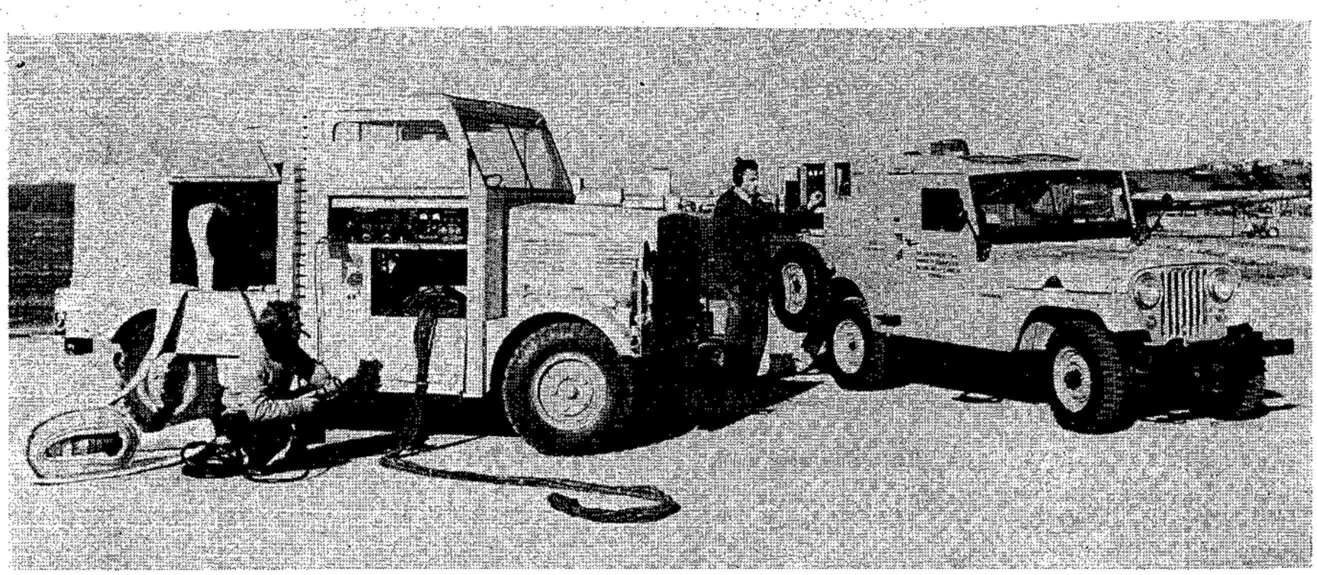

FOR THE CF-105. On the left, the electronics and fire control system servicing unit, and right, the engine starting jeep. Latter will be used initially for the J-75's and later for the Iroquois engines to be fitted to the production models of supersonic Arrow 105.

Avro Arrow Ground Support

Increases in complexity of our modern weapons' systems Mean new problems for designers of auxiliary equipment

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Importance of adequate ground support in the overall weapons system concept is widely recognized.

Among many services ground support vehicles must provide are engine starting, standby power, electrical and hydraulic power for ground checkout and trouble shooting of various aircraft components and systems, air conditioning of various components aboard the aircraft, refueling, towing, etc.

These are the ground support requirements which Consolidated Diesel Electric Corp. of Canada, Ltd., has built into two new vehicles designed as part of Avro Aircraft's CF-105 Arrow all-weather interceptor weapons system.

Preliminary design of these vehicles was begun early in 1956 in co-operation with Avro Aircraft, Ltd. As a result of several discussions with Avro's logistics engineers, proposals for a starter vehicle and an electrical servicing-air conditioning vehicle were presented to the aircraft manufacturer. These proposals and studies made by Avro were eventually incorporated in definitive specifications, which were issued for competitive bidding in the summer of 1956. Consolidated was awarded the contracts as a result of this competition.

The decision to supply two vehicles, rather than one which would combine the services of both, was based on several considerations.

One combined vehicle would have been an extremely large and heavy piece of equipment. This would have presented problems in handling around the aircraft, transportation by air, etc.

Dividing the functions between two vehicles would permit greater utilization of the equipment since power for servicing and starting would not always be required by the same aircraft at the same time.

Where possible the same equipment has been used on both types of vehicle, reducing the spare parts requirement and the number of new types of equipment with which maintenance personnel must become familiar. Among the interchangeable items on the vehicles are the gas turbine compressor, DC generator system, comfort heaters, flexible air ducts, batteries, various meters.

