



**Roscommon
Equipment
Center**

PROJECT NO. 2

WIRING CONVERSION ON MILITARY VEHICLES

Sept. 1973

Revised Sept. 1981

Revised for Web Page June 1998

NORTHEAST FOREST FIRE SUPERVISORS

WIRING CONVERSION ON MILITARY VEHICLES
ROSCOMMON EQUIPMENT CENTER
PROJECT NO. 2

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INTRODUCTORY REMARKS

Military vehicles, having 24 volt electrical systems, are being used in increasing numbers by many fire organizations throughout the country. This report attempts to provide usable information for modifying or converting the 24

volt system to a 12 volt system.

With few exceptions a 12 volt system is more desirable because of the availability of 12V accessories for civilian use.

PROBLEM

The 24 volt electrical systems on military units are incompatible with added 12 volt accessories such as:

1. Lights (head, tail and stop, clearance)
2. Turn signals and 4-way flashers
3. 2-way radios
4. Electric rewind hose reels
5. Electric start pump engines
6. Sirens
7. Emergency beacons
8. Miscellaneous other accessories.

OBJECTIVES

1. Investigate and develop methods of providing 12 volt energy for accessories on vehicles equipped with 24V electrical systems.
2. Provide cost figures for each method.
3. List advantages and limitations of each.
4. Provide detailed drawings and diagrams of electrical circuits where desirable.
5. List conclusions and the preferred methods.

DESCRIPTION OF 24 VOLT ELECTRICAL SYSTEM NORMALLY USED ON MILITARY VEHICLES

The normal components of the 24V system are two 12V storage batteries connected in series, a 24 volt generator, a generator regulator and an assortment of wire conductors connected to the various loads of the system such as lights, ignition system, and starter. At the risk of over describing these components, a closer look at some of them may be warranted.

Batteries.

Batteries in the 24 volt system are connected in series, that is, the positive terminal of one battery is connected to the negative terminal of the other. Because they are connected in series, the voltage of the two 12 volt batteries add to each

other producing a potential of 24 volts. If the 12 volt batteries were connected in parallel, positive terminal to positive terminal, their total voltage would still be 12 volts. The series and parallel connections are discussed further in another part of this report referred to as "Series-Parallel Switch".

Battery Removal and Installation. Be sure polarity of batteries is maintained. Failure to connect the batteries as they were originally intended can result in serious and costly damage to the generator and generator regulator.

Disconnect the battery ground cable when

working on any part of the electrical system. Disconnect the ground cable before fast charging the battery in the vehicle. When removing the battery, disconnect the battery ground cable first. When installing the battery, wait until last to connect the ground cable.

Maintain Electrolyte Level. Underfilling causes the electrolyte to become too concentrated, making the plates deteriorate more rapidly. The low level also exposes the tops of the plates, which harden and become chemically inactive.

Overfilling. This causes electrolyte to spill out, corroding the battery parts and cell covers. Normally water is the only part lost from battery electrolytes. This loss of water generally is due to evaporation, especially in hot weather and while charging battery.

Overcharging. Overcharging causes a loss of water in the cells by separating the electrolyte into hydrogen and oxygen gases. Overcharging causes the battery to heat up inside and oxidates the positive plate grids, resulting in a loss of cell capacity and early failure. If a battery uses too much water, check it for overcharging.

<p><i>WARNING!</i> The hydrogen gas being released from a battery is highly explosive and precautions should be taken to ventilate the area around the battery and to guard against any sparking that might ignite this gas.</p>

Undercharging. A battery which stays undercharged will become sulfated. The sulfate normally formed on the plates will become dense, hard, and chemically irreversible if allowed to remain on the plates for long periods. The lowered specific gravity levels also make the

battery more likely to freeze in cold weather.

Generator and Generator Regulator.

The generator and generator regulator work together to produce 24 volts. During normal operation the generator supplies all current and recharges the batteries. During peak operation, batteries help generators to supply current. During starting, batteries supply all load current.

The generator regulator limits the amount of voltage and amperage to that level for which the electrical system was designed. It also prevents overcharging of the batteries and disconnects the generator from the batteries when the engine is not running. If batteries were not disconnected, current would flow through the generator to ground which would discharge them.

The generator regulator cannot prevent overcharging of one of the two 12 volt batteries connected in series if there is an imbalance in the charge of the two batteries. This process is also discussed in another section of this report. An imbalance between two batteries does not automatically level off when they are connected in series. Batteries connected in parallel can level off, and current taken from them is equally divided between the two. The best way to prevent an imbalance in the level of the batteries is to balance the load on them.

A 24 volt system gives more cranking power to the starter and provides better starting under extreme conditions. This advantage is probably offset by the many disadvantages encountered in civilian use of military vehicles. In particular, ready availability of 12 volt accessories used for normal civilian use.

SYSTEMS CONSIDERED IN THIS PROJECT

- A. Complete exchange of electrical system from 24V to 12V.
- B. Utilization of one of the two 12 volt batteries.
- C. Installation of an additional and separate 12 volt system.
- D. Series-Parallel Battery Switch system.
- E. Balanced Load system.
- F. Installation of an additional 12 volt battery.
- G. Other methods known to be possible but not investigated.

A. Complete Exchange of Electrical System from 24V to 12V

A complete exchange of all of the 24 volt systems components is possible but cost may be prohibitive. No attempt has been made to establish such cost but it would involve replacing the following items:

- 1. Generator
- 2. Generator regulator
- 3. Starter and solenoid switch
- 4. Ignition components
 - a. distributor condenser
 - b. spark plugs
 - c. coil
- 5. Electric fuel pump (on some unit)
- 6. Dashboard instruments and gauges
- 7. Lights
- 8. Electrical controls used on some units to shift drive train components.

On some simple military units such as Jeeps, it may be practical to exchange the major components. This would be especially true if one or more of the original 24 volt components were defective. However, on most of the larger military vehicles a complete exchange would be a major undertaking.

It is not known if a 12V engine starter motor would be available. The starter mounting and drive mechanism must interchange with the original 24V unit and each make of vehicle and engine would have to be investigated separately.

Some consideration can be given to retaining the 24V starter and using a series-parallel relay switch such as that described in the Series-

Parallel section, for 24 volt starting only. Except for starting, all other items could be 12 volt.

