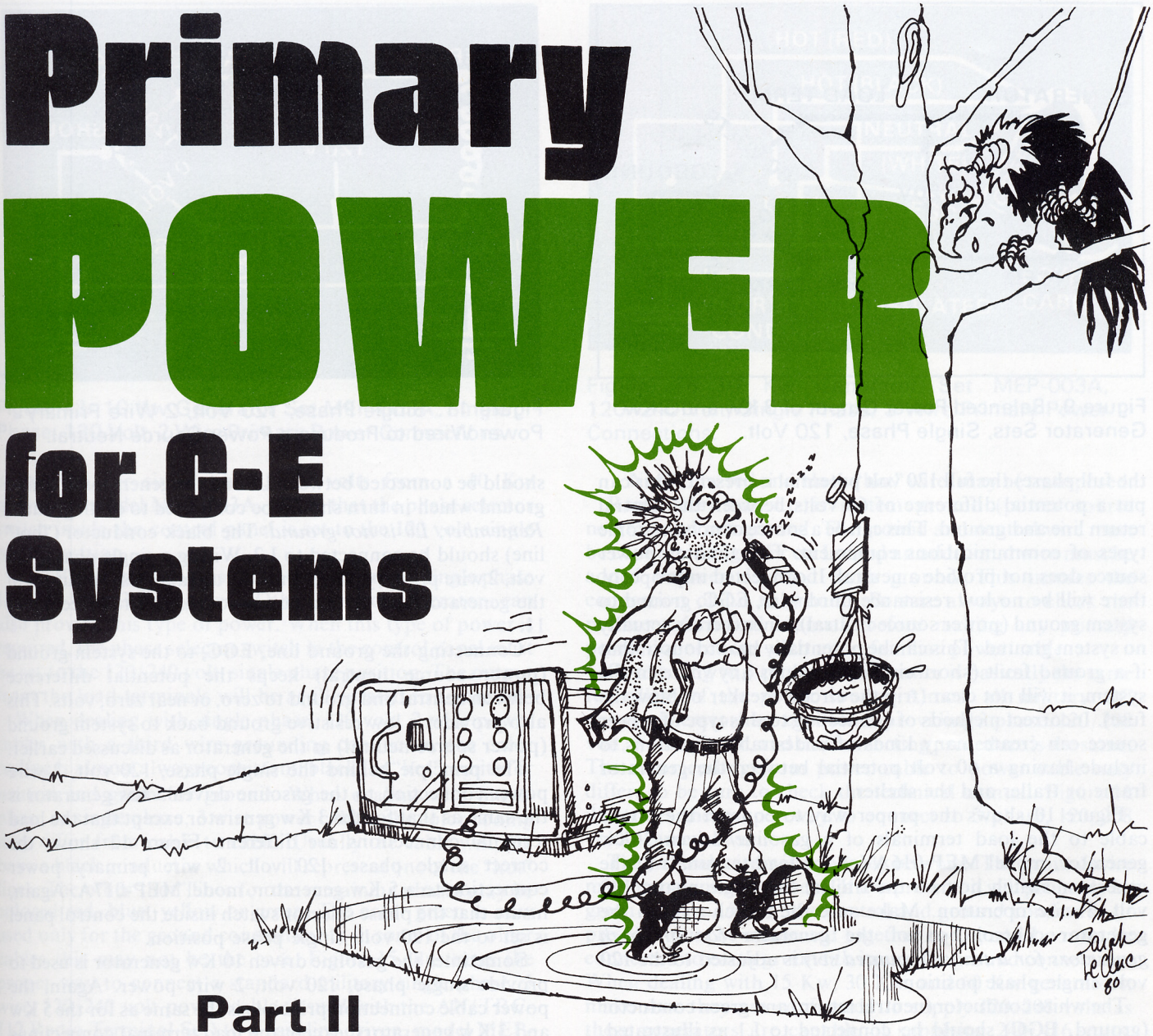
Primary POWER for C-E Systems



Part II

by Kenneth Tollstam, Jr.

