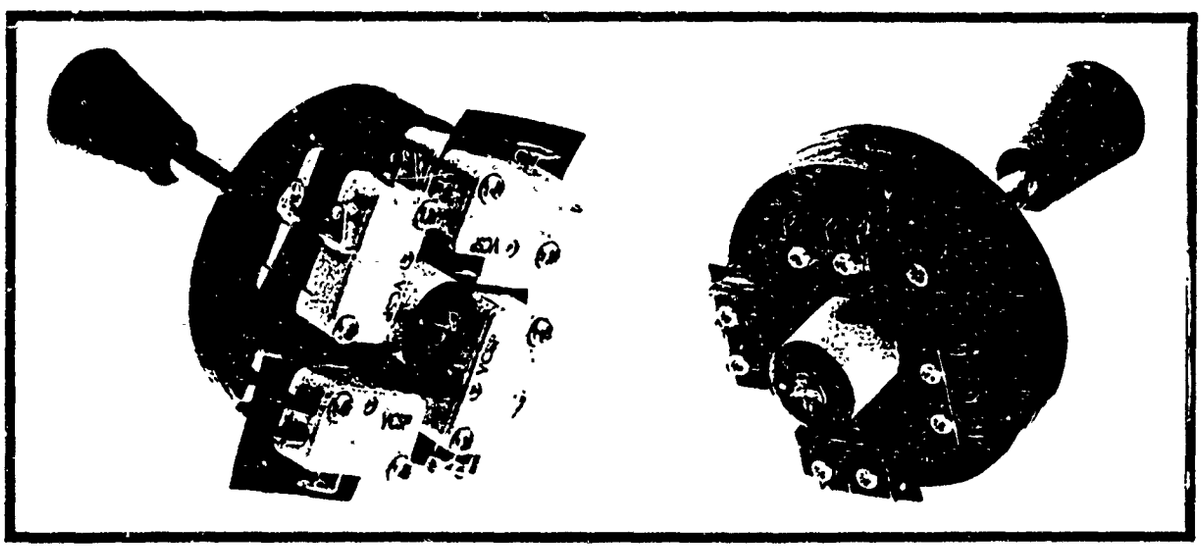
VCSP Switch MINI

Voltage	Resistive Load	Tungsten Lamp Load NC – NO	Inductive Load
AC			
125	10	2 1	10
250	10	1.5 1	10
DC			
Up to 15	15	3 1.5	15
30	10	3 1.5	10
50	3	0.8 0.8	2.5
75	1	0.6 0.6	0.5
125	0.5	0.5 0.5	0.07
250	0.25	0.25 0.25	0.03

Cross References

Push Button Switching Assemblies, with plain buttons or illuminated screens – see Burgess Micro Switch Digest, page 9.

It is intended that Burgess General Information Sheet DS100 should be read in conjunction with this Data Sheet.



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