B. Utilization of One of the Two 12 Volt Batteries

Diagram #496 shows a 12 volt circuit taken directly from one of the two 12 volt batteries, in a 24V system, to supply current to 12 volt accessories. While this system is very simple and inexpensive, it is very limited. If the 12 volt load is small, this system is usable with certain precautions.

It must be recognized that any current taken out of one battery at a rate unequal to that taken from the other battery will create an imbalance between the two batteries. The battery that has a lower level (specific gravity) of charge will call for current from the generator which will result in overcharging the higher level battery.

To prevent overcharging of the one battery, the operator must frequently rotate the batteries to alternate the 12 volt load. The operator can check the battery charge level with a hydrometer. When the hydrometer shows a fully charged battery, it would be exchanged with the other battery.

As shown on Diagram #496, 12 volts can be taken only from the battery closest to the electrical ground.

The problem of overcharging and the imbalance between the two batteries should not be minimized. Not only is the life of the overcharged battery appreciably shortened, but the other battery charge can drop so low that the total 24 volt system can become ineffective.

In summary, except for very light duty and units which are not used often, this system should not be used. It is entirely unreasonable to use this system when heavy drain 12V accessories are used.

C. Installation of an Additional and Separate 12 Volt Electrical System

If an additional 12 volt system is added, all 12 volt accessories can be operated independently

of the 24 volt system.

All of the major components of the 24 volt system may be used as originally intended. The engine starter, ignition system, generator, generator regulator, and the two 12 volt batteries connected in series can continue to function as original equipment. The vehicle's 24V lighting system may be transferred to the 12V system or left on the 24V system.

Any additional 12 volt loads such as lights (including head, tail, stop and turn, clearance, emergency beacon), 2-way radios, electric rewind hose reels and electric start pump engines can be connected to the separate 12 volt system. The separate 12 volt system's components include a 12V generator or alternator, a regulator, and a 12V storage battery.

Included in this project was the actual installation, and the testing of a complete and separate 12 volt system, on a GMC 6X6 military 2-1/2 ton truck that was converted to a water tanker. Drawings and specifications of the alternator mounting and drive components are included in this report.

An alternator was used for this particular installation, but a generator would work as well. The mounting bracket and drive components, designed for the alternator, can be modified to fit a generator.

An alternator (automotive type) was used because of its compact size and because they have been used almost exclusively in automotive applications. The small physical size of the alternator is a definite advantage where mounting space is at a premium. However, because an alternator needs an outside source of current to excite its magnetic field before it can produce current, the electrical connections are somewhat more complicated than a generator system. Two requirements that must be met for alternators are:

1. The alternator must not be run when it is disconnected from its charging circuit.
2. Current from the battery must be supplied to the field of the alternator before it can generate current.

To fulfill these two requirements, a relay connected to the ignition switch must be used.

The relay should be a single pole-single throw with a 24V coil. When the ignition switch is closed to start the engine, it supplies the relay coil with 24 volts. The relay contacts close, completing the 12 volt circuit between the 12 volt battery and the alternator. This prevents the alternator from being driven by the vehicle engine when it is not connected to its charging circuit and also supplies current to excite the alternator fields.

Diagram #494 shows the necessary connections between the alternator and the regulator. It is desirable to use the same type of connectors normally found in automotive electrical circuits. These connectors are molded rubber plugs that have the necessary wires secured to them. The plugs are made to prevent improper connections, that is, they can only be installed in the correct relation to the proper component. If these plug connectors are not available, the circuit can be completed with conventional terminals but they must be identified by colors, numbers, etc. to prevent incorrect connections.

Alternators driven by conventional engines used in trucks, cars, Jeeps, etc. have a drive ratio of about 1:2. This means that the alternator RPM is twice as great as the engine RPM.

When adding a 12V generating system, it is desirable to have the alternator drive sheave installed directly on the end of the engine crankshaft. Drive sheaves can be installed on existing generators, fan and water pump shafts, or air compressors, but this imposes an additional load on the drive belts and bearings of these components that was not originally intended. This may reduce the life of the belts and bearings.

Drawing #B-407 gives detailed information about mounting a drive sheave directly on the engine crankshaft of a GMC 6X6. Note that this drive sheave must be specially machined to fit the crankshaft. Similarly, drive sheaves for other vehicles must be designed and machined to fit each specific crankshaft. A special sheave may also be necessary if it is attached to any other driving shaft. To determine the diameter of a drive sheave, all intermediate drive ratios must be considered. For example, if a drive sheave is connected to the existing 24 volt generator shaft, which already runs twice as fast as the engine, a one to one ratio would be correct.

All information related to the alternator drives would also apply to a generator.

All electrical loads except the heavy drain accessories, such as an electric motor for hose reels and engine starters, are supplied current, more or less directly, from the alternator. During peak operation the battery helps the alternator supply current. When heavy drain accessories such as electric motors and starters are in use, all of the current is supplied from the battery. These heavy drain accessories require large cables to carry the current from the battery.

It is desirable to locate the battery close to the heavy drain accessories to eliminate long runs of heavy cable conductors. A much smaller wire conductor from the alternator to the battery (charging circuit) can be used making it feasible to locate the battery a considerable distance from the alternator.

REC Newsnote #9 is an updated look at adding a separate 12 volt system to an existing 24 volt system. It is included in Appendix B.

D. Series-Parallel Battery Switch System

The primary purpose for using the series-parallel switch, as shown in Diagram #490, is to automatically connect the two 12 volt batteries in parallel to provide 12 volts to heavy drain, intermittently used accessories such as electric rewind hose reels and electric start pump engines. The two 12 volt batteries are normally connected in series, which provide 24 volts, on military vehicles.

When the batteries are connected in parallel, they supply 12 volt energy to the accessories equally from each battery. It is important that the accessory being used drain the 12 volt batteries equally to maintain balanced levels. Imbalanced battery levels can lead to overcharging of one of the two batteries connected in series. The components of the circuit, Diagram #490, are as follows:

1. Orpin series - parallel (S-P) switch Model C manufactured by Automatic Battery Corporation of America, 102 S. Bright Street, Goldsboro, NC

Special attention should be given to the fact that this series-parallel switch is primarily sold to be used with vehicles with 12 volt

systems to provide 24 volts to the engine starting system. The S-P switch in Diagram 490 is used in just the opposite manner. It is intended to drop 24 volts down to 12 volts. The S-P switch requires a slight modification before it can be used in this manner.