In Part I of "Primary Power for C-E Systems," which appeared in the Spring 1980 issue of TAC, Tollstam dealt with grounding, ground rods, basic power source characteristics and power generator load considerations. In this article he describes common power generator connections and discusses the use of power transformers.

COMMON POWER GENERATOR CONNECTIONS

Some technical manuals for both communications assemblages and power generation equipment are vague in their instructions for connecting the power cables to the load terminals. The technical manuals for the power generation equipment do not give any guidance for connecting the equipment grounding conductor, EGC. These generators were designed to power many different kinds of equipment, not just communications equipment, and it is the user's responsibility to configure the generator to supply the proper kind of power. The following will explain in detail the basic connections to be made to the common generator sets (gasoline/diesel DOD models) currently in use by the military.

The gasoline driven 3 Kw, 5 Kw, and 10 Kw generators are designed so that they can provide the three kinds of power described earlier at the turn of a switch. The diesel driven 15 Kw, 30 Kw, and 60 Kw generators are usually operated to provide 3 phase, 120/208 volt, 4 wire power into a central distribution system. The gasoline driven 3 Kw and 5 Kw generators are usually used to provide single phase, 120 volt, 2 wire power for communications assemblages. Both types of generators operate basically the same. When the generators are providing single phase, 120 volt power, they provide a balanced output as illustrated in figure 9.

Between either load terminal and ground, there is a potential of 60 volts. Between both load terminals (across

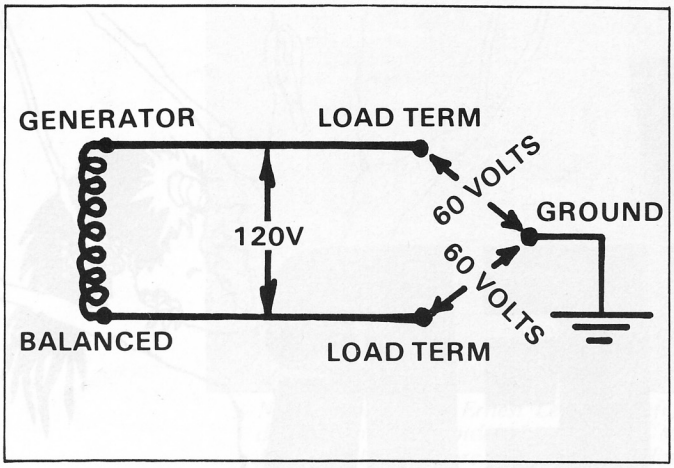


Figure 9. Balanced Power Output of 3 Kw and 5 Kw Generator Sets, Single Phase, 120 Volt.

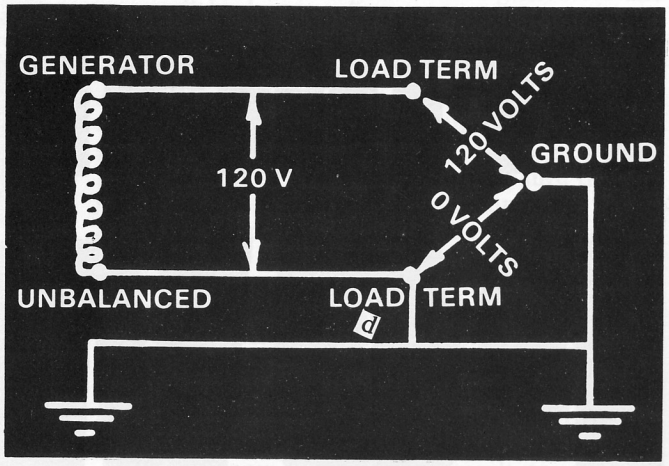


Figure 11. Single Phase, 120 Volt, 2 Wire Primary Power Wired to Produce a Power Source Neutral.

the full phase) the full 120 volt potential is present. This can put a potential difference of 60 volts between the neutral return line and ground. This can be a source of noise to some types of communications equipment. This floating power source does not provide a neutral. If connected improperly, there will be no low resistance third wire, EGC, ground to system ground (power source neutral), since there is actually no system ground. This can be potentially hazardous in that if a ground fault (short circuit) develops anywhere in the system, it will not clear (trip the circuit breaker or blow the fuse). Incorrect methods of connecting to this type of power source can create many kinds of undesirable situations to include having a 60 volt potential between the generator frame or trailer and the shelter.

