

FUEL OIL TANKS  
ELECTROLYSIS PROTECTION

INITIAL TESTS AND ADJUSTMENT OF CATHODIC PROTECTION SYSTEMS

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anodes are specified to be located above the concrete slab centered between the tanks in the sand environment.

1.07 Type "D" Durichlor anodes (2" dia. x 60" long) are specified to be installed in 7" dia. holes with coke backfill except as noted in Paragraph 1.06.

1.08 The tanks are specified to be covered with a half lapped layer of Tapecoat along with any pipes that are buried or in the tank manhole. The drainoff pipe cap is to be left bare. The tank is first Tapecoated, except for the threaded collars, then installed in the excavation. The pipes may be Tape-coated prior to being screwed into the threaded collars of the tank, except for the threaded ends of the pipes. The area around the threaded collars and joints in the pipe are required to be Tapecoated also to provide a complete Tapecoating job; this must be done after the pipes are screwed in place.

1.09 The arrangement of anodes located around tanks results in corrosion protection of the tanks with a minimum amount of drainage current by virtue of the tank being in the raised earth potential field around the anodes. A minimum amount of current is drained from the station grounding system and the steel reinforcing of the micro-wave tower footings connected to the station grounding system. A limitation of current drained from the reinforcing steel of the tower footings is important since it is known that a current exchange between the reinforcing steel and its concrete environment greater than about 2 milliamperes per square foot of steel reinforcing area will destroy the bond between the steel and the concrete.

1.10 At some locations such as at underground power feed points along the hardened cable route and the overseas cable terminal, the fuel oil tanks were encased in concrete. No cathodic protection has been provided for the tanks at these installations.

1.11 See 877-207-100 for description and use of the copper-copper sulfate half cell mentioned herein.

## 2. INSPECTION ITEM IRREGULARITIES OBSERVED

2.01 The leads from the anodes were brought to a terminal in the tank manhole on the first installations. Holloway shunts were installed in order that the current to the individual anodes could be conveniently measured. It was found that the shunts would be connected in as many different ways as there were contractors doing the work. The method

of terminating the anode leads was changed and a 10 terminal porcelain block was provided to simplify terminating the anode leads. This method also did not prove satisfactory.

2.02 Drain holes are being provided in the tank manholes; the holes being located immediately above the tank in the corners of the manhole. These drain holes have not in all cases been effective for several reasons:

(a) Where the natural ground water level varies the level of the water changes in the manholes and the terminals may be immersed at times. While underwater they will corrode in the case of a rectifier installation.

(b) The geology may be tightly packed soil, clay or rock with poor water drainage. The tank is installed and back filled with sand. Water may accumulate in and around the tank and back up into the tank manhole and around the anode terminals and these will corrode in case of a rectifier installation.

(c) The drain holes may be plugged up with mud or inadvertently plugged up with cement by a workman through a misunderstanding of instructions.

2.03 The areas around the threaded collars of the tanks where the pipes are screwed into the tank have not been Tapecoated in many cases. If this condition exists, it can be readily observed in the tank manholes.

2.04 In those cases where this Tapecoat has been omitted on the threaded collars in the tank manhole, it can only be surmised that a similar condition exists at any threaded collars outside the manhole which have been covered over with sand and topped with earth and also in some cases surfaced with asphalt material for driveways. The swing joints in the fill and vent pipes would probably also have been left bare. Two cases where high ground water level has resulted in water getting in the tank have been reported through corroded pipes, loose swing joints, and corroded areas around collars. In these cases the tanks were not cathodically protected.

2.05 At one location where water stood in the tank manhole, there was a film of oil on the surface of the water. This oil had softened the insulation on the anode lead wires.

2.06 Oil may be spilled sometimes on the Tapecoat in the tank manhole. This oil will soften the Tapecoat. Most all insulating materials will be affected by contact with oil. It is not known whether the presence of oil in the tank manholes is the result of oil

dropping off the stick used to test the tank for the presence of water in the tank or spillage from filling the tank at the drainoff pipe. The tank should be filled at the fill pipe provided for the purpose.

2.07 At one location where an oil filled Type N rectifier was installed, a lightning surge operated the D.C. fuse and, since this fuse was under oil, the gases generated destroyed the fuse holder. A filter for use in the D.C. output circuit to mitigate lightning surges, was designed by the Good-All Electric Company. This filter was tested for its effectiveness in protecting the rectifiers from lightning surges by the Bell Laboratories and was found to be adequate. Instructions were issued to install these filters at all stations equipped with Type N rectifiers and remove the oil from the rectifiers to prevent possible future damage to the fuse holders. The manufacturer advised that the rectifier would not overheat if this was done. This filter is covered by Drawing WA 21169.

2.08 On the more recent installations air cooled rectifiers with a built-in filter are being installed.

### 3. DIFFICULTIES ENCOUNTERED IN TESTING

3.01 Where Holloway shunts are installed it has been found necessary in many instances to rewire the shunts. In many cases the wires of the shunts had been cut off or so misused that there was no alternative except to replace the shunt. For this reason, the electrolysis tester should have available a supply of shunts for replacement purposes.

3.02 It has been found that adequate protection for the fuel oil tanks will not be obtained if a few of the anodes take the largest part of the total load current on the rectifier. Where this condition exists, it would appear, at first, that the rectifier capacity is inadequate. If the currents discharged by the anodes can be equalized the total current required for a given amount of protection will be less as a more uniform raised earth potential field will be developed around the tank. The reason for one anode taking more current than another is no doubt due to the manner in which the anode is installed.

3.03 Anode installations are being made by different contractors and although all have the same installation instructions, circumstances may govern the manner in which they are installed. For instance, at one location in a low earth resistivity area, it was noted that one or two anodes took most of the

current, some anodes took only a few milliamperes. Measurements of the resistance of the individual anodes to earth indicated variations in resistance but these variations would not account for the large difference in current discharged by the various anodes. Measurements of the voltage between the individual anodes and the tank indicated variations as much as 0.8 volt. All voltages measured were of the same polarity. The anodes were positive to the tank. This variation in voltage accounted for the variation in the anode currents with the low rectifier voltage applied.

3.04 Investigation revealed that the contractor bored holes larger than specified. The amount of backfill ordered was only sufficient to take care of backfilling the smaller holes specified. It is not known how the contractor distributed the backfill among the anodes, whether he obtained additional prepared backfill or backfilled some of the anodes with low earth resistivity soil.

3.05 At another location it was learned that the tank was installed near the berm of a hill. The anodes installed near the berm may have been in dry soil increasing the resistance to earth. In some cases the sides of the excavation for the tank may have caved in making it necessary for the anode and its backfill to be enclosed in a stovepipe in order to place the anode at the proper location near the tank.

3.06 The conditions and circumstances under which the anodes are placed are no doubt so varied that most any kind of variable results may be obtained.

3.07 The most uniform tank to soil potentials will be obtained where the anode currents are equal and the earth resistivity is equal, conditions which may seldom be realized. It has been found that in low earth resistivity areas it is more necessary to balance the anode currents than in high earth resistivity areas, and this is particularly true for the multiple tank installations. If the anode currents are not reasonably well balanced on the multiple tank installations, the 3 ampere size rectifier may be overloaded before securing adequate protection for the tanks. Even with reasonably balanced anode currents on two multiple tank installations the three ampere rectifier has been found to provide almost the required amount of protection on the initial tests. Twelve ampere rectifiers are now being specified on all multiple tank installations. Polarization effects will provide little benefit because the protection is being secured from the raised earth potential field, which depends upon the magnitude of the anode currents. Only about 25 per cent or less of the capacity of the 12 ampere rectifiers

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will be required for the protection of the fuel oil tanks; the excess capacity may be found useful in protecting buried portable water tanks or waterwell systems associated with the larger stations.

3.08 In high earth resistivity areas, little difficulty should be experienced in providing adequate tank to soil potentials even with large unbalances in the anode currents. Experience indicates nearly uniform tank to soil potentials may be obtained with large unbalanced anode currents. Therefore, it appears that there may be little need to balance the anode currents in such areas unless some unusual condition causes one or more anodes to take much greater current than the other anodes. The current requirements per anode in high earth resistivity areas has been found to be of the order of 50 milliamperes or less. (Fig. 1)

3.09 In low earth resistivity areas a more uniform anode current is required to secure adequate protection and the current per anode may be of the order of 100 milliamperes per anode. Where one or more anodes take currents of two or more times the average anode current for adequate protection then consideration should be given to reducing the currents to those anodes taking the high currents.

3.10 Where measurements indicate an anode lead wire is open it may be necessary to locate the missing anode and replace it, if the current to the other anodes will not insure adequate over-all protection for the tank. On multiple tank installations it will be impractical to replace, in the same location, anodes that may be located below the bottom level of the tanks or below the concrete slab on which the tanks rest. Replacements of such anodes should be made as outlined in Note J of Drawing WA 19012.

3.11 In locating an anode it has been found that it is necessary to disconnect the lead wire to this anode from the rest of the system and apply test current or tone to this one anode lead wire alone. An auxiliary ground for the test current or test tone should be a ground separate from and not connected to the station ground system. It may be possible to use the station ground system for an auxiliary ground in those locations where the anodes are located more than ten feet from the station ground wire around the building. In some cases the anode nearest the building may have been placed within about five feet of the buried ground wire around the building due to space considerations. In such cases it may be impossible to locate the anode using the station ground system as an auxiliary ground.

3.12 Batteries may be used to supply the test current and a half cell and high resistance voltmeter used to explore the surface of the ground for the anode location. The tone method of Holiday detection may also be used.