- a. The jumper wire between terminals #2 and #4 must be removed.
- b. The red and green insulated wires should be connected to terminal #3.

An instruction and installation booklet is supplied with each S-P switch when purchased. This booklet should be used as reference material only. Diagram #490 should be followed exactly to avoid possible damage to the electrical circuit.

2. A selector switch - DPDT toggle switch
3. One solenoid switch for each accessory - single pole, normally open, continuous duty w/12 volt DC coil common to case (note: this item is commonly used in starting circuits of automobiles and is usually supplied with electric rewind hose reels).
4. One momentary push switch for each accessory - normally open and grounded to frame when closed.
5. One heavy duty power relay such as Potter & Brumfield Type PR5DY SPDT w/12V DC coil.

The series-parallel switch and circuit (Diagram #490) functions as described in the following example.

A 6X6 military truck converted to a water tanker, with a 24 volt system, has a 12 volt electric rewind hose reel and a 12 volt electric start water pump. The two 12 volt batteries are connected in series to produce 24 volts potential.

When the operator wishes to start his pump engine or hose reel, he pushes the momentary push switch which completes the coil circuit of the series-parallel switch and automatically connects the batteries in parallel (positive to positive and negative to negative). As long as

the operator holds the push switch closed, the batteries are connected in parallel producing 12 volt potential to the solenoid relays of the reel and pump starter.

A selector switch between the push switch and the S-P switch allows either the hose reel or the pump starter to be used. (One at a time only).

When the S-P switch is energized, 12 volt potential is also available at terminal "I" which is connected to the solenoid relays, through the selector switch, of the hose reel and pump engine starter. When the 12 volts from terminal "I" reaches these solenoid relays, the accessory immediately starts running. Twelve volts from terminal "I" also operates an additional relay that disconnects the batteries from the vehicle's generator charging circuit.

Because the batteries are disconnected from the vehicle's electrical system, while the 12 volt accessories are being used, all items such as lights, instruments, electric fuel pumps, etc. continue to operate from 24 volt current supplied from the generator. If the vehicle engine is not running, driving the generator, no 24 volt energy will be available for these items during the period the 12 volt S-P accessories are being used. The vehicle engine starter cannot be used simultaneously with the 12 volt accessories.

The following summarizes the operating sequence of this system.

1. Operator sets selector switch (hose reel or pump starter).
2. Operator depresses and holds appropriate push button switch.
3. Series-parallel switch is activated and automatically provides 12 volts to the hose reel or pump starter.
4. Vehicle (6x6) 24V generator and electrical system is automatically disconnected from the batteries.
5. When operator releases the push button switch, system automatically returns to 24 volts.

In case of failure in the field, of the S-P system, it can be converted back to the original 24V system quickly by the operator with simple instructions. If the accessories, dependent on 12 volts, have manual back-up systems, the unit could be effectively used until a repair was made.

Limitations - the series-parallel switch system can be used only with accessories that are used intermittently. It cannot be used for continuous duty items such as for lights. However, this system can be used in conjunction with the Balanced Load Systems described in the Balanced Load section.

E. Balanced Load System

The principle of this System involves dividing up the load of the 12 volt items and connecting them to the two 12 volt batteries in a manner that will insure an equal drain on each battery. Diagram #495 shows one possibility for a balanced or split load system.

All 12 volt loads connected to the battery (Bat. A) that is grounded to the vehicle's frame can also be grounded to the vehicle frame. For example: A clearance light needs only a supply wire when the light is grounded to the frame.

All 12 volt loads connected to the other battery (Bat. B) MUST BE INSULATED FROM THE FRAME. This necessitates the use of two wire accessories. For example: A head light would have a supply wire and it must also have a ground wire which would go all the way back to the battery negative post. This negative wire conductor must not be grounded to the vehicle frame. If several negative wires are necessary they can be connected to a terminal block in a convenient location, and only one wire needs to run all the way to the battery negative terminal.

The wattage of the 12 volt items should be calculated as closely as possible to accumulate an equal load on each battery. If, after this system has been put in service, the load appears to be greater on one battery than the other (overcharging would be indicated), and additional load can be added to the high battery or some of the load from the low (overloaded) battery can be transferred to the high battery.

While the split load system will probably work well for lights, transistorized 2-way radios or

other like loads, it would not be satisfactory when heavy drain accessories, such as electric motors, are used. It probably would be impossible to balance the load when accessories such as electric rewind hose reels and electric start pump engines are used.

Because of this, it is reasonable to use the series-parallel switch system covered in Section D in conjunction with the balanced load system. By using the balanced load system all of the lights on the vehicle can be changed to 12 volts. Items such as sealed beam head lights, turn signals, and emergency beacons are readily available from commercial sources as opposed to the relatively hard to obtain 24V items.

F. Installation of an Additional 12 Volt Battery

A very simple solution to providing 12 volt current to heavy drain accessories such as electric motors on hose reels and electric start pumps is to use an entirely separate 12V battery. This battery should be located near the accessories to eliminate long cable conductors.

There is no means of automatically recharging the battery in this system, except as noted under "Other Methods", and its success depends on the operator of the unit maintaining an adequate charge in the battery by using a battery charger.

G. Other Methods Known to be Possible but not Investigated

Resistors can be used to limit the current going to a particular accessory. A resistor converts the unused current, the difference between 12V and 24V, to heat. Because of this they are limited to

relatively low drain accessories. It is impractical to use resistors with electric starters and hose reels because of the high amperage, 35 amps. or more, required to operate them.

Small items such as 2-way radios and turn signal lights, can probably be operated satisfactorily. Except for a few light load accessories, resistors do not offer much of a solution. When the total 24 volt system is considered, other methods of reducing the voltage seem to be more reasonable.

Another version of the auxiliary 12V storage battery can be used to supply current to all 12V accessories by connecting the 24V charging wire from the generator to the 12V battery and installing a resistor to limit the charging current to 12 volts and 8 or 10 amperes. In this way the auxiliary battery can be recharged without the usual battery charger.

While this system appears to be a simple solution, it leaves a lot to be desired. Overcharging of one of the three batteries is inevitable because it would be impossible to maintain an equal level of charge in them.