Figure 10 shows the proper way to connect the power cable to the load terminals of a gasoline driven 3 Kw generator, model MEP-016A (or the load terminals of the generator switch box on the trailer) for single phase, 120 volt, 2 wire operation. Make sure the switch (S1) in the generator control box of the generator *(or on both generators for a trailer mounted set)* is adjusted to the 120 volt, single phase position.

The white conductor (neutral return) and green conductor (ground, EGC) should be connected to L1 as illustrated. Additionally, a 6 or 8 AWG insulated conductor (wire) should be connected between L1 and the generator or trailer ground which in turn should be connected to earth ground. *Remember, L0 is not ground.* The black conductor ("hot" line) should be connected to L2. Wiring a single phase, 120 volt, 2 wire primary power this way unbalances the output of the generator and gives a power source neutral. See figure 11.

Connecting the ground line, EGC, to the system ground (power source neutral) keeps the potential difference between neutral and ground to zero, or near zero, volts. This also provides a low resistive ground back to system ground (power source neutral) at the generator as discussed earlier.

The principle behind the single phase, 120 volt, 2 wire power connection to the gasoline driven 5 Kw generator is the same as that for the 3 Kw generator except that the load terminal connections are different. Figure 12 shows the correct single phase, 120 volt, 2 wire primary power connection to a 5 Kw generator, model MEP-017A. Again, insure that the phase selector switch inside the control panel is set to the 120 volt, single phase position.

Sometimes the gasoline driven 10 Kw generator is used to provide single phase, 120 volt, 2 wire power. Again, the power cable connection principle is the same as for the 5 Kw and 3 Kw generators, except the load terminal connections are different. Figure 13 shows the correct primary power

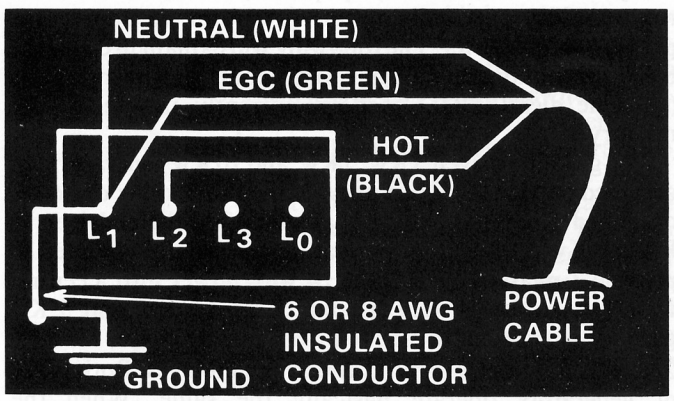


Figure 10. Load Terminal Connections for 3 Kw Generator Set, MEP-016A, Single Phase, 120 Volt, 2 Wire Operation.

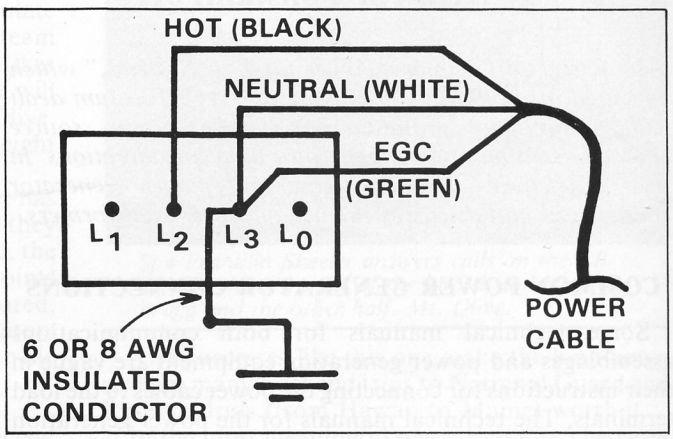


Figure 12. 5 Kw Generator Set MEP-017A, Single Phase, 120 Volt, 2 Wire Primary Power Connections.