Proven Components

Another factor which should result in high utilization without excessive maintenance is the use of components which have been fully developed and are in general service. While most of these components have been modified to some extent for this application, service life and performance of the basic item has been demonstrated in the past. Typical are the automotive chassis, the AC and DC generators, the heater, the gas turbine compressor, valves.

Much of this servicing equipment is basically the same as that developed by Consolidated's parent organization for the U. S. Navy and Air Force.

The electrical servicing-air-conditioning unit was built up on an extended version of a chassis originally designed for U. S. Air Force and in large scale service with that organization as the MA-2 multi-purpose servicing unit.

This is a heavy duty truck type chassis manufactured at Consolidated's plant in Stamford, Connecticut. A Ford V-8 industrial engine is used as the prime mover. A special four-forward-speed transmission provides either rear axle or four-wheel drive. An all weather cab is provided for the driver.

For the Arrow application the wheel base was increased to 108 inches and the frame was lengthened approximately 12 inches at the rear. This modification greatly simplified the installation of the servicing equipment, permitting excellent accessibility of all components for maintenance purposes. The automotive electrical system operates on 24 volts DC.

The servicing equipment installed

on this unit includes an industrial type 30 kva, 120/208 volt, 400 cycles per second, three phase alternator, gas turbine compressor, two air cycle refrigeration machines, distilled water tank and inter-com equipment. In addition two electrical output cables and a flexible air duct are installed for carrying the vehicle's services to the aircraft.

The alternator is installed in a housing directly behind the cab. It is driven from a power take-off on the transmission through a two-step chain drive. The alternator is mounted on a pad on the chain drive case.

The chain drive is actually two separate components. The input half has its sprockets so sized in relation to the output speed of the power take-off and the sprocket ratio in the rear half of the drive, that generator speeds of either 3,428 rpm or 6,000 rpm can be obtained, depending upon which end of the case is used for the input end. Thus either industrial or aircraft generators can be used with this chain drive.

The chain drive used on this equipment is identical to the drives used on U. S. Air Force and Navy equipment, and is capable of providing several thousand hours of service.

DC Supply

The DC supply is obtained by rectifying output of a small alternator. The complete system comprises the alternator, an air-cooled rectifier and a voltage regulator.

The system was originally developed for the U. S. Army Signal Corps as a high output engine driven DC power source for mobile communications equipment. The Signal Corps has used this equipment in military jeeps and light trucks with considerable success.

The gas turbine compressor is a U. S. Air Force MA-1A self-contained unit, installed at the rear of the chassis. Modifications had to be made to this unit to integrate its control system with the air conditioning controls and to improve accessibility to some components and external connections.

This unit can provide approximately 120 pounds per minute of uncontaminated air at a pressure of 50 psia at temperature 370°F. on a standard 59°F. day at sea level. The basic unit is manufactured by Airesearch Manufacturing Company of Phoenix, Arizona. It is installed on all Consolidated's U. S. Air Force MA-2 vehicles.

The bleed air obtained from the GTC is ducted to two Airesearch air cycle refrigeration units, modified to Consolidated's specifications from B-47 units. These air conditioning units are located in the same housing as the 30 kva alternator, directly behind the cab.

Controls for the various components are installed in the right side of the cab, accessible from outside of the unit. The AC controls are contained in one box, with the DC and air conditioning controls in a second box. An inter-com unit is located alongside the control boxes, and a second inter-com unit is installed inside the cab for use by the driver.

A 15-gallon distilled water tank is located in the cab, directly below the control boxes. It is designed so that the water can freeze and thaw repeatedly. Exposure to —65°F is permissible without failure or leakage.

While no provision has been made for melting ice, sufficient heating can be provided to maintain water temperature at +60° in an ambient temperature of —20°F, provided the water is initially at +60°F. This water is required to top off the tank in the aircraft's evaporative cooling system.

Two servicing cables and a flexible air duct are provided, stowed in the generator housing.

One cable carries the 400 cycle AC and the DC to a receptacle on the aircraft. The second cable is used for the inter-com connection to the aircraft.

The air duct, 3½ inches inside diameter, was originally developed for use with pneumatic starting systems operating at pressure of about 50 to 60 psi at temperatures to 450°F. Normally a larger diameter duct, up to eight inches diameter, is used for delivering cooling air to an aircraft. Use of the small diameter duct was dictated by the limitation on the size of the cut-out which could be provided in the aircraft skin for this purpose.

The servicing unit was designed primarily for checking out electronics installations in the Arrow.