3.13 Where the anode is under an asphalted surface it may be impossible to use either of the two methods outlined above unless the asphalted surface has been permeated by moisture. Where it is impossible to locate the anode through the asphalted surface by the above methods it will be necessary to resort to the Low Frequency Method of locating underground pipes and cables as covered in Plant Series Section 634-220-500. This method will indicate whether the anode lead wire is open.

3.14 The low frequency method of locating the anodes is possible due to the current flowing in the circuit setting up a magnetic field which is not affected by the asphalted surface. To avoid possible secondary effects the lead wires to all other anodes may have to be open.

3.15 The approximate location of an anode with an open lead wire can be determined by locating first all of the anodes on which no trouble exists. The approximate location of the anode with the open lead can then be determined from the station drawings. The end of the wire will no doubt be in contact with the earth and can be located by the tone method of Holiday detection.

3.16 Anodes installed under the concrete slab on which the tanks rest would not be expected to be located by any of the above methods because of the shielding effect of the steel reinforcing in the concrete slab.

## 4. MEASUREMENT OF INDIVIDUAL ANODE CURRENTS

4.01 The measurement of individual anode currents is easily accomplished where Holloway shunts are installed. Where there are no Holloway Shunts installed, as will be the case where the anode lead wires are terminated on a P222 ten terminal porcelain block, a Holloway shunt may be placed temporarily in each wire.

4.02 Where anode terminal boxes are provided, the anode currents can be determined from the voltage drop across the resistor in the anode lead using ohms law. The earliest installations used two 25 ohm resistors and the later installations use one 25 ohm resistor and one 100 ohm resistor in series with each anode lead wire. The current may be calculated from the voltage drop E across either series resistor as follows:

<u>RESISTANCE—OHMS</u>	<u>CURRENT THROUGH RESISTANCE - MILLIAMPERES</u>
12.5	80 E
25	40 E
50	20 E
100	10 E

With resistors in series in an anode lead, little or no voltage read across either resistor or combination of parallel resistors indicates the circuit to that anode is open. Either series resistor may be paralleled with a spare resistor for current adjustment purposes.

4.03 An anode terminal box containing series resistors is being provided inside the building under the rectifier in accordance with Drawing WA 19012. The wire terminals in the tank manhole are eliminated. The older installations, where it is justified, may be provided with an anode terminal box and the wire terminals eliminated in the tank manhole in accordance with Drawing WA 21189, if desired. This is discussed more fully in Section 6.

#### 5. EFFECT OF VARIABLE ANODE TO TANK VOLTAGES ON ANODE CURRENTS

5.01 As mentioned in Paragraph 3.03, measurements of the anode to tank voltages at one location showed variations of as much as 0.8 volt. This variation in voltage can cause a large difference in the individual anode currents particularly in low earth resistivity areas. For example: A multiple tank installation with 16 anodes requires 0.1 ampere per anode and the individual anode to tank resistances measure about 1.6 ohms each as measured with a megger. The parallel resistance of all 16 anodes measures 0.15 ohms. The anode to tank voltage with the rectifier on is 0.9 volt. The total current to all anodes is 3.0 amperes. Three anodes take 1.5 amperes of current leaving 1.5 amperes to be divided among 13 anodes or an average of 0.116 ampere per anode.

5.02 The calculated load resistance is  $0.9 \div 3.0$  or 0.3 ohm. With 0.9 volt and 0.15 ohm resistance the load current should be 6 amperes. The 0.8 volt anode to tank voltage is a back voltage which opposes the 0.9 volt driving voltage from the rectifier reducing this particular anode current to  $(0.9 - 0.8) \div 1.6$  or 0.062 ampere. If variable anode to tank voltages did not exist each anode would take 0.187 ampere with 3.0 amperes total current.

5.03 Although resistors could be put in the leads of the three anodes taking the 1.5 amperes of current the one anode with the 0.8 volt anode to tank back voltage will take only a small part of the current it should take. A practical solution is to install 125 ohm resistors in the individual leads to all anodes which will require a driving voltage of approximately 125 (ohms) x 0.1 (ampere anode current) or 12.5 volts; this will force the anode with the 0.8 volt anode to tank back voltage to take about 93 per cent of the average individual final anode currents.

#### 6. TROUBLE CONDITIONS WHICH JUSTIFY THE INSTALLATION OF AN ANODE TERMINAL BOX IN THE BUILDING AND THE ELIMINATION OF TERMINALS IN THE TANK MANHOLE

6.01 Arrange for the installation of an anode terminal box with series resistors in each anode lead wire and the elimination of the terminal in the tank manhole in accordance with Drawing WA 21189 when the following conditions exist:

(a) The anode terminal block in the tank manhole may become submerged or it becomes severely corroded due to manhole moisture conditions and Items (b) or (c) following apply. Note: If tests indicate however, individual anode currents are nearly equal, and the tank to soil potentials are fairly uniform, then consideration should be given to the installation of a common series resistor as covered in Section 7 and the provision of an epoxy coating of "B" plug compound brushed over the terminals in the manhole. If the terminal in the manhole is the upright type ("B" cable terminal) with a dome cover then consideration might be given to removing it, and connecting all the anode leads together in a butt type joint, placing the joint in an eight ounce plastic water glass with "B" plug compound as outlined in Section 11.

(b) The anode to tank open circuit volts varies over a wide range causing a wide range in anode currents and the possibility arises of overloading the rectifier before satisfactory tank to soil potentials can be obtained.

(c) The anode to earth resistance varies over a wide range with a corresponding variation in anode currents and it becomes necessary to increase or decrease certain anode currents to bring about satisfactory tank to soil potentials opposite these anodes.

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*Note:* A certain amount of adjustment or equalization of the anode currents can be obtained by connecting together the center taps of the series resistors in the anode terminal box for the anodes taking small and large currents. Also, an increase in some anode currents can be obtained by making use of unused resistors in the anode terminal box, paralleling these resistors with resistors in the anode leads of those anodes to which it is desired to increase the current. A copy of Drawing WA 21189 should be marked to show any circuit changes and left at the rectifier.

(d) Lightning troubles are experienced with the rectifier and its associated filter.

### 7. CONDITIONS UNDER WHICH A COMMON SERIES RESISTOR MIGHT BE INSTALLED IN SERIES WITH THE POSITIVE RECTIFIER LEAD

7.01 A common series resistor might be provided in the positive rectifier lead if the tank to soil potentials measured around the perimeter of the tank are fairly uniform and changing from one rectifier step to another makes too great a change in the tank to soil potential. Tests indicate a common series resistor may be found practicable only when the earth resistivity is high (greater than about 50 meter-ohms). A common series resistor should not be used where the terminals in the tank manhole are corroding or may be at times submerged in water. In general more satisfactory all around results will be obtained by providing an anode terminal box and eliminate the terminals in the tank manhole in accordance with Drawing WA 21189.

7.02 Where a common series resistor is to be provided, use two Ohmite 160 watt size non-inductive resistors in an OEC-125 resistor cage. The 5, 10, 25 and 50 ohm sizes of resistors (Paragraph 14.06) can be connected in series or parallel combinations to get the desired resistance. The value of resistance should be calculated so that the voltage drop across the resistance is at least 8 or 10 volts. The resistor cage can be mounted on the side of the rectifier with four 1/4 inch dia. x 1/2 inch long bolts. Where the type "N" rectifiers are installed, the installation of the resistor cage should be located where convenient.

7.03 A 118-A protector should be connected between the anode side of the resistor and the station ground bus bar. If lightning troubles are experienced a KS 14595 capacitor should be used in parallel with the protector.

### 8. MEASUREMENT OF TANK TO SOIL POTENTIAL

8.01 The measurement of the tank to soil potential is generally made on the surface of the ground around the perimeter of the tank and in the curb box. Where an asphalt covering or a gravel covering has been placed on the surface of the ground, it may be possible to measure the tank to soil potential only in the curb box. Under such conditions the current per anode should be made approximately equal. An anode terminal box should be provided to insure this equalization. The tank to soil potential around the tank can then be assumed to be the same as in the curb box.

### 9. INITIAL TESTING AND APPLICATION OF REMEDIAL MEASURES - MAGNESIUM ANODE INSTALLATION

9.01 The initial testing work on magnesium anode installations consists of measuring the individual open circuit anode to tank voltages, anode to tank resistance (not including any series resistance), closed circuit anode currents and the tank to soil potential. The tank to soil potential should be measured with the anode disconnected and connected. The results of tests on single tanks should be recorded on Form P-2808.

9.02 As mentioned in Paragraph 1.04, magnesium anodes are being installed for the 300 to 2,000 gallon size tanks except at certain locations. These anodes are being installed on a cross the board basis and it has been found that in 50 per cent of the cases insufficient current is drawn by the anodes to provide a tank to soil potential of at least -0.85 volt to a copper-copper sulphate half cell reference. Where tests indicate insufficient protection is being secured and adequate protection is required, it will be necessary to arrange for the installation of a rectifier to force drain current to the magnesium anodes. When these magnesium anodes fail they should be replaced by Durichlor anodes in accordance with Drawing WA 19012. The plan shown on Drawing WA 21189 should be used because of conduit space limitations for the anode lead wires.

9.03 An inspection should be made of the tank and piping for incomplete tape-coating work. Where such incomplete work is found, it should be patched as outlined in Section 12 - PATCHING TAPECOAT COVERING ON TANKS.