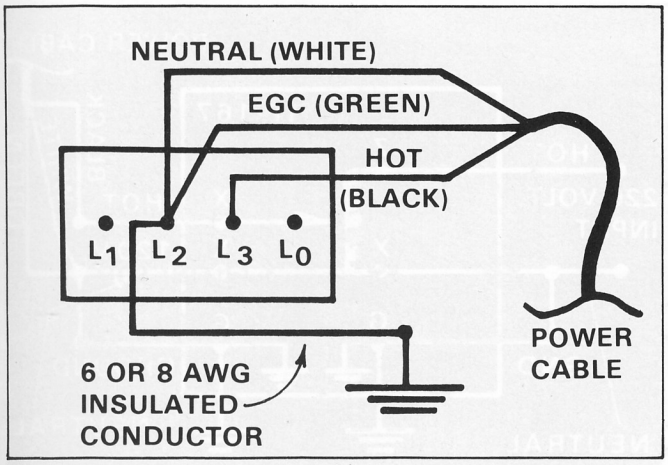


Figure 13. 10 Kw Generator Set MEP-003A, Single Phase, 120 Volt, 2 Wire Primary Power Connections.

connection for single phase, 120 volts from a 10 Kw generator, model MEP-003A. Insure that the phase selector switch inside the control panel is set to the 120 volt, single phase position.

The 10 Kw generator is often used to supply single phase 120/240 volt, 3 wire power. Other types of generators can also provide this type of power. When this type of power is required, the phase selector switch in the control panel must be set to the 120/240 volt, single phase position. The output from the load terminals will be as illustrated in figure 14.

When dealing with single phase, 120 volt, 2 wire power cables with a third wire grounding conductor, the color coding is almost always consistant: black for "hot", white for neutral and green for ground. When dealing with multi-phase or single phase, 3 wire power cables, the color coding may differ from cable to cable. Usually the cable will still have a black conductor which will represent one of the "hot" lines. The other "hot" lines for the remaining phases may be colored red, blue, yellow or green. The color green is now used only for the ground conductor but in some of the older cables this may not be the case. Figure 15 illustrates the proper way to connect a standard military single phase, 3 wire, 120/240 volt power cable (issued with the AN/TRC-112 Radio Terminal Set) to a gasoline driven, model MEP-003A, 10 Kw generator.

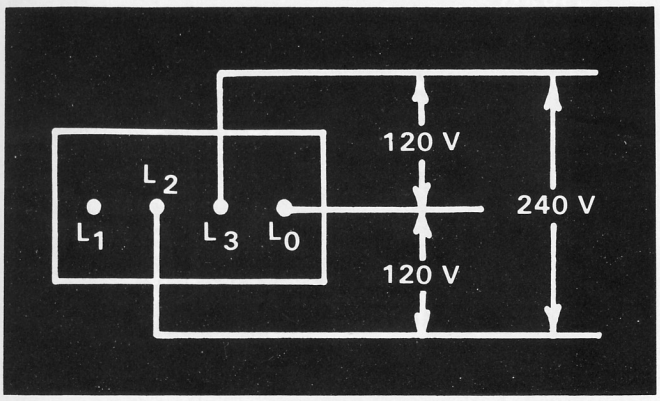


Figure 14. 10 Kw Generator Set MEP-003A, 120/240 Volt, Single Phase, 3 Wire Primary Power Connections.