Resistor and auxiliary batteries offer some solutions but require diligent maintenance by the operator. Other solutions seem to be more promising and more reliable.

COSTS

Because of the wide variety of vehicles having 24 volt systems, it is difficult, if not impossible, to quote accurate cost figures. With the exception of a few electrical system components, all cost considerations are comparative only in relation to the different systems. Each system in the following list is given a cost number; the highest number indicating the most expensive, the lowest the least expensive.

- #1 - (System B) Utilization of one of the two 12-volt batteries
- #2 - (System E) Balanced load system
- #3 - (System F) Installation of an additional 12-volt battery
- #4 - (System D) Series-parallel battery switch system, including:

Series-parallel switch, Orpin Model C,
manufactured by Automatic Battery
Corporation of America, 102 S. Bright
Street, Goldsboro, NC

Heavy duty power relay such as Potter &
Brumfield

Type PR5DY SPDT w/12V D.C. coil
Also dust cover

Selector switch DPDT toggle switch

One solenoid switch for each accessory

Single pole, normally open, continuous
duty w/12V D.C. coil common to
ground

#5 - (System C) Installation of additional and
separate 12-volt system, including:

Battery 12V

Alternator 12V

Regulator 12V

Drive components for alternator:

Special sheave

Mounting bracket for alternator

V-belt

Ammeter

Disconnect relay switch w/dust cover

#6 - (System A) Complete exchange of
electrical system components from 24V to
12V.

While the above cost comparisons may be of
interest to some, they do not necessarily reflect
the desirability nor the total potential of each
system. This is reviewed in the summary
section which follows.

SUMMARY

System A - Complete exchange of electrical system components from 24V to 12V

In general, this is the most desirable solution.
For some vehicles, a complete exchange of the
systems components impractical. It will require
patience and someone with automotive electric
system experience.

Some components on the more complicated
vehicles such as dashboard instruments,
electrical drive train shift mechanisms, air brake
warning systems, electric fuel pumps and
gauges may be difficult to replace with 12V
items. Other major items such as generators,
regulators, starters, ignition systems and other
related components can be exchanged. The
cost, however, can probably be justified only if
the vehicle is in excellent condition and a long
life can be expected. This system would be the
most expensive of the several alternatives, but
provides the best end product.

System B - Utilization of one of the two 12 volt batteries

This system is by far the simplest and least
expensive of all the possibilities investigated.
However, it has very definite limitations and
should only be used when the electrical load is
light. It is not recommended that this system be

used for heavy drain accessories such as hose
reels and electric start pumps as they would
rapidly create an imbalance in the two batteries.

Diligent maintenance is required to prevent
overcharging of the one battery which will
appreciably shorten its life. This system can
also jeopardize the overall potential of the 24V
system if not properly maintained.

In short, use this system only for light,
infrequently used loads.

System C - Installation of an additional and separate 12-volt system.

An additional 12V system completely separate
from the 24V original system seems to offer one
of the better solutions for providing current for
12V accessories.

All lights as well as heavy drain electric motor
accessories can be operated with this system.
The separate 12 volt battery is automatically
protected and charged any time the vehicle's
engine is running. Very little maintenance would
be required and this system should have a high
degree of dependability.

The cost of this system should be justifiable on
most any vehicle that requires additional

accessories and that is expected to be reliable and used frequently. The original 24V system can remain intact and will function as originally intended.

System D - Series-parallel battery switch system.

The series-parallel system as described in the text of this report can provide 12V current to heavy drain intermittently used accessories with a reasonable degree of dependability.

The actual installation of this system is fairly complicated but can be successfully accomplished by any competent individual if the instructions and diagrams provided are carefully followed. Once the installation is completed, the complexity of this system would not be of primary concern to the operator of the unit.

The series-parallel system has definite possibilities but it is limited to providing 12 volt current to intermittently used accessories such as an electric rewind hose reel and an electric

start pump. See Balanced Load System for more information.

System E - Balanced Load System

The Balanced Load System would be very inexpensive from the material cost standpoint. It would require running new wire conductors to the various loads and switches and replacing or adding the desired lights to the vehicle.

This system should function reliably if Diagram 495 is followed and lights are the only type of load in the system. Also, it can be used in conjunction with the series-parallel system which would more or less make it possible to use all 12V accessories.

The original 24V system would remain intact to provide power for all 24V items.

System F - Installation of an additional 12 volt battery

Refer to Page 8.

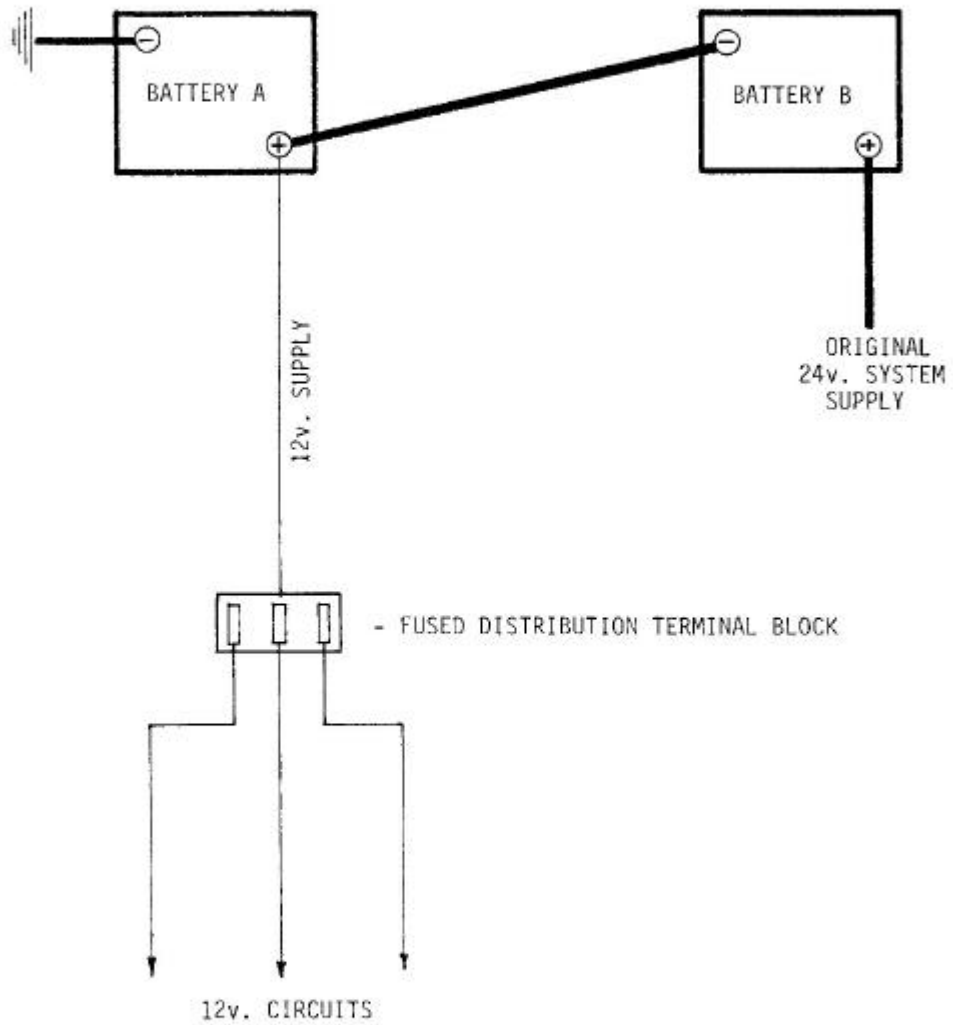
BATTERY AND GENERATING SYSTEM SAFETY

1. Be absolutely certain that the correct polarity of the batteries is maintained.
2. Disconnect battery ground cable when working on any part of the electrical system.
3. Test batteries to prevent overcharging.
4. **WARNING!** Make sure area around batteries is adequately ventilated.
5. Polarize generator any time generator or generator-regulator has been disconnected.
6. Do not attempt to polarize any system that uses an alternator.
7. Keep batteries properly charged at all times.

APPENDIX A

1. Diagram #496
Utilizing One of the Two 12 Volt Batteries
2. Diagram #494
Alternator-Regulator Wiring Diagram
3. Drawing #B-407
12 Volt Alternator Mounting Designed for
G.M.C. 6X6 2-1/2 Ton Truck
4. Diagram #490
Series-Parallel Battery System
5. Diagram #495
Balanced Load 12V Lighting System
6. Battery Equalizer

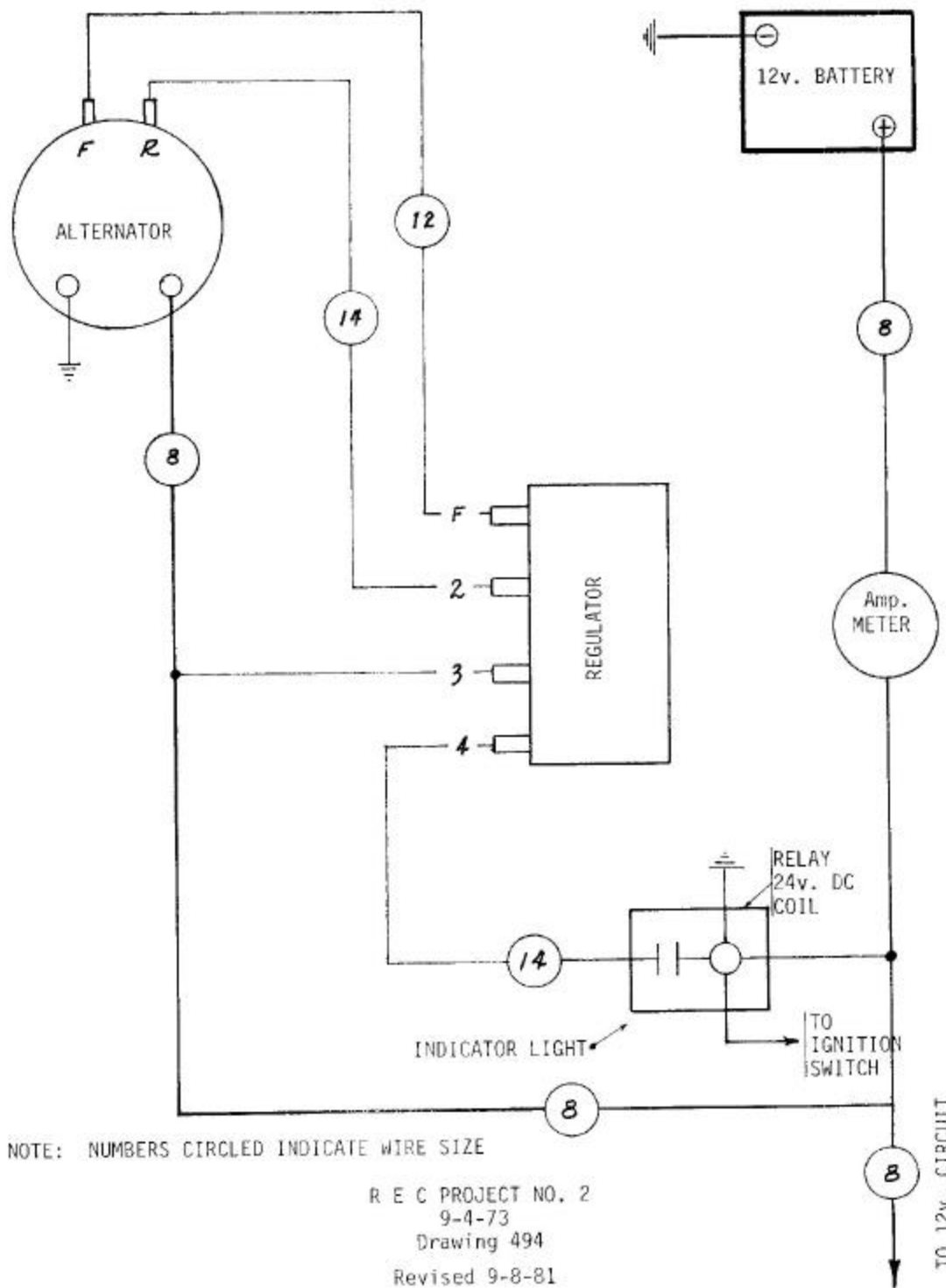
UTILIZING ONE OF THE TWO 12 Volt BATTERIES



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Drawing 496
Revised 9-8-81

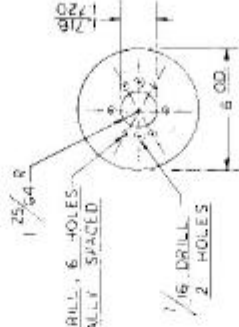
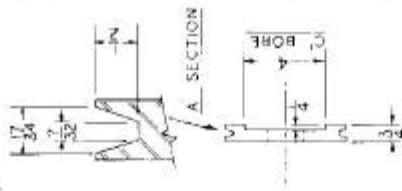
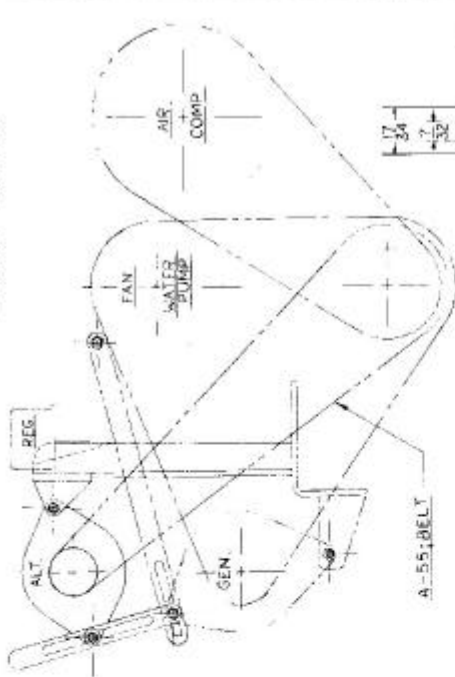
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ALTERNATOR - REGULATOR WIRING DIAGRAM



RGA/ld

ASSEMBLY MOUNTING

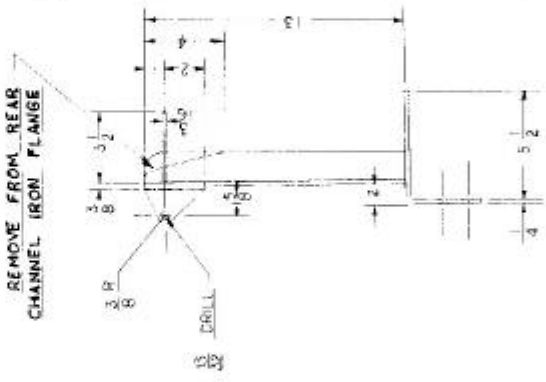
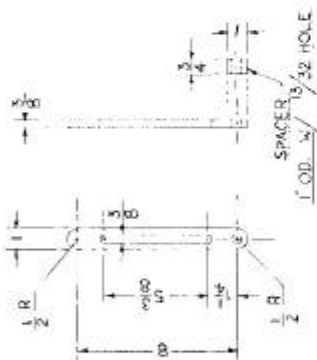


12 VOLT ALTERNATOR MOUNTING
DESIGNED FOR GMC 6 X 6

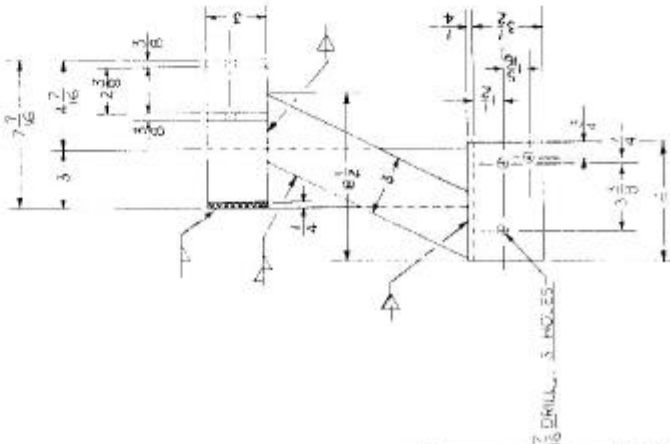
MAT'L - 1/4" X 6" X 1/4" X 3" FLT. STL.
3/8" X 3" X 3/8" X 1" FLT. STL.
3/16" X 3/2" FLT. STL.
3" X 4" CHANNEL
6" DIA. X 1/4" FLT. STL.

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9-4-73

FOREST FIRE EXPERIMENT STATION		MICHIGAN DEPARTMENT OF NATURAL RESOURCES	
12 VOLT ALTERNATOR MOUNTING		GMC 6 X 6	
SCALE	DATE	TRACED BY	DATE
BY - [Signature]	9-5-73	CHECKED BY	
DRAWN BY - [Signature]	10/28/73	APPROVED BY	

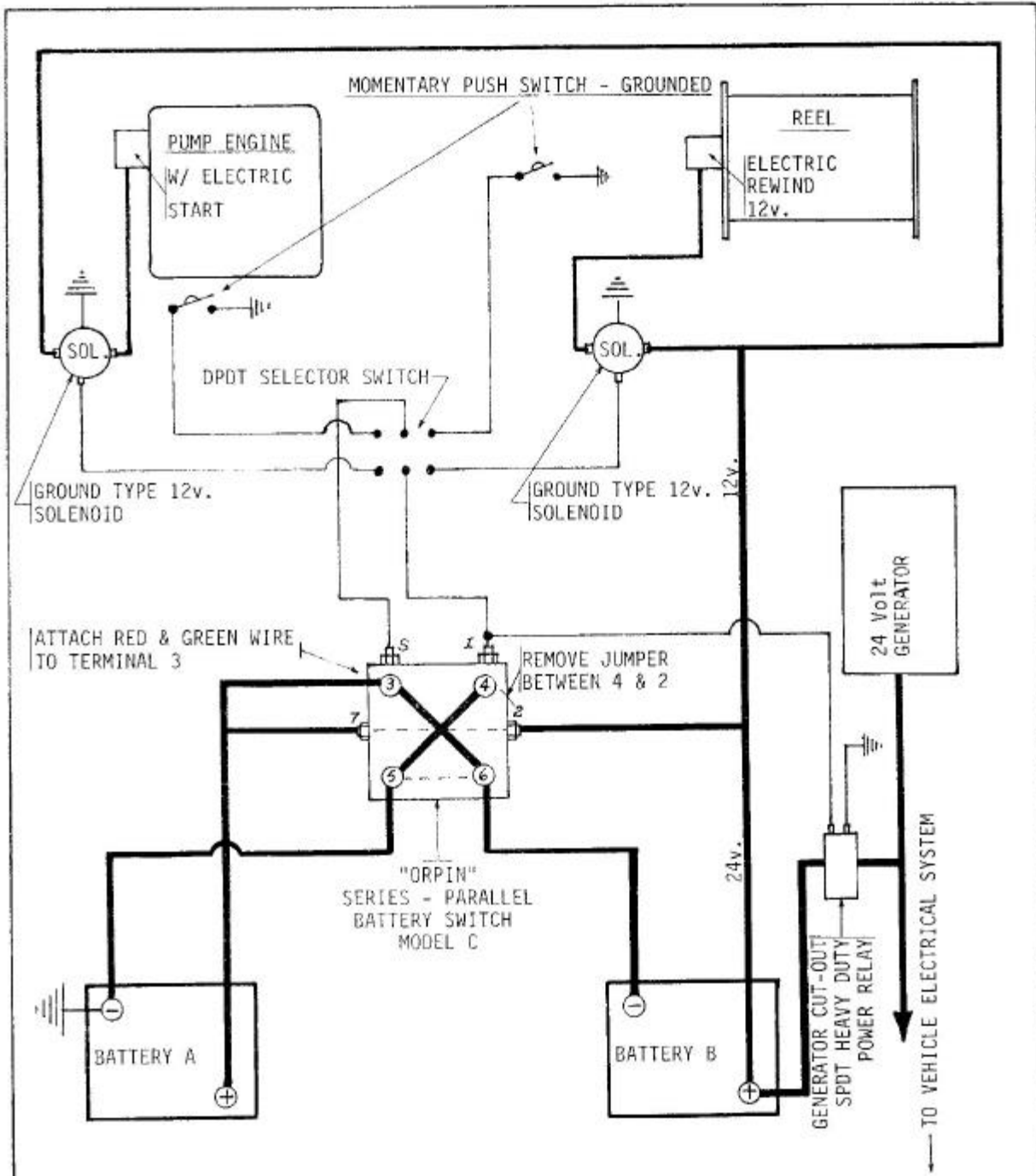


REMOVE FROM REAR CHANNEL IRON FLANGE



7 DRILL - 3 HOLE



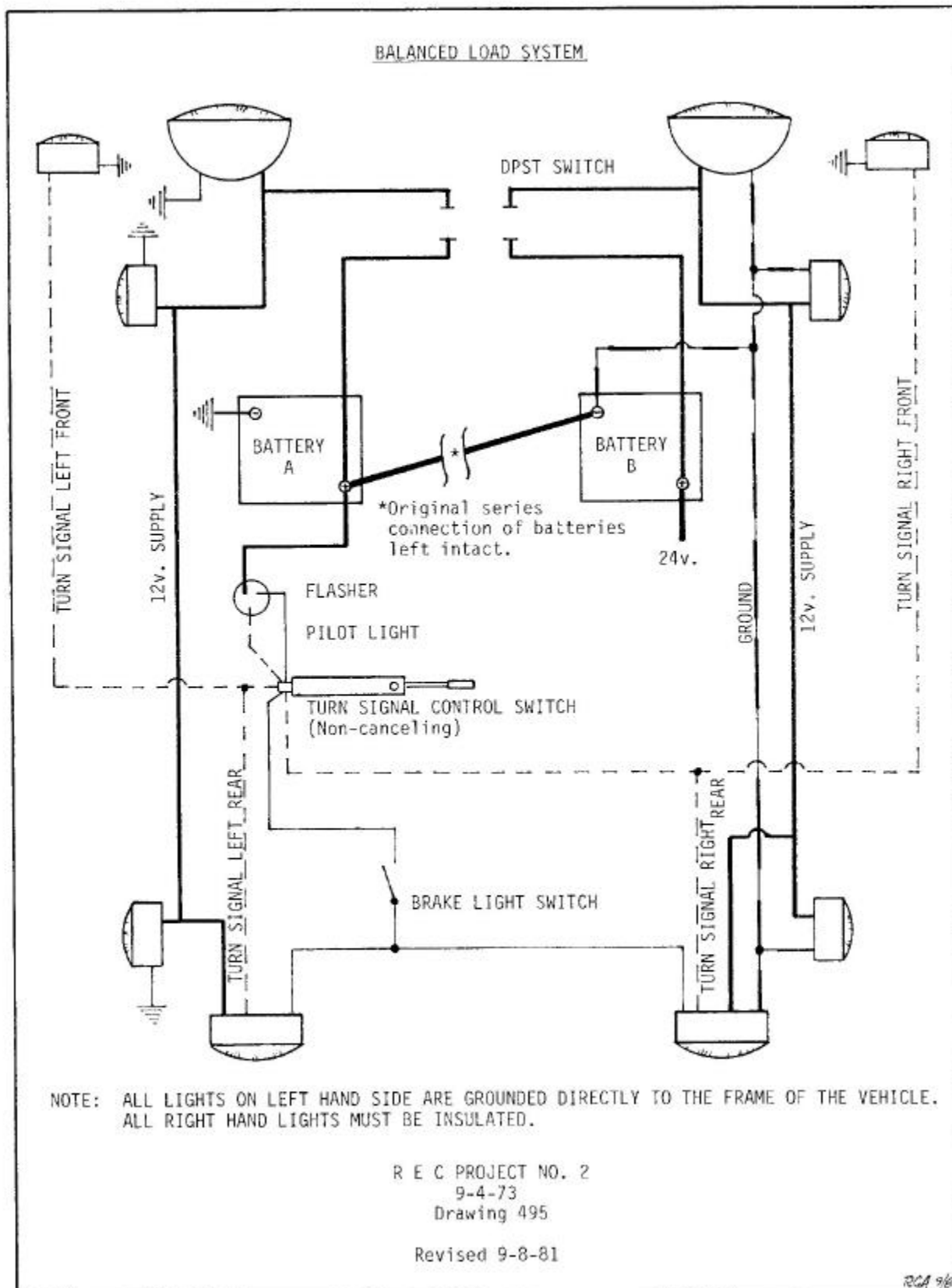


SERIES - PARALLEL BATTERY SYSTEM: 24 Volts to 12 Volts

R E C PROJECT NO. 2
 9-4-73
 Drawing 490
 Revised 9-8-81

RGA 1/61

BALANCED LOAD SYSTEM



**Adding a 12 Volt DC
Charging Circuit**

Roscommon Equipment Center
Northeast Forest Fire Supervisors
in Cooperation with
Michigan's Forest Fire Experiment Station

U.S. Military vehicles operate with 24 volt DC electrical systems. Fire departments converting excess military vehicles to fire fighting equipment generally need 12 volt DC to power many of their accessories. REC Project #2, *Wiring Conversion on Military Vehicles*, highlighted several ways to provide 12 volt power. This Newsnote provides an updated look at one of REC Project #2's alternatives, installing an additional and separate 12 volt electrical system.

In many cases it is not practical to change the vehicle's 24 volt system over to 12 volt. The procedure discussed here allows all of the major components of the 24 volt system to stay intact. The engine starter, the ignition system, generator, regulator and the two 12 volt batteries connected in series continue to function as original equipment. The vehicle's 24 volt lighting system may be transferred to the 12 volt system or left alone on a 24 volt system.

Any additional 12 volt loads such as lights (including head, tail, stop, turn, clearance, emergency beacon), two-way radios, electric rewind hose reels, electric pump engine starters can be connected to the separate 12 volt system. The separate 12 volt system components include a 12 volt alternator with a regulator and a 12 volt storage battery.

The major considerations for installing a separate 12 volt system include:

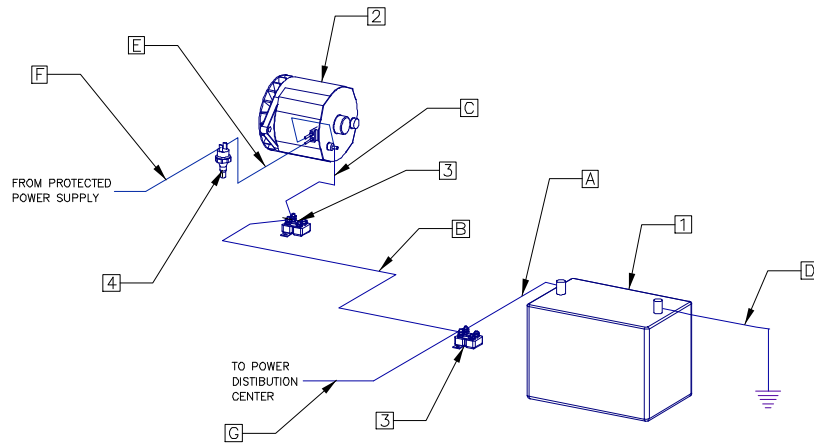
- Finding a space to mount the alternator. The alternator will be driven by a belt. It is desirable to have the alternator drive sheave installed directly on the end of the engine crank shaft. Drive sheaves can be installed on existing alternators, generators, fan or water pump shafts, but this imposes an additional load on the drive belts and bearings of these components that was not originally intended. This may reduce the life of the belts and bearings.

Often an extra sheave is not available and one must be specially machined to fit the crank shaft or drive components shaft. Normally, automotive alternators have a drive ratio of about 2:1. This

means that the alternator RPM is twice as great as the engine RPM. Make sure that you determine the correct drive ratios. For example, if a drive sheave is connected to the existing 24 volt generator shaft which already runs twice as fast as the engine, a 1:1 ratio would be correct.

- Determine the mounting bracket for the 12 volt alternator. It is important to establish good mounting points for the 12 volt alternator mounting bracket. REC has mounting bracket designs for some military vehicles. Make sure your bracket is attached to the engine block or a component attached to the block and that the belt alignment between the drive and driven pulleys is square.
- Completing the 12 volt circuit. An alternator needs an outside source of current to excite its' magnetic field before it can produce current. We suggest connecting a wire from the power distribution panel (fuse or circuit breaker) to the alternator activation terminal.
- Avoiding battery drain. A switch is needed to disconnect the alternator field activation wire to prevent battery drain. You want the 12 volt electrical circuit to be closed only when the engine is operating. This can be done in a number of ways. The preferred method is using an oil pressure switch to close the field activation wire part of the circuit. This is automatic and will close the circuit only when the engine is running. Other alternatives are use the ignition activated circuit or a manual control in which the operator switches on a toggle switch at startup and turns it off in shutdown. While simple to install, the manual toggle switch operation will result in battery drain or other problems if the procedure is forgotten.

The one page diagram on the next page of this report shows a complete 12 volt DC charging circuit and provides additional details.



Item	Description	Capacity	Note
A	Charging wire (alternator end)	Cross sectional area sufficient to handle full alternator output.	This section of wire is unprotected unless a fusible link type wire is used. If standard wire is used this section should be kept as short as possible.
B	Charging wire	Cross sectional area sufficient to handle full alternator output.	
C	Charging wire (battery end)	Cross sectional area sufficient to handle full alternator output.	This section of wire is unprotected unless a fusible link type wire is used. If standard wire is used this section should be kept as short as possible.
D	Ground wire	Cross sectional area sufficient to handle the sum of all the loads that may be used at one time.	
E	Alternator Field activation wire	This is a low amperage load usually less than 2 amps. The wire should be sized to handle a load equivalent to the circuits fuse.	If this wire has power and the engine/alternator is not running there will be a small drain on the battery.
F	Power supply for alternator field activation wire	This is a low amperage load usually less than 2 amps. The wire should be sized to handle a load equivalent to the circuits fuse.	In order to install a separate 12VDC system, a power distribution (fuse/circuit breaker) panel should be installed. All accessory circuits including this circuit should be connected to the protected side of this panel. All accessory circuit wiring should be sized to handle an electric load at least 125% of the capacity of the fuse/circuit breaker protecting the circuit (NFPA 1906).
G	Power supply to vehicle accessories	Size equal to the rating of the circuit breaker/fuse in the charging wire circuit. (Item #3)	This wire can be used to power accessories that have an individual electrical demand less than the output of the alternator. If an accessory has a load requirement higher than the alternator output it should be connected directly to the battery with proper short circuit protection.
1	Battery; 12 Volt	Size dependent on electrical component demands.	
2	Alternator; 12 Volt	Size dependent on electrical component demands.	
3	Circuit breaker/Fuse	Size equal to the rating of the alternator.	A circuit breaker or fuse may be used. Two are required because with the engine running there are two power sources, one at each end of the charging wire circuit.