**10. INITIAL TESTING AND GENERAL APPLICATION OF REMEDIAL MEASURES - RECTIFIER INSTALLATION**

10.01 From the previous discussion it will be evident that the electrolysis tester may be faced with a variety of situations in order to place in operation a cathodic protection system for a tank installation. The fundamental installation is in place but minor changes may have to be made to place the installation in satisfactory operation. The following may be used as a guide in placing the protection system in operation. First check to see that the negative side of the rectifier is connected to the tank and the positive side to the anodes.

**10.02 Installation with Anode Terminal Box Installed Adjacent to the Rectifier**

(a) Determine the earth resistivity in an area near the tank clear of other underground structures if equipment is available to do so. Record the results in Block 1 on Form P-2808. Refer to Figure 1 and determine the probable current per anode for the earth resistivity measured.

(b) Open the anode terminal box and count the number of anodes connected. Multiply the number of anodes by the current per anode determined in (a) above and adjust the output current of the rectifier as near as possible to this value of current. If the earth resistivity is not known use a figure of 50 milliamperes per anode in high earth resistivity (sandy or mountainous) areas and 100 milliamperes per anode in low earth resistivity (clay or black loam) areas.

(c) Open the tank manhole and measure the tank to soil potential (with the rectifier turned off and on) to a copper-copper sulphate half cell reference electrode with the electrode lowered to the bottom of the plastic curb box adjacent to the tank. Re-adjust the rectifier output current to make the tank to soil potential about -0.95 volt. Make similar measurements of the tank to soil potential in case of multiple tank installations. Readjust the rectifier output, if necessary, to make the average of these potentials about -0.95 volt.

(d) Measure the individual anode currents by the method outlined in Paragraph 4.02. The individual anode currents should be within about  $\pm 10$  percent of the average current per anode. The current to any individual anode may be increased by paralleling resistors or shorting out some resistors but this should not be done unless the measurements of the tank to soil potential in the next step (e) indicate it is necessary.

(e) Measure the tank to soil potential around the perimeter of the tank at the surface of the earth at the locations indicated in Block 2 on Form P-2808 and record the results on this form. These potentials may be equal to the potential at the bottom of the curb box or possibly about 0.2 volt less negative. A potential of -0.75 or -0.85 volt should be satisfactory for the surface potential measurements provided the potential at the bottom of the curb box is not more than about -0.95 volt. Where thick gravel or black top has been placed over all or parts of the tank, it may be impractical to measure potentials through these materials especially where it is very dry. In such cases the potential at the bottom of the curb box may have to be relied on as a criterion.

(f) Record the final value of resistance used in series with the anodes on Form P-2808. Record also the voltage of the rectifier and the rectifier output current as read on the meter on the rectifier after all adjustments have been completed.

(g) Measure the open circuit anode to tank potential and anode to tank resistance (do not include the series resistance in the anode terminal box) and record these measurements on Form P-2808. Disconnect the positive rectifier lead from the bus bar in the anode terminal box and measure the resistance between this bus bar and the station ground. Record this measurement on Form P-2808. Complete Form P-2808 for any other items applicable.

(h) Where all conditions are satisfactory except that changing the rectifier one step causes too great a change in the tank to soil potential, either install a series resistor in the positive anode lead wire in accordance with Section 7 or where an anode terminal box is installed with all resistors of 25 ohm value, replace the right hand 25 ohm resistors in the anode terminal box with 100 ohm noninductive resistors, Ohmite Cat. No. 2005. These should be ordered from the manufacturer of the anode terminal box. The resistors can be easily replaced.

(i) The situation may be found where two or three anodes take a greater portion of the current than the other anodes where an anode terminal box is equipped with 25 ohm resistors only. All of the right hand resistors should be replaced with 100 ohm resistors. This should provide satisfactory equalization of the anode currents. The later installations of anode terminal boxes are being furnished with 25 ohm resistors on the left side and 100 ohm resistors on the right side.

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### 10.03 Installation with Buried Cable Terminal in Fuel Oil Tank Manhole

- (a) Determine the earth resistivity in an area near the tank clear of other underground structures if equipment is available to do so. Record the results in Block 1 of Form P-2808. Refer to Figure 1 and determine the probable current per anode for the earth resistivity measured.
- (b) Open the fuel oil tank manhole and remove the green dome cover from the cable terminal. A Holloway shunt will be found connected in series with each anode lead wire. Count the number of anode lead wires. Multiply the current per anode determined as in (a) above by the number of anodes. Turn on the rectifier and adjust the output current as near as possible to the value of current thus determined. If the earth resistivity is not known use a figure of 50 milliamperes per anode in high earth resistivity (sandy or mountainous) areas and 100 milliamperes per anode in low earth resistivity (clay or black loam) areas.
- (c) Measure the tank to soil potential (with rectifier turned off and on) to a copper-copper sulphate half cell reference electrode with the electrode lowered to the bottom of the plastic curb box adjacent to the tank. Where the installation is not equipped with a plastic curb box, locate the half cell over the end of the tank at the manhole end. Re-adjust the rectifier output to make the tank to soil potential as near as possible to -0.85 volt.
- (d) Measure the tank to soil potential with the half cell located above the edge of the tank at the locations shown in Block 2 on Form P-2808 and record the results on this form. These potentials should be about -0.85 volt to -0.95 volt.
- (e) Measure the individual anode currents by measuring the millivolt drop across each Holloway shunt. (One millivolt measured on the shunt equals 100 milliamperes). In high earth resistivity areas the individual anode currents may be permitted to vary as much as 50 percent or more and there could still be fairly uniform tank to soil potentials around the tank as measured in (d) above. In low earth resistivity areas the anode currents should not vary more than about  $\pm 10$  percent of the average for best results.
- (f) Where it is necessary to equalize the anode currents, 100 ohm noninductive resistors may be installed in place of the Holloway shunts provided water never rises high enough in the manhole to submerge the live parts of the buried cable terminal for

any appreciable length of time. If the water does rise high enough to submerge the live parts, an anode terminal box should be installed as outlined in Section 6. Where the Holloway shunts are replaced by resistors, the spring mounting clips furnished with the resistors can be utilized in mounting the resistors. The bent portion normally inserted in the end of the resistor should be straightened out and the end soldered to the resistor terminal. The hole in the spring clip must be reamed out slightly to fit over the size of terminal post provided on the buried cable terminal. The green dome cover for the buried cable terminal must be discarded as it will not fit over the resistors mounted on the cable terminal. It will cost much less to replace the Holloway shunts with 100 ohm Ohmite noninductive resistors, where water conditions permit, than to install the anode terminal box.

(g) While the anodes are disconnected measure the open circuit anode to tank voltage and anode to tank resistance for each anode. Record the results on Form P-2808.

(h) With all resistances connected in the final arrangement, complete Form P-2808 for tank to soil potential, resistance added, anode currents, and the rectifier current and rectifier voltage as read on the rectifier.

### 10.04 Installation with P-222 Porcelain Block Terminal in Fuel Oil Tank Manhole

(a) Where the anode lead wires have been brought into the tank manhole and terminated on one or two P-222 Porcelain Blocks, the individual anode currents cannot be measured with the testing equipment normally available without first breaking open the soldered connections. To facilitate future testing work an Anode Terminal Box could be installed in accordance with Section 6 if the P-222 Porcelain Block is likely to become submerged by water in the manhole. If there is no water problem, then an Electrolysis Resistance Mounting Board could be installed which is much cheaper than the Anode Terminal Box. The Electrolysis Resistance Mounting Board is described in Paragraph 14.09.

(b) If the tank to soil potential is uniform around the tank, the necessity for measuring the individual anode currents becomes questionable, however, it may be found that the lowest step on the rectifier results in too high a tank to soil potential or changing the rectifier one fine step will result in too high a tank to soil potential. If this is the case resistance must be installed in series with the positive rectifier lead, and it is

preferable to provide 100 ohm resistances in series with each anode lead wire by either one of the means outlined in (a) above than to provide a common series resistor as outlined in Section 7.

(c) The installation of the resistors in each anode lead wire serves to equalize the individual anode currents, make a more uniform raised earth potential field around the fuel oil tanks and provide a fine control of variations in the tank to soil potential with changes in the fine output control on the rectifier.

(d) Measurements of tank to soil voltages, anode currents and other tests as outlined in 10.03 should be made and recorded on Form P-2808.

10.05 Grounding Chain Link Fence to Avoid Affecting the Fence Adversely

(a) There may be some locations where the anodes are located close to the chain link fence enclosure or the earth resistivity is so high that the fence may be affected adversely if it is not bonded to the office grounding system. On the earlier installations the fence was not bonded; on the later installations the fence is specified to be bonded to the office grounding system in accordance with Figure 2, which is a part of the architects base Drawing No. KSM-14 covering Standard Fencing and Cattle Guard Details. An inspection of the fence should be made for the grounding connections as shown on Figure 2 and arrangements made to ground the fence as required.

10.06 Rectifier Replacement - A value of -0.85 to -0.9 volt tank to soil potential at the surface of the earth is desired. The 3 ampere rectifier will be found large enough to provide this requirement for all single tank installations and many two and three tank installations. The three ampere rectifier was specified on the first multiple tank installations but the specifications were later changed to install the 12 ampere size for all multiple tank installations. The Good-All rectifier Type AN20-3AFZ (20 volt, 3 ampere) is interchangeable with the Type AN18-12AFZ (18 volt, 12 ampere) rectifier as far as wall mounting is concerned. It is thus possible to interchange these two types if required. The earliest installations used the Good-All Type N20-3 (20 volt, 3 ampere) rectifier which is of different construction.