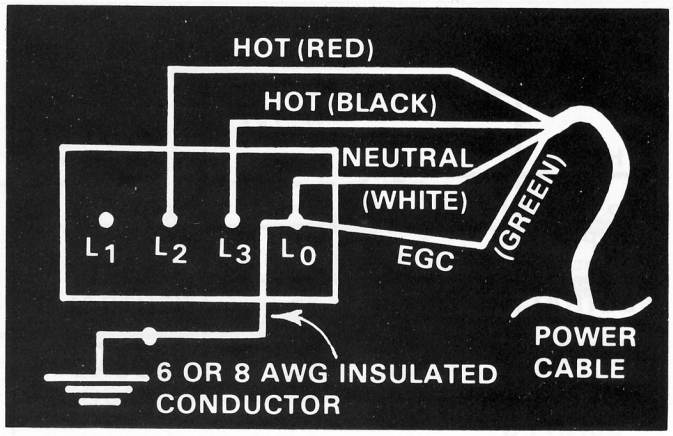


Figure 15. 10 Kw Generator Set MEP-003A, 120/240 Volt, Single Phase, 3 Wire Primary Power Connections.

Note: The red and black "hot" wires may be transposed. Remember that Lo is system ground (power source neutral) and not ground. The ground and neutral wire must be connected together on Lo and an additional wire must be added between Lo and earth ground. This insures the connection of Lo to ground. Be sure always to check the pertinent technical manuals before making any primary power connections with an unfamiliar power cable.

Connecting to 3 phase, 4 wire power is basically the same regardless of the power source. Almost all military AC power generators are capable of providing 3 phase, 120/208 volt, 4 wire power, and the connecting procedure is the same. The color coding from power cable to power cable may differ, so be sure to check the technical manual. Figure 16 illustrates the proper way to connect to 3 phase, 120/208 volt, 4 wire power.

The neutral wire will probably be white. The ground wire may or may not be present. If it is present, it will probably be green or bare. Again, the neutral and ground conductor (if present) must be connected together to Lo, and Lo must be connected to earth ground to insure the ground connection. When dealing with 15 Kw, 30 Kw, and 60 Kw generators, make sure they are configured to supply 120/208 volts as these generators are capable of supplying 240/416 volts. Check the technical manual.

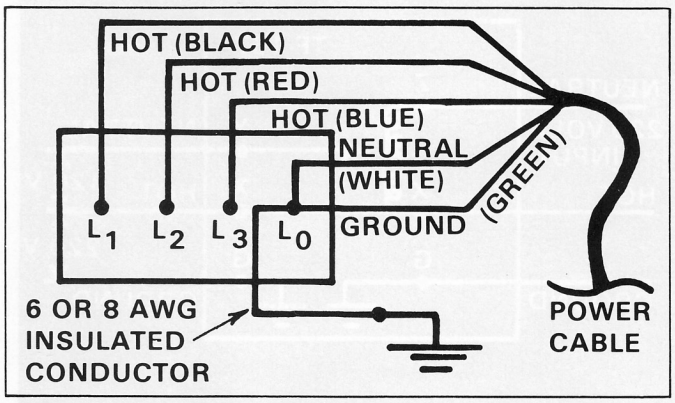


Figure 16. 3 Phase, 120/208 Volt, 4 Wire Primary Power Connections for Most Military AC Power Generator Sets.

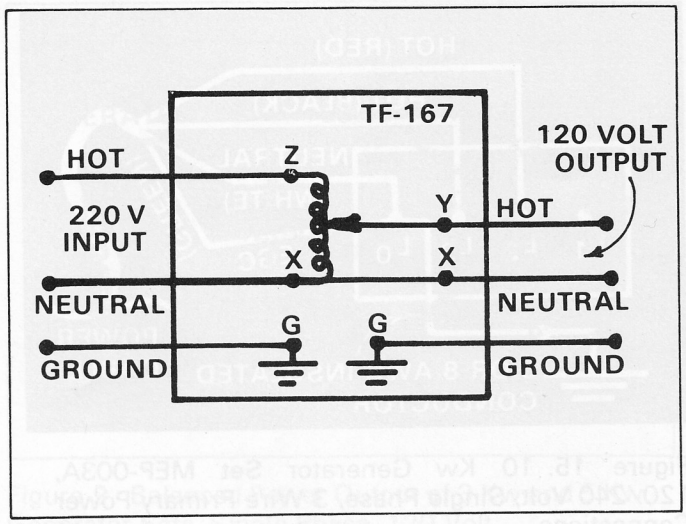


Figure 17. Single Phase Autotransformer TF-167.