When this equipment is operating considerable heat is created. A steady supply of cooled air must be provided to keep the equipment at a reasonable temperature. Should the supply of cool air be interrupted extensive damage to the electronic equipment might result. For this reason, controls for the AC output, gas turbine compressor and air conditioning equipment have been tied together to provide a fail-safe system. It is impossible to deliver AC to the aircraft until the air conditioning system has been placed in operation.

In addition, thermal switches in the conditioned air duct will interrupt the AC output and shut off the supply of bleed air from the gas turbine compressor if the air temperature rises to 94°F.

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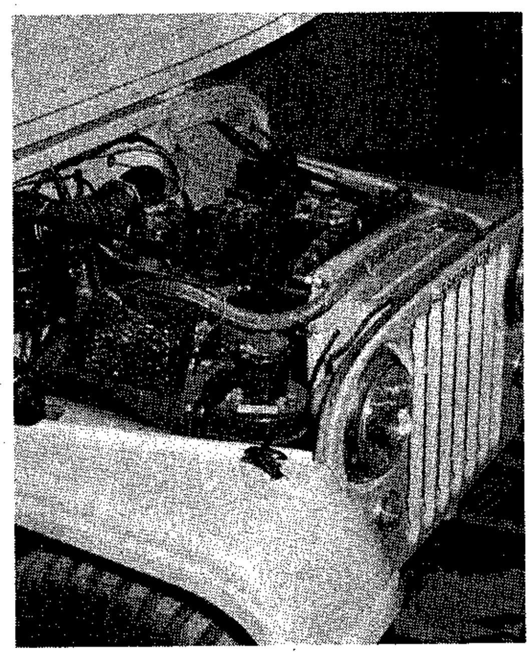
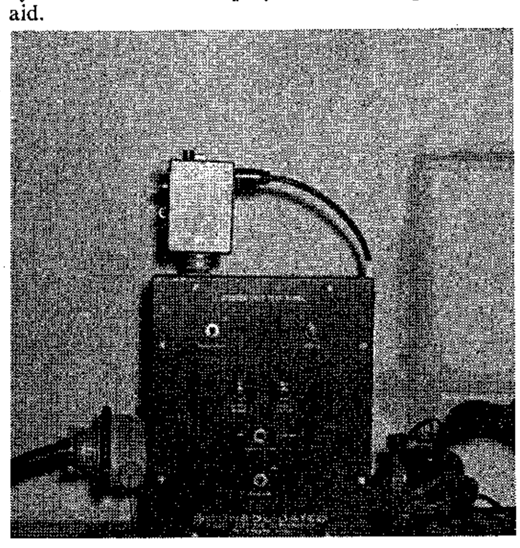
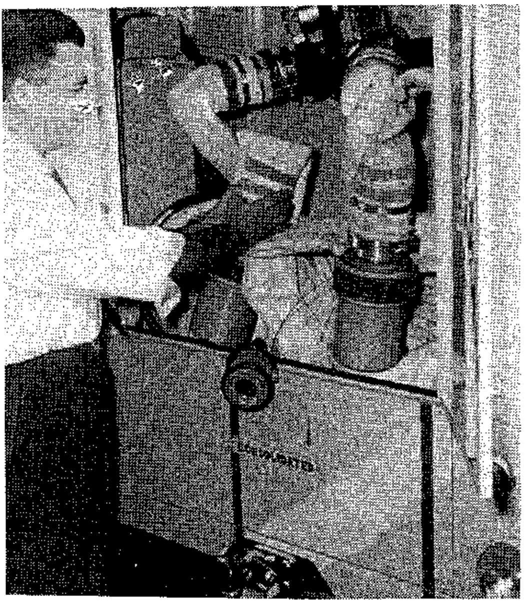
CONTROL PANEL of the starter jeep. Intercom is provided between unit and pilot during starting operation.



MODIFICATIONS to the jeep included fitting of new generator system and a powerful personnel heater in the engine compartment. Pictured below, the compact

TEST PANEL used to check operation of starter unit prior to plugging into the aircraft. Device simulates engine start cycle and can be employed as training aid.





STARTER unit rear housing with bleed air ducts, servicing cable coupling, and air valves. Pictured is Manny Lenkowsky, author of this article.

Ground Support

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Operating procedure for this vehicle is quite simple. Once the cables and air duct have been plugged into the aircraft, the generator drive is engaged by means of the power take-off on the transmission. The engine manual throttle, located on the automotive instrument panel in the cab, is then pulled out. When the throttle is in the full out position a governor takes over and maintains engine speed constant throughout the range from no load to full load.