10.07 Plastic Curb Box - The plastic curb box is illustrated on Drawing WA 19012 together with the locations where they are specified to be installed. Ordering information is given on the drawing. It is an insulating

pipe extending from the surface of the ground to a point just below the center line of each tank and alongside the tank midway between the two ends of the tank. The plastic curb box is 7-3/4 inches in diameter across the top and the body is 4-7/8 inches inside diameter. This curb box is large enough so that a half cell can be lowered inside after the lid is removed. Curb boxes were not specified for the first tank installations. Where the surface of the ground is black topped or covered with gravel, curb boxes should be installed to provide a reference location for the measurement of tank to soil potentials.

11. **REMEDIAL MEASURES - WATER CONDITIONS SUCH THAT ANODE LEAD TERMINALS IN TANK MANHOLE MAY BE SUBMERGED**

11.01 No Equalizing Resistors Required -

Where no series resistors are required in the individual anode leads to equalize the currents to the anodes, and water conditions are such that the terminal may be submerged or the terminals are corroding badly, the following procedure may be used: (this method makes it impractical to measure the individual anode currents without special measuring equipment, and it would be preferable to install an anode terminal box in accordance with Drawing WA 21189).

- (a) Remove the anode lead wires from the terminals in the tank manhole.
- (b) Remove all parts of the terminal except the part fastened to the manhole wall.
- (c) Obtain a split bolt connector for 1/0 stranded wire (Reliable No. 1/F) and make a butt joint of the No. 8 anode lead wires and the positive D.C. output wire from the rectifier. Insert the butt joint into an 8 oz. clear plastic water tumbler (dime store item).
- (d) Mix together the ingredients of a can of "B" plug compound (Spec. AT 7751), 100 gram size, and pour the mixture in the water tumbler around the butt joint. Secure the tumbler in an upright position until the compound sets. (100 grams is approximately 3-1/2 ozs. and 232 grams is approximately 8 ozs.)
- (e) Secure the tumbler to the part of the terminal left fastened to the manhole wall to keep the tumbler above the possible water level.

11.02 Equalizing Resistors Required in All Anode Lead Wires - Arrange to install an anode terminal box in accordance with Drawing WA 21189 to equalize the anode currents. This drawing also provides for eliminating the anode terminals in the tank manhole.

## SECTION 171-199-902PT

### 12. PATCHING TAPECOAT COVERING ON TANKS AND PIPING

12.01 An inspection should be made of the tapecoating of the tank and piping in the tank manhole. Any part of the tank or piping, except the drain-off cap, not covered with Tapecoat should be patched as outlined in the following. It may be possible that the swing joints in the fill and vent pipes may not stay watertite and have not been covered with Tapecoat. Bare joints or uncovered portions of the tank under the surface of the ground can be located, where it is considered necessary and practical to do so, by the tone method of Holiday detection. M-45 Butyl Rubber Moulding Tape together with W-31 Butyl Rubber Primer should be used for patching and waterproofing. The Butyl Rubber Moulding Tape can be applied in all temperatures. The moulding tape when covered with a layer of Chasekote No. 750 Tape can be expected to stay flexible and allow the swing joints to turn appreciably without the seal around the joints being broken.

- (a) Surface Preparation - Before applying the primer, prepare the surfaces by wire brushing to remove any rust, scale, dust or dirt. Oil or grease should be removed with a suitable solvent. The surface of the metal should be as dry as it is practical to make it.
- (b) Primer - Brush on a coat of W-31 Butyl Rubber Primer. It dries very quickly. Only a small amount of surface should be covered at one time.
- (c) Application - M-45 Butyl Rubber Moulding Tape is applied spirally cold with a minimum of overlap. More than one layer can be applied to provide a thicker coating as the Moulding Tape will adhere to itself. It will form a soft homogeneous mass adhering to the metal to which it is applied. It is furnished in two inch wide rolls with a polyethylene separator between the layers on the roll; the polyethylene separator should be discarded. Chasekote No. 750 has a Butyl Rubber adhesive and should be used as an outer protection for the soft moulding tape.

### 13. DAMAGE DUE TO LIGHTNING

13.01 Parts Replacement - The most probable parts that may be damaged by lightning surges with a correctly wired rectifier are the 1,000 mfd. 50 volt capacitor, the meter and its associated switch and the selenium stack. A spare of each of these parts should be available for replacement purposes. One each of the 3 ampere and 12 ampere selenium

stacks should be available. Any spare parts needed on a rush basis may be obtained by telephoning the Rectifier Plant Manager of the Good-All Electric Company, at Ogallala, Nebraska, Telephone Number 308-284-4081.

### 14. MATERIAL ORDERING INFORMATION

14.01 The terminal block used in the first installations in the tank manholes, to terminate the anode lead wires and mount the Holloway shunts, is similar to the KS 16551 terminal or the "B" underground cable terminal. It is no longer being specified. The terminal blocks used were made by the Utility Products Company, 3111 West Mill Road, Milwaukee 9, Wisconsin. The following information is being furnished in case it is desired to order any replacement parts for the buried cable terminals or any of the other items not listed in the catalog of supplies.

CABLE TERMINAL CAT. NO.	DOME	CAPACITY	EQUIPPED FOR
8 PM 12#	6" DIA X 8" HIGH	12 PR.	6 PR. *
15 PM 36#	6" DIA X 15" HIGH	36 PR.	6 PR. *

\*FURNISHED WITH ONE CAT. NO. L1B6 BLOCK. TO EQUIP TERMINAL FOR ADDITIONAL CAPACITY, ONE CAT. NO. L1B6 BLOCK MUST BE ORDERED FOR EACH ADDITIONAL 6 PAIRS.

#THE DESIGNATION PM INDICATES THE TERMINAL IS EQUIPPED WITH A GALVANIZED BRACKET FOR POLE MOUNTING.

14.02 P-222 Porcelain -- This is a 10 terminal porcelain block similar to the Western Electric 84-B protector mounting. The 84-B protector mounting is rated "Manufacture Discontinued." The 84-B protector mounting can be used where the P-222 Porcelain is specified. The P-222 Porcelain may be obtained from:

Reliable Electric Company  
11333 Addison Street  
Franklin Park, Illinois

This information is being furnished in case a replacement is desired. The P-222 Porcelain is no longer being specified.

14.03 The protector furnished as part of the Anode Terminal Box is made by the Reliable Electric Company. It consists of one or more (depending upon the size of the Anode Terminal Box) 5 pair protector mountings No. 224 equipped with P-495-L discharge blocks and P-663 carbon blocks. A P-222 Porcelain is used in the No. 224 Protector Mounting. The Reliable Electric Company's discharge blocks and carbon blocks are interchangeable with Bell System blocks as follows:

CARBON BLOCK	DISCHARGE BLOCK	AIR GAP	BELL SYSTEM BLOCK
P-663	P-495-L	.006"	26-30
P-663	P-495-Y	.01"	26-31A

14.04 Split Bolt Connector for 1/0 stranded wire available at electrical supply houses such as Graybar. Reliable No. 1/F is suggested. Other brand names are available.

14.05 W-31 Butyl Rubber Primer, M-45 Butyl Rubber Moulding Tape and Chasekote No. 750 Tape. The primer comes in gallons but it may be obtained in quarts. The moulding tape is supplied in 2 inch wide by 50 feet long rolls with a polyethylene film between the layers to prevent the layers sticking together. The No. 750 tape is a polyethylene tape with a butyl rubber adhesive to be compatible with the moulding tape. The No. 750 tape is supplied in 100 foot rolls and the minimum width is one inch. These materials may be ordered from:

Fuller Engineering Sales  
5940 Reeds Road  
Mission, Kansas 66204  
Tel. No. 913-262-1231

14.06 Vitreous Enameled Resistors and Resistor Cages. Noninductive resistors should be used in the positive d.c. lead for lightning reasons. They should be placed in a resistor cage for mechanical protection. When two resistors are placed in a cage and connected in the circuit the current rating is reduced to about 66 percent of the rated current in free air. The size resistors which most likely will be used as discussed in Paragraph 7.02 are as follows:

OHMITE CAT. NO.	OHMS	CURRENT RATING IN CAGE		NOMINAL WATTS RATING
		ONE RESISTOR CONNECTED	TWO RESISTORS CONNECTED	
2401	5	5.66 AMPERES	3.73 AMPERES	160
2402	10	4.0 AMPERES	2.64 AMPERES	160
2403	25	2.53 AMPERES	1.67 AMPERES	160
2404	50	1.79 AMPERES	1.18 AMPERES	160

The 160 watt noninductive resistor dimensions are 1-1/8" x 8-1/2".

A. Cat. No. OEC-125 resistor cage for two resistors, is available from Petroleum Electronics Manufacturing, Inc., 3301 Charles Page Boulevard, Tulsa, Oklahoma. The resistor cage should be ordered equipped with the size Ohmite resistors required because of the small parts mounting details required.

The Cat. No. OEC-125 resistor cage measures 3" high x 3-7/8" x 11-7/16" long overall. The cage is equipped with two mounting brackets with 5/16" wide slots. The mounting hole centers are 10-1/4" apart.

14.07 Ohmite Cat. No. 2005 noninductive, 50 watt, 100 ohm resistors should be ordered from Custom Control, Inc., 5601 Merriam Drive, Merriam, Kansas. This Company manufactures the anode terminal box and is in a position to ship a small quantity of 10 or more resistors upon receipt of order.

14.08 Filter for Type N20-3 Rectifier (Rectifier with round case). Order from Good-All Electric Company, Ogallala, Nebraska per Good-All Electric Company Drawings 52A229, in enclosure per Drawing 52C193.