POWER TRANSFORMERS FOR PRIMARY POWER

In Europe where the standard commercial power is 3 phase, 220/380 volt, 4 wire, it is sometimes necessary to use step-down power transformers to operate equipment designed to operate at 120 volts. The 3 types of transformers commonly used are the single phase autotransformer, the single phase isolation transformer, and the 3 phase, 4 wire wye transformer. Most transformer power ratings are given in kilovoltamperes (KVA) and the load calculations are the same as those for power generators.

A good example of a single phase autotransformer is the TF-167. See figure 17.

Be very careful when connecting an autotransformer to an electrical power source. On the input side of the transformer, make certain that the "hot" line of the input is connected to the top of the transformer coil (terminal Z in figure 17). If the "hot" and neutral lines on the input side of the transformer are transposed, there will still be 120 volts across the output; however, the neutral line will carry a 220 volt potential measured to ground all through the equipment connected to it. See figure 18.

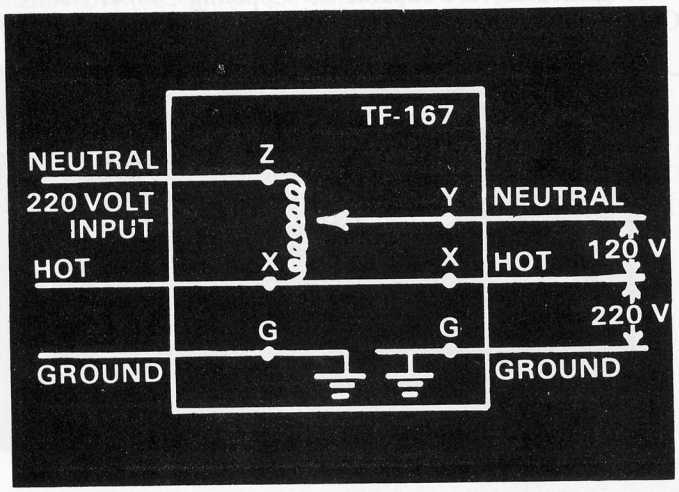


Figure 18. Example of Improper Connections to Audiotransformer TF-167.

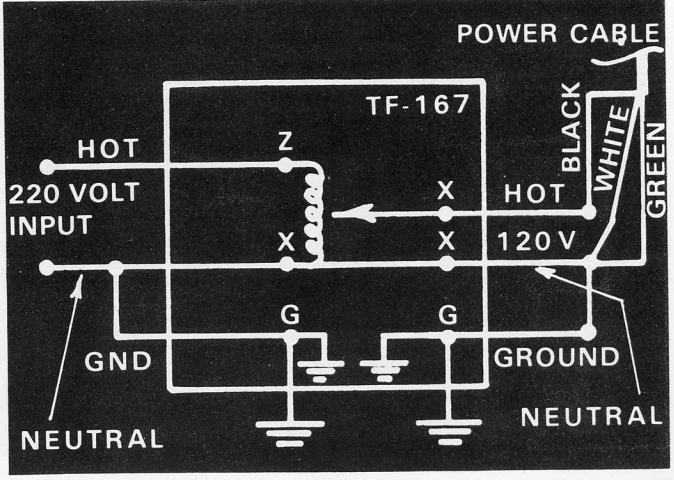


Figure 19. Audiotransformer TF-167 Connected for Supplying Primary Power.