Next step is starting the gas turbine compressor. To do this only the master switch and start switch are operated. The start and acceleration to operating speed are automatic once the start switch has been operated. A start is normally made in less than 30 seconds.

When the GTC has reached operating speed the bleed air valve can be opened by operation of the "Load Valve" switch on the GTC instrument panel. Placing the air conditioning switch in the on position will admit bleed air to the air cycle machines and cooled air will be supplied to the aircraft.

A temperature regulator, triggered by a pick-up in the cooled air output duct, will maintain a pre-set temperature by opening a modulation valve and mixing hot bleed air with the cooled air as required. The amount of hot bleed air mixed with the cooled air depends on the ambient air temperature. On the Arrow equipment the output temperature is set at 60°F.

As previously mentioned, a thermal switch in the output air duct will shut down the system outputs if the air temperature reaches 94°F. To permit starting the equipment when the ambient temperature is above 94°F a time delay has been incorporated in the thermal switch circuit. As an added safety feature it is not possible to close the AC output contactor until the time delay relay has cycled, bringing the over-temperature protection into operation.

Starter Unit

The starter unit is built up on a special jeep chassis manufactured by Willys Motors to Consolidated's specifications. It would have been uneconomical to use the same chassis for this unit as for the servicing unit, since the starter unit does not carry as much equipment.

The engine in this vehicle is a standard jeep engine with special 24 volt electrical equipment. A mechanical governor is installed, and the setting of the governor can be regulated by a control on the automotive dash panel. For normal driving, the governor can be inactivated by pushing the control full in. When the governor control is pulled out the engine speed is maintained at approximately 2,000 rpm.

The DC power supply in the starter unit is the same as in the servicing vehicle. However, in the starter unit the generator is belt-driven from the engine, replacing the standard Willys generator. In the starter unit the output from the DC system is used to supply the normal automotive load, such as battery charging, in addition to supplying the power for the gas turbine compressor, inverter, aircraft engine controls and inter-com.

The gas turbine compressor is installed on the vehicle directly behind the cab. The GTC is completely interchangeable with the GTC on the servicing unit.

Bleed air from the GTC is taken to a "Y" duct, the stem of the "Y" being connected to the GTC output valve. A valve is mounted on each branch of the "Y", operated by a 28-volt electric motor. These valves were developed for this application and will open or close in ½ second. A 45 ft. long flexible air duct, similar to the conditioned air duct on the servicing unit, is clamped to the output side of each valve.

The two air hoses and the electrical output cable are contained in a separate housing at the back of the unit. The "Y" duct and valves are also in this housing. On the right side of the housing is the control panel containing the AC and DC meters, circuit breakers and output switches. A 500-volt-ampere, 115-volt, 400 cycles per second, single phase, aircraft type inverter is installed below the control panel in the rear housing.

An inter-com unit is located below the control panel, providing communications with the aircraft crew. A second inter-com is provided in the vehicle cab.

The electrical cable was manufactured specifically for this application and is made up of nine separate conductors. The inter-com audio and AC conductors in the cable are shielded to eliminate interference and noise pick-up. A polyvinyl chloride outer casing protects the cable. The casing will remain flexible at —65°F.

In making a start, the DC is fed out to the aircraft through the cable, energizing the engine control circuit. The pilot has two engine start switches, one for each engine. Operating the left engine start switch operates the port valve on the "Y" duct in the starter unit, admitting air to the left engine sarter. Once the left engine is started the switch is returned to the off position, closing the valve. The same cycle can then be repeated to start the right engine.

To prevent cross-connecting the air ducts they have been color-coded and placarded. In addition to its use for starting, this unit may also be used for inhibiting the engines. For this purpose over-ride switches are installed in the starter unit to operate the two valves.

To ensure proper sequencing of components on the starter unit, a special test panel has been fabricated. Using this test panel it is possible to simulate a complete engine start cycle, with selector switch for either port or starboard engine. This will provide a positive check against cross-connection of control leads and will also be of use as a training device. In addition it is possible to mount an inter-com unit on the control panel to check out inter-com operation.

In preparing specifications for these vehicles, Avro included the requirement that they comply with military specifications covering such things as radio noise suppression, ability to operate under adverse environmental conditions, air transportability. The units meet these requirements satisfactorily.

If required the vehicles can be quickly converted for operation at —65°F by addition of simple winterization kits.

Over-all, the units are examples of the requirement for custom design and development to meet highly specialized needs for aircraft ground support equipment.