14.09 Electrolysis Resistance Mounting Boards for mounting 10 or 20 Ohmite 50 watt noninductive resistors in locations where the P-222 Porcelain is to be eliminated may be obtained from the Alexander Plastic Company, 911 West Commerce Street, Dallas, Texas, 75208, Telephone 214-748-9538. Specify on order ATT-10 or ATT-20 for mounting 10 or 20 resistors. The mounting board is made of 1/4 inch thick plastic material in the shape of an L 6-1/2" high and 1-1/2" wide and about 15-1/2" and 31" long for the 10 and 20 resistor sizes, respectively. All necessary holes are drilled except the holes in the 6-1/2" high part of the L for securing the mounting board to the cable straps mounted on the wall from which the P-222 porcelains were removed. The 3/16" holes required to be drilled to secure the mounting board to the cable straps will have to be tailored for each location. The following is furnished with each mounting board:

	NO. OF RESISTORS	
	10	20
3/4" LONG 8-32 RHB MACHINE SCREWS	20	40
8-32 BRASS NUTS	40	80
NO. 8 BRASS WASHERS	20	40
T & B LUG NO. 14-6	11	21
3/4" LONG 10-24 RHB MACHINE SCREWS	2	2
10-24 BRASS NUTS	2	2
NO. 10 BRASS WASHERS	4	4
BASIC MOUNTING BOARD	1	1
DRIP SHIELD	1	1

The 50 watt 100 ohm Ohmite noninductive resistors are not furnished and may be ordered from Custom Control, as outlined in Paragraph 14.07.

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**15. DRAWINGS - Not Attached**

- DRAWING WA 19012.....ELECTROLYSIS PROTECTION SYSTEMS - FUNDAMENTAL INSTALLATION GUIDE FOR ORIGINAL TANK INSTALLATIONS OR REPLACEMENT OF TANKS DUE TO CORROSION.
- DRAWING WA 21169.....SEPARATE FILTER FOR TYPE "N" RECTIFIER.

**Drawings - Ordering Information**

Order drawings from:

Long Lines Dept.,  
Room 506, 74 New Montgomery Street  
San Francisco, California

Use Long Lines Form GP-45  
(Obtain from 415-397-6800 Loc 442)

**16. ATTACHMENTS**

- FIGURE 1..... GRAPH OF MILLIAMPERES PER ANODE VS. EARTH RESISTIVITY IN METER-OHMS.
- FIGURE 2..... STANDARD FENCE GROUNDING ARRANGEMENT.
- DRAWING WA 18665..... 20 VOLT, 3 AMPERE RECTIFIER WITH FILTER.
- DRAWING WA 18974..... 18 VOLT, 12 AMPERE RECTIFIER WITH FILTER.
- DRAWING WA 21168..... 18 VOLT, 3 AMPERE TYPE "N" RECTIFIER.
- DRAWING WA 21189..... SCHEMATIC CIRCUIT OF ANODE TERMINAL BOX. (INCLUDES MODIFICATION OF EXISTING FUEL TANK ELECTROLYSIS PROTECTION SYSTEMS TO INCORPORATE THE ANODE TERMINAL BOX AND ELIMINATE THE TERMINAL BLOCK IN THE FUEL TANK MANHOLE.)
- FORM P-2808..... RESULTS OF CORROSION TESTS ON FUEL OIL TANKS.

**17. TROUBLE SHOOTING GUIDE**

<u>SYMPTOM</u>	<u>POSSIBLE TROUBLE</u>
NO D.C. VOLTAGE OR CURRENT.....	A.C. FUSE IN RECTIFIER BLOWN. D.C. FUSE BLOWN. WALL SWITCH ABOVE RECTIFIER OPEN. CIRCUIT BREAKER IN DISTRIBUTION CABINET OPEN. RECTIFIER STACK SHORTED. WIRING BURNED OPEN. FILTER CAPACITOR SHORTED. FILTER CAPACITOR CIRCUIT OPEN (NOTE 1). METER DAMAGED. METER SWITCH DAMAGED.

<u>SYMPTOM</u>	<u>POSSIBLE TROUBLE</u>
----------------	-------------------------

D.C. VOLTAGE BUT NO D.C. CURRENT.....	D.C. FUSE BLOWN. SHUNT BURNED OPEN. METER SWITCH DAMAGED. FILTER CAPACITOR CIRCUIT OPEN (NOTE 1).
D.C. CURRENT BUT NO D.C. VOLTAGE .....	VOLTMETER SIDE OF METER CIRCUIT OPEN. METER SWITCH DAMAGED. WIRING BURNED OPEN. FILTER CAPACITOR CIRCUIT OPEN (NOTE 1)
LOW D.C. VOLTAGE FOR NORMAL STEP.....	TROUBLE IN VOLTMETER. ONE ELEMENT OF RECTIFIER STACK DEFECTIVE. FILTER CAPACITOR CIRCUIT OPEN (NOTE 1).
LOW D.C. OUTPUT).....	(ONE OR MORE ANODE LEAD WIRES OPEN. (ONE OR MORE RESISTANCES IN ANODE TERMINAL BOX OPEN.
D.C. VOLTAGE )	
D.C. VOLTAGE )	
NORMAL. )	
HIGH D.C. OUTPUT CURRENT, )	(ONE OR MORE PROTECTORS PERMANENTLY GROUNDED IN ANODE TERMINAL BOX.
D.C. VOLTAGE )	
NORMAL. )	

NOTE (1) THE 1000 MFD, 50 VOLT CAPACITOR IS PRACTICALLY A SHORT CIRCUIT TO LIGHTNING SURGES AND HAS BEEN FOUND VERY EFFECTIVE IN PREVENTING TROUBLES DEVELOPING IN RECTIFIERS. FOR THIS REASON AN OPEN IN THE CAPACITOR CIRCUIT SHOULD BE SUSPECTED IN CASE ANY EQUIPMENT IS DAMAGED DUE TO LIGHTNING SURGES.

**18. REPORTS AND RECORDS**

18.01 Lightning Damage Report - A report of lightning damage to any part of the fuel oil tank cathodic protection system should be made on an "Abnormal Report." Forward the report through lines of organization\* to Toll Service Supervisor and General Plant Operations Manager-Toll. The General Plant Operations Manager-Toll will report to Long Lines if station is owned by them.

\*It is expected that this report will normally originate with the testrooms after the cathodic protection system is placed in service, since the periodic routine tests on the rectifier will be made in connection with other scheduled tests and inspections at the station.

18.02 Initial Tests on Rectifier - A copy of Form P-2808 showing the initial test results shall be prepared by the electrolysis forces and distributed as follows:

Chief Engineer	1 Copy
District Plant Manager-Toll	1 Copy
General Plant Manager	1 Copy
Office Making Routine Tests and Inspections	1 Copy
Record Binder at Rectifier	1 Copy

18.03 Initial tests on the rectifier should include a record of the D.C. open circuit voltage for Steps 1 to that step which results in rated D.C. voltage output. A record of this should be attached to the rectifier for future trouble shooting purposes.

18.04 Initial tests on the rectifier should include the voltage across each individual resistor and protector in the anode terminal box after the final adjustment of individual anode currents. It may be found necessary to short out one of the series resistors or parallel unused resistors with working resistors to adjust the individual anode currents to the desired value. The potentials across the resistors and protectors should be measured, recorded in Table A on Drawing WA 21189 and attached to the rectifier for future trouble shooting purposes. Drawing WA 21189 should be marked also to show any necessary changes in the resistor circuits as outlined above.

18.05 Attach a supplemental sheet to the initial Form P-2808 and add the following data:

1. Type protection (Rectifier and impressed current anodes or galvanic anodes).

2. Made ground data.
  - a. Core Material
  - b. Backfill
  - c. No. of units
3. Rectifier Data
  - a. Type
  - b. Rated DC output (volts and amps.)
  - c. Actual DC output (volts and amps.)
  - d. Rectifier Protection Filter.
4. Indicate value of series resistance if used, or whether an anode terminal box is installed.

18.06 The responsibility for making the initial tests and adjustments, annual tests and periodic tests is covered in addendum 065-320-301PT.

18.07 Annual Tests - At this time no report will be required concerning the tests made on an annual basis. The record of rectifier output voltage and current maintained at the rectifier should be corrected to show the new values in case the annual tests show the need for a change in these values.

18.08 Where anode terminal boxes are installed the carbon blocks in the terminal box should be removed after the lightning season and inspected. Any grounded carbons should be replaced.

18.09 Routine Tests - No report of the periodic tests made by the testroom forces is considered necessary to be made to the District Office unless a considerable change in the output current is noted. This is covered in the addendum to Plant Series 065-320-301.

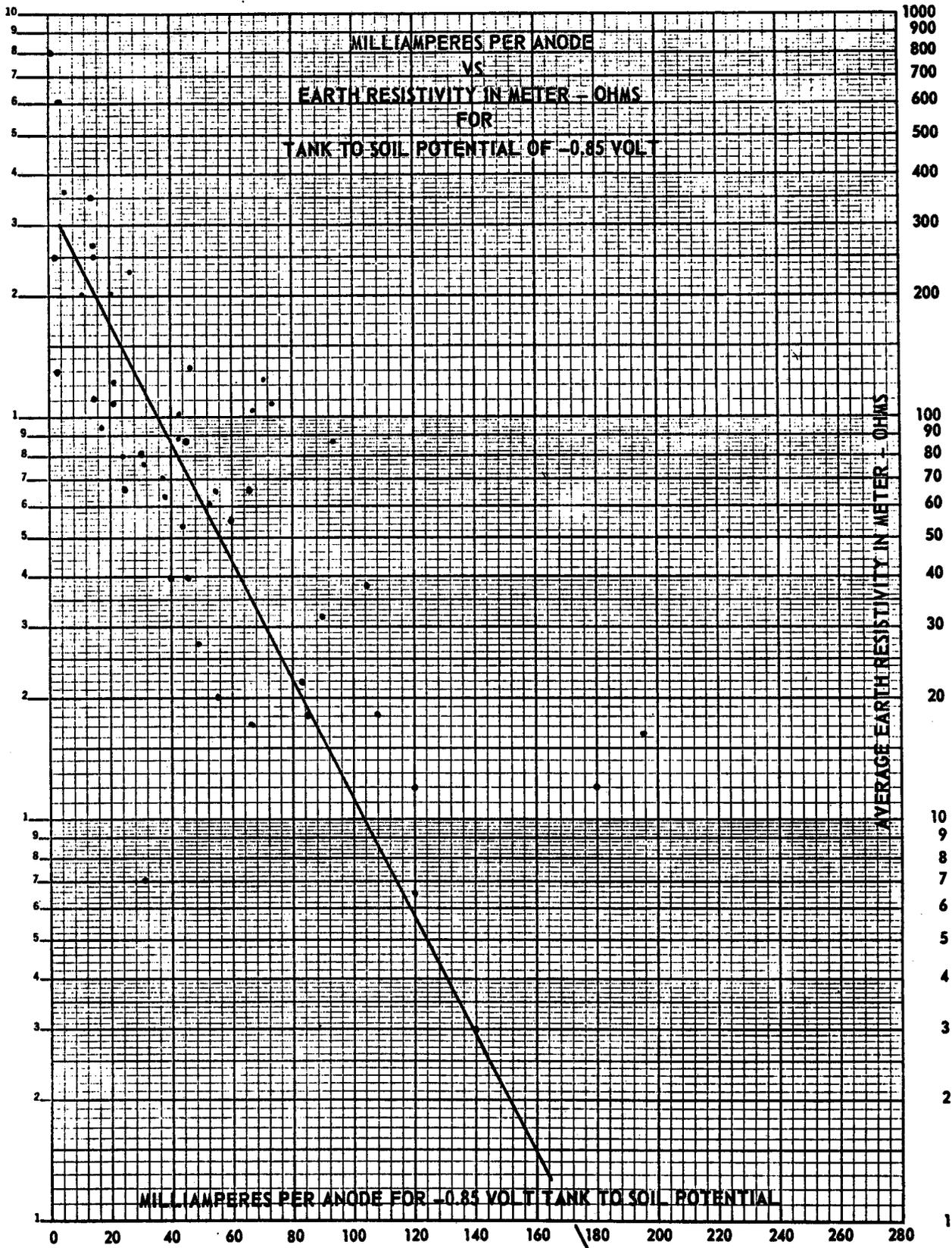
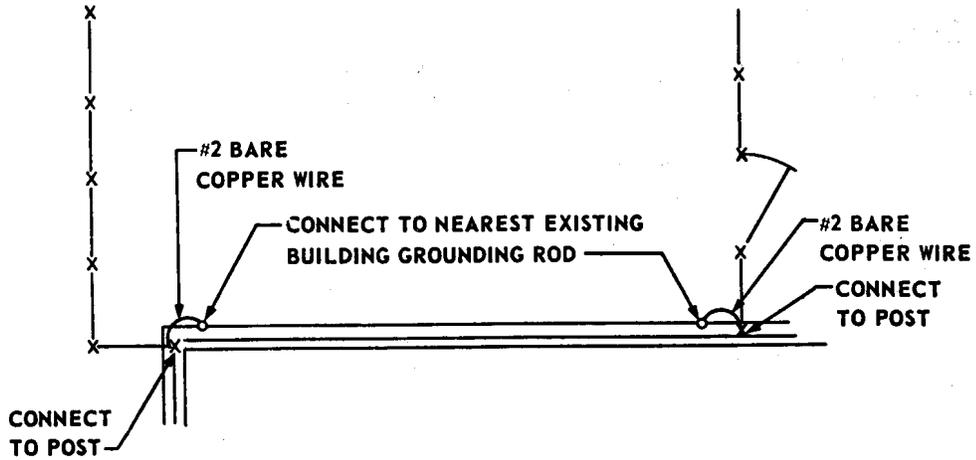
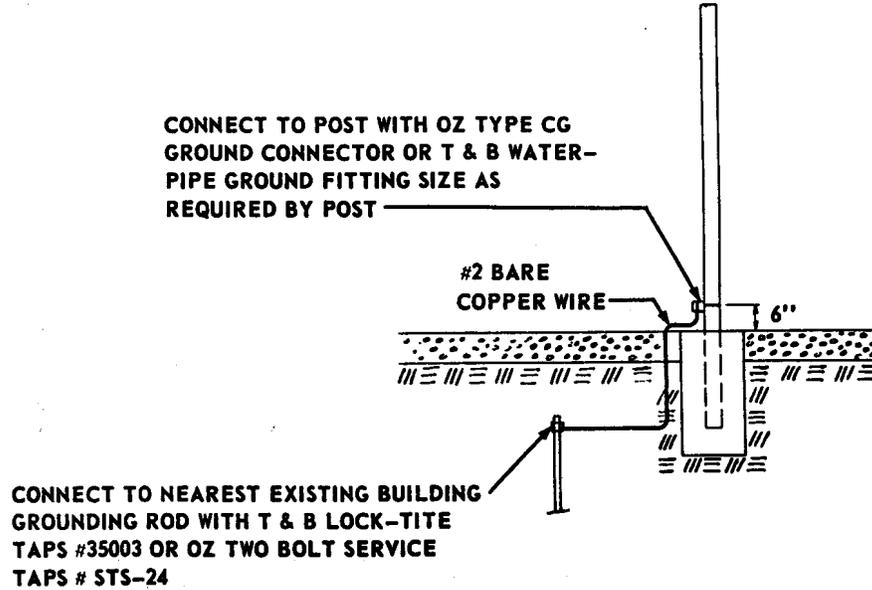


FIG. 1

METHOD OF GROUNDING THE CHAINLINK FENCE TO THE EXISTING BUILDING GROUNDING SYSTEM IS SHOWN BELOW:  
 (DETAILS BELOW ARE A PART OF ARCHITECTS BASE DRAWING KSM-14 COVERING "STANDARD FENCING AND CATTLE GUARD DETAILS")



TYPICAL PLAN OF CHAINLINK FENCE  
 (NOT TO SCALE)



TYPICAL CHAINLINK POST DETAIL  
 (NOT TO SCALE)

FIG. 2-STANDARD FENCE GROUNDING ARRANGEMENT

**CORROSION TESTS ON FUEL OIL TANKS**  
**REFERENCE BSP 635-461-901PT**

NAME OR ROUTE \_\_\_\_\_

STATION \_\_\_\_\_

TANKS - NO. & SIZE \_\_\_\_\_

DATE INSTALLED \_\_\_\_\_

TYPE OF ANODES \_\_\_\_\_

DATE INSTALLED \_\_\_\_\_

DATE OF TESTS \_\_\_\_\_

TESTERS \_\_\_\_\_

JOB OR ESTIMATE \_\_\_\_\_

BLOCK 1		
EARTH RESISTIVITY		
S	R	METER-OHMS
5'		
10'		
20'		

METER - OHMS = 1.92 SR  
 WHERE S = ELECTRODE  
 SPACING IN FEET.  
 R = MUTUAL RESISTANCE  
 IN OHMS

NOTES: SEE OTHER SIDE OF THIS FORM FOR  
 TYPICAL ARRANGEMENTS OF ANODES  
 AROUND TANKS.

- (1) APPLIES TO SINGLE TANK INSTALLATIONS.
- (2) APPLIES TO 2, 3 AND 4 TANK INSTALLATIONS.
- (3) APPLIES TO 3 AND 4 TANK INSTALLATIONS.
- (4) APPLIES TO 4 TANK INSTALLATIONS.

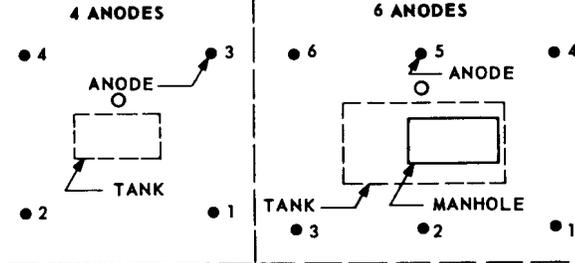
REMARKS \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

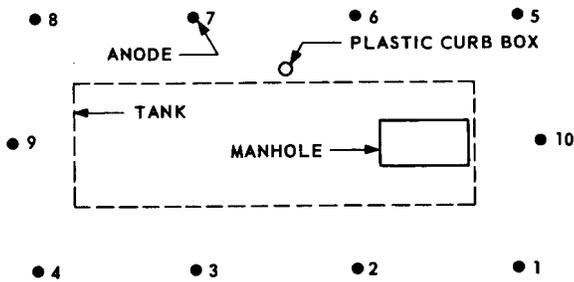
BLOCK 2											
ANODE NUMBER		TESTS ON ANODES						TANK TO SOIL POTENTIAL			
AS INDICATED IN TYPICAL ARRANGEMENT SHOWN ON REVERSE SIDE OF THIS FORM	AS SHOWN ON FUEL TANK INSTALL. DWG. FOR STATION. DRAWING WA _____	OPEN CIRCUIT ANODE TO TANK		ANODE CURRENTS IN MILLIAMPERES WITH SERIES RESISTANCE OF -OHMS			SERIES RESIS- TANCE ADDED IN OHMS	FINAL ANODE CURR- ENTS M.A.	APPROX. EDGE OR CORNER OF TANK OPPOSITE ANODE	APPROX. OVER ANODE LOCATION	
		VOLTS	RESIST.	NONE	25	50					100
1											
2											
3											
4											
5											
6								(1)	(2)		
7								(1)	(2)		
8											
9											
10								(1)	(3)		
11									(3)		
12											
13											
14									(4)		
15									(4)		
16											
17											
18											
19											
20											
SUM OF ANODE CURRENTS								MA			
MEASURED TOTAL ANODE CURRENTS								MA			
COMBINED ANODES TO TANK RESISTANCE								OHMS			
TANK TO SOIL POTENTIAL AT BOTTOM OF PLASTIC CURB BOX						TANK 1	TANK 2	TANK 3	TANK 4		
RECTIFIER OFF											
FINAL READING AFTER ADJUSTMENTS - RECTIFIER ON											
SERIES RESISTOR, IF REQUIRED, ADDED IN						FINAL RECTIFIER READINGS					
POSITIVE RECTIFIER LEAD _____ OHMS.						VOLTS _____	CURRENT _____	AMPS.			

TYPICAL ARRANGEMENTS OF ANODES AND TANKS

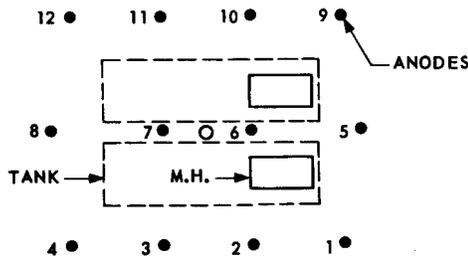
SINGLE TANK INSTALLATIONS



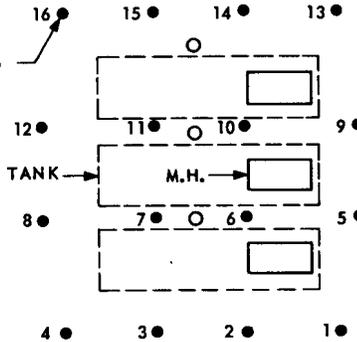
8 OR 10 ANODES



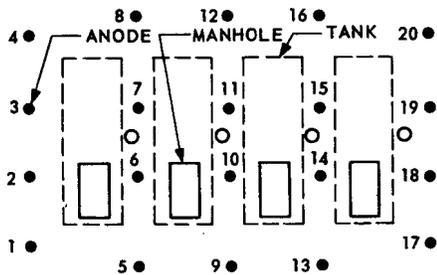
TWO TANK INSTALLATION



THREE TANK INSTALLATION



FOUR TANK INSTALLATION

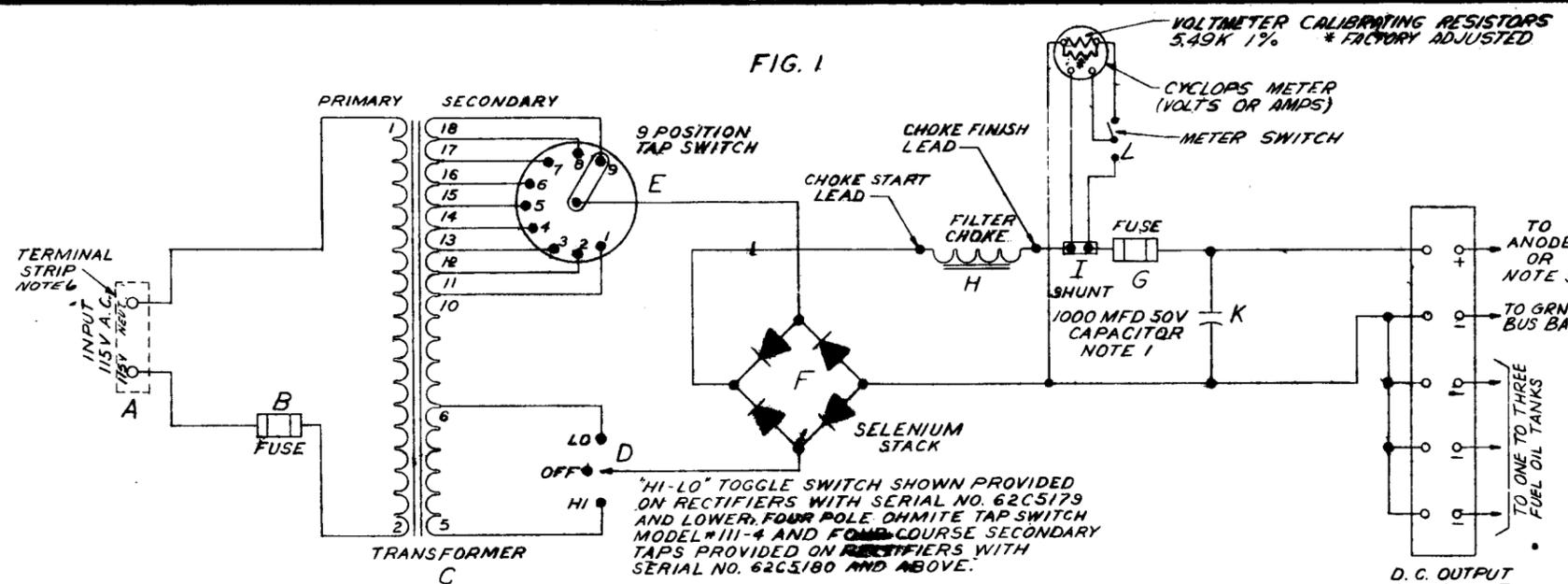


BLOCK 3			
TANK SIZE GALS.	DIMENSIONS		NO. OF ANODES
	APPROX. DIA.	APPROX. LGTH.	
120	2'2"	4'7"	4
300	3'1"	5'7"	4
550	3'1"	5'7"	6
1,000	4'3"	9'2"	6
2,000	5'4"	12'1"	6
3,000	5'4"	18'0"	6
4,000	5'4"	24'0"	8
5,000	6'0"	24'0"	8
7,500	8'0"	20'0"	8
8,000	8'0"	20'0"	8
10,000	8'0"	27'0"	10
12,000	9'0"	25'0"	10
15,000	9'0"	32'0"	10
10,000	8'	27'	10
	8'	32'	10
	9'	25'	10
15,000	11'	17'	8
	8'	40'	10
	9'	32'	10
	10'	26'	10
20,000	11'	21'	10
	11'	28'	10

○ PLASTIC CURB BOX, WHEN PROVIDED, CONSISTS OF NON-METALLIC PIPE WITH REMOVABLE HEAD 7 3/4" IN DIA. AT SURFACE OF GROUND AND AN OPEN BOTTOM 7' TO 8' DEEP ENDING WITH THE CENTER LINE OF TANK AND NEAR SIDE OF TANK. FOR TANK TO SOIL POTENTIAL MEASUREMENTS AT THE BOTTOM OF PIPE NEXT TO TANK.

NOTE: ANODE NUMBERING SYSTEM EMPLOYED BY ARCHITECTS HAS NOT BEEN UNIFORM. SEE FUEL TANK INSTALLATION DRAWING FOR STATION INVOLVED FOR ACTUAL NUMBERING.

**AN INITIAL SUPPLY  
OF FORM P2808  
HAS BEEN ATTACHED TO  
THIS PRACTICE TO ELIMINATE  
FIELD ORDERING.**



ISSUE	
6-5-63	REMOVED
10-28-63	CHG'D. NOTES
6-19-1964	CHG'D CHOKE COIL H FROM #115A TO #F1096 ADDED NOTE 6.

**A. TERMINAL STRIP**  
 KULKA # 601-2 (NOTE 6)  
**B. 1. FUSE HOLDER HXP-L**  
 250V (BUSSMAN)  
**2. FUSE AGC-3 (BUSSMAN)**  
**C. TRANSFORMER (NOTE 4)**  
**D. TOGGLE SWITCH # ST#2E**  
 SPDT JBT BRAND (ROES)  
**E. TAP SWITCH MODEL # III-9**  
 (OHMITE)  
**F. STACK # BIBQNEV**  
**G. 1. FUSE HOLDER HXP-L**  
 250V (BUSSMAN)  
**2. FUSE AGC-4 (BUSSMAN)**  
**H. CHOKE #F1096 COIL**  
 RESISTANCE 0.72 OHMS  
**I. SHUNT 5 AMP MODEL 45B**  
**J. CURTIS TERMINAL STRIP**  
 #RH-5 FOR 5 TERMINALS  
 AND H-7 FOR 7 TERMINALS  
**K. CAPACITOR 1000 MFD**  
 50VDC (MALLORY #HC5010)  
**L. METER SWITCH**  
 #MS3505B-27 TOGGLE  
 SWITCH SPDT  
**M. CYCLOPS METER (BEEDE)**  
 25V-5A, MODEL 45B

TO ANODES OR NOTE 5  
 TO GRND BUS BAR  
 TO ONE TO THREE FUEL OIL TANKS

**D.C. OUTPUT TERMINAL STRIP**  
 NOTE 3

DRAWING BASED ON  
 GOOD-ALL ELECTRIC CO.'S  
 DRAWING 52B225 REV. D

NOTES (CONT'D):  
 6. TO CONFORM WITH THE LATEST EDITION OF NFPA NO. 70-NATIONAL ELECTRICAL CODE THE MOST RECENT RECTIFIERS WILL HAVE A KULKA 601-3 TERMINAL STRIP WITH TERMINALS MARKED 115V, NEUT., AND GRND. (GRND TO CASE).

- NOTES:
- LEADS TO 1000 MFD CAPACITOR TO BE KEPT AS SHORT AS POSSIBLE & AWAY FROM OTHER WIRING.
  - WALL MOUNTING ARRANGEMENT FOR THE AN20-3AFZ RECTIFIER IS THE SAME AS FOR THE AN18-12AFZ RECTIFIER (8 VOLT - 12 AMPERE)
  - RECTIFIERS WITH SERIAL NOS. 62C5178 AND LOWER HAVE 5 TERMINALS, WITH SERIAL NOS. 62C5180 AND OVER HAVE 7 TERMINALS, 5 NEGATIVE AND 2 POSITIVE.
  - TRANSFORMER #2918 WITH FOUR COURSE TAPS ON THE SECONDARY PROVIDED WITH RECTIFIERS SERIAL NO. 62C5180 AND ABOVE, TRANSFORMER #2510-1 WITH HI-LO TAPS ON THE SECONDARY PROVIDED ON RECTIFIERS WITH SERIAL NO. 62C5179 AND LOWER.
  - TO ANODE TERMINAL BOX AT RECTIFIER LOCATION PER DWG. WA91656 FOR MODIFICATION OF EXISTING SYSTEMS OR DWG. WA19012 FOR NEW INSTALLATIONS. (CONTD TO LEFT)

**ELECTROLYSIS PROTECTION RECTIFIER**

20 VOLT 3 AMPERE  
 FUEL OIL TANK PROTECTION  
 MICROWAVE STATIONS  
 GOOD-ALL ELECTRIC CO.  
 RECTIFIER MODEL AN20-3AFZ

INITIAL PROJ.	DRAWN BY	CHECKED BY	DATE
	R.K.L.	D.R.W.	8-30-62

AMERICAN TEL. AND TEL. CO.  
 LONG LINES ENG. DEPT.  
 WESTERN AREA

**WA18665**

WA18665



ISSUE **M**

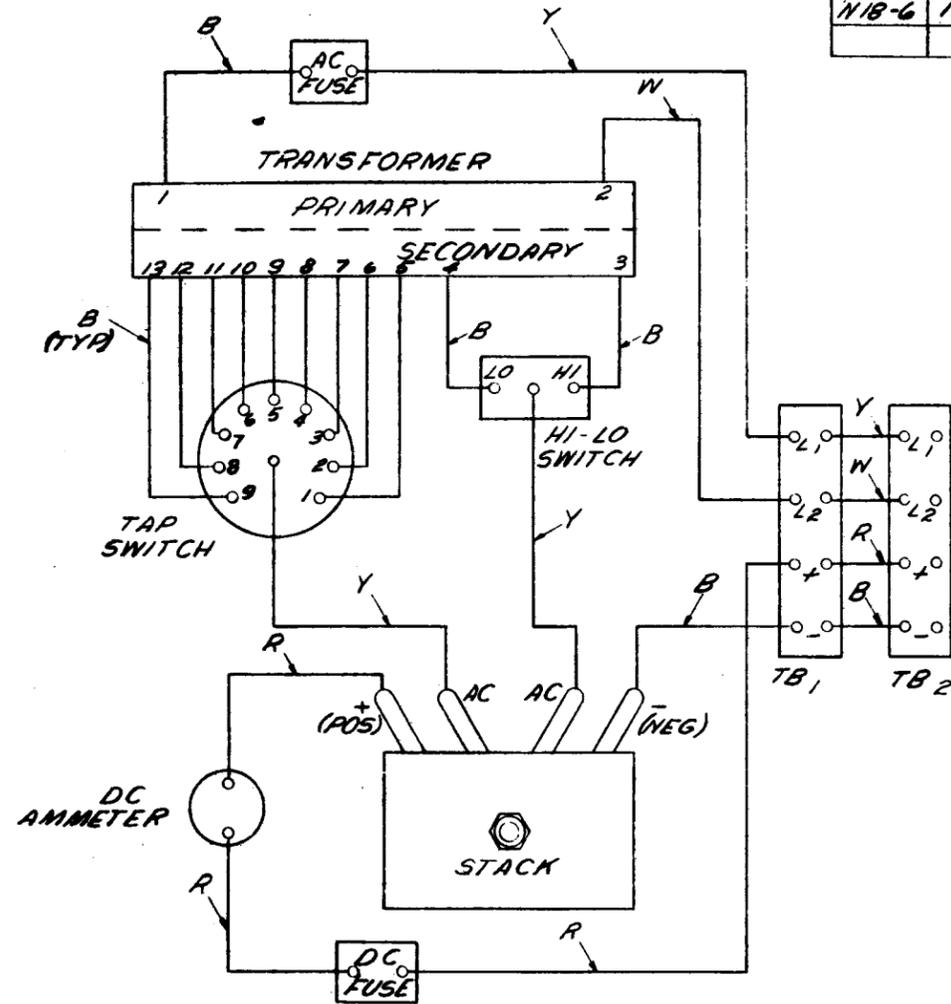
MODEL	CASE SIZE	WIRE SIZE		AC SPARE FUSE SIZE		DC SPARE FUSE SIZE	STACK CODE	TRANSFORMER SPEC. NO.		TAP SW. (OMITE)	TAP SW. KNOB (OMITE)	METER FACES	
		AC LINE	SEC	115V	230V			115V	230V			AMPS	RED LINE
N18-3	N-2	18	18	ABC-3	ABC-3	4	B1BQNIÉV	N1020	N1019	111-9	5116	0-4	3
N18-6	N-2	14	14	ABC-3	ABC-3	7 1/2	B1MQNIÉV	N1018	N1001	212-9	5116	0-8	6

WITH KNOB 5116 USE DIAL 379

NOTES:

- COLOR CODE B=BLACK; W=WHITE; Y=YELLOW; R=RED
- HI-LO SWITCH - CUTLER HAMMER #8802K6
- METER - BEEDE MODEL #411
- TB<sub>1</sub> & TB<sub>2</sub> - KULKA #602-4
- DC FUSE HOLDER - AMP #HXP-L  
AC FUSE HOLDER - 115 & 230V UNITS - AMP #HXP-L
- TB MARKING - L<sub>1</sub> YELLOW; L<sub>2</sub> WHITE; + RED; - BLACK

BASED ON GOOD-ALL ELECTRIC CO. DWG. 528240



**R**

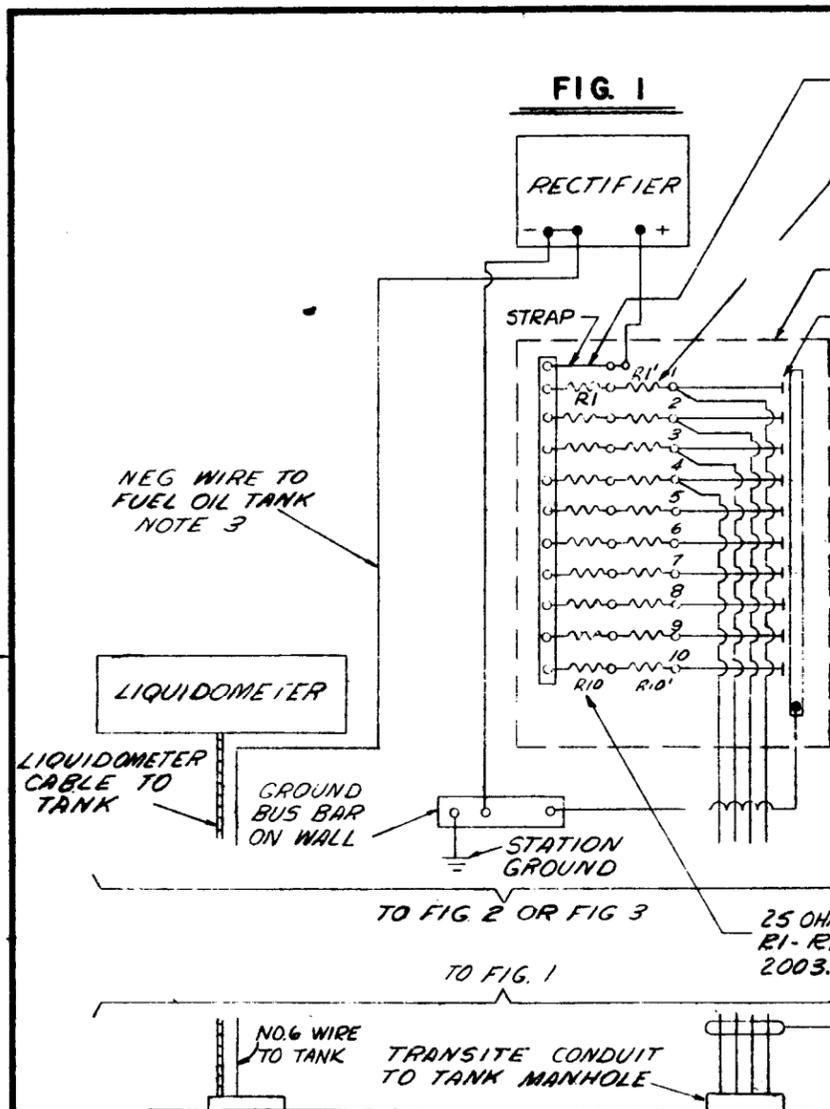
WA 21168

**ELECTROLYSIS PROTECTION RECTIFIER**  
 18 VOLT 3 AMPERE  
 FUEL OIL TANK PROTECTION  
 MICROWAVE STATIONS  