This can create a very dangerous situation. This actually caused a multiplex unit, TD-754/G, to explode. The TD-754/G has an AC input line filter, as does most military electronic equipment. The filter has electrolytic capacitors between both sides of the line ("hot" and neutral) and ground. Having a 220 volt potential between neutral and ground caused one of the electrolytic capacitors to break down and violently explode. This explosion caused major damage to the equipment, bending the entire case out of shape. The equipment was not even being used nor was it turned on; it was merely plugged into the power receptacle.

The correct way to connect a single phase autotransformer, such as the TF-167, for supplying primary power is illustrated in figure 19.

Another commonly used transformer is the single phase isolation transformer as illustrated in figure 20.

With this kind of transformer, there are the same kind of floating power output problems as are encountered with the single phase 120 volt output of a power generator. Figure 21 illustrates the proper way to connect a single phase isolation transformer for primary power.

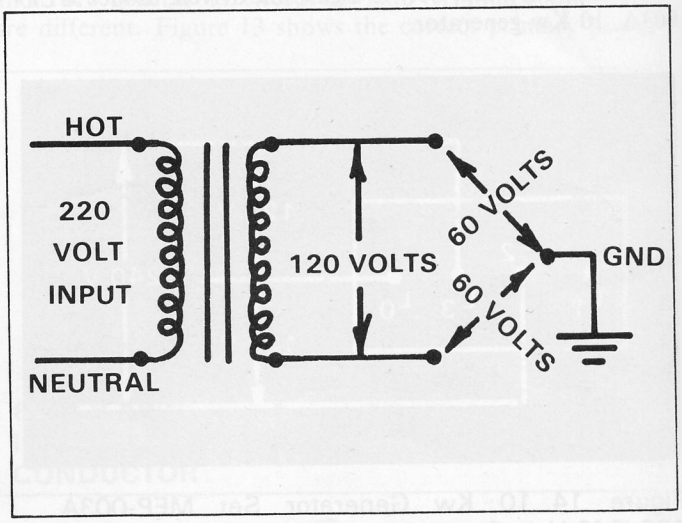


Figure 20. Single Phase Isolation Transformer.

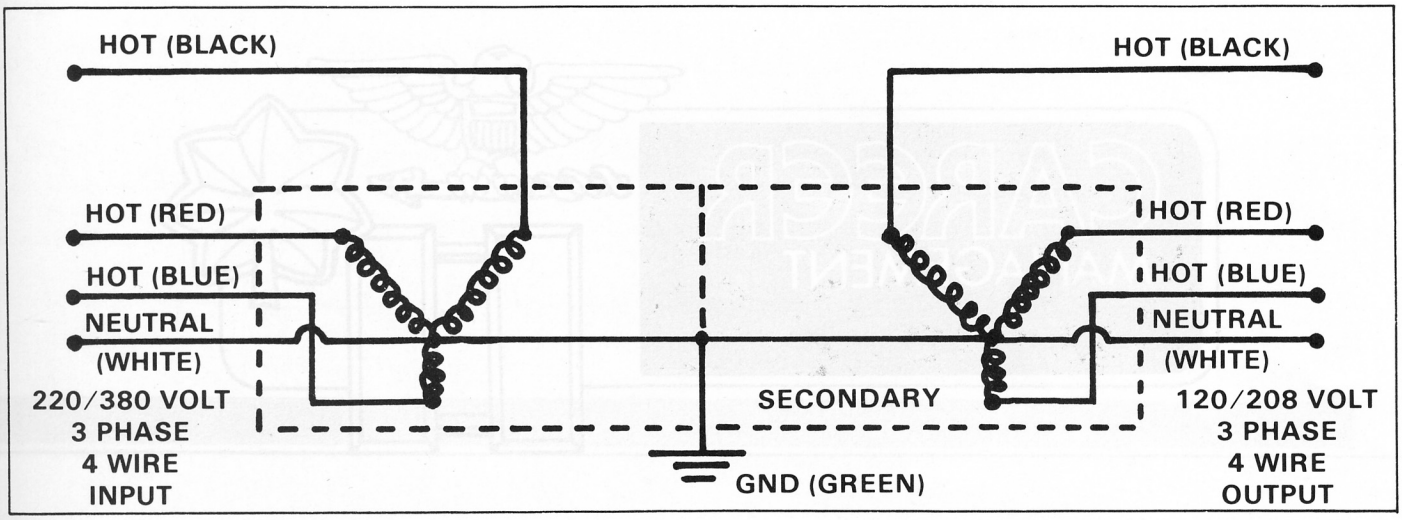


Figure 22. 3 Phase, 4 Wire Wye Transformer.

The last kind of transformer normally encountered is the 3 phase, 4 wire wye transformer as illustrated in figure 22.

The output of this kind of transformer is the same as the 3 phase, 4 wire output of a power generator, and the load should be connected in the same manner.

When dealing with power transformers, there may not be any technical manuals available to refer to for information. Most transformers have a data plate which will give the voltage and power ratings and show the line and load terminal configurations. Always make sure that the transformer to be used will operate on the line voltage available, will supply the voltage needed, and will adequately handle the load. An unfamiliar transformer without descriptive information, either on the transformer or elsewhere, should be left alone.

The frequency of the line current, whether it is 50 or 60 Hz, will generally not affect the operation of most military electronic equipment. Most of the power generators used in the military can supply both 50 and 60 Hz. A transformer will supply the same frequency at the output that is applied to the input. Because inductive reactance is more efficient at higher frequencies, some inductive devices, such as electric motors and transformers, designed to operate at 60 Hz may overheat when operated at 50 Hz. Inductive electric motors will also tend to rotate slower at 50 Hz than at 60 Hz. It is important to check whether or not the inductive equipment is rated to operate at the line frequency available. If the equipment will only operate at 60 Hz and the only line frequency available is 50 Hz, as is the case in Europe, then a rotary power converter will be necessary. A rotary power converter consists of an electric motor which turns a power generator. The 50 Hz line current powers the electric motor which turns the power generator which produces a 60 Hz power output. The same rules that apply to the load connections and calculations of standard military power generators also apply to rotary converters.

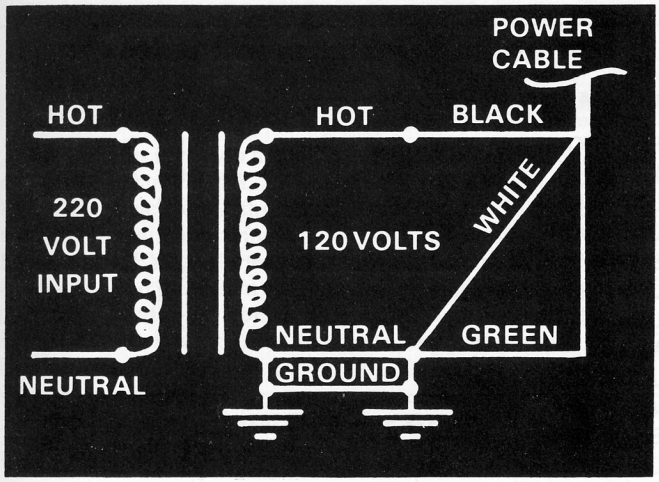


Figure 21. Single Phase Isolation Tranformer Connected for Supplying Primary Power.

Though not all the aspects of primary power distribution have been covered in detail, this article offers a basic foundation from which to work. Primary power considerations are vitally important to safety, both personal and equipment. Electric power must be treated with respect. The harnessing of electrical energy has been the single most important influence on our highly technical society. When electricity goes to work for us, every bit of it must be controlled. Loss of control can result in injury or death.

Primary power considerations are also important to quality, dependable telecommunications. No less planning should go into primary power than goes into the establishment of systems and circuits.

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Kenneth Tollstam, Jr. has served four years in tactical Signal battalions in Europe. He has also served as the OIC of an electronics maintenance shop and as a C-E commodity manager for the 9th Infantry Division where he was promoted to WO2. Tollstam holds a B.A. from St. Martin's College in Washington. He recently separated from the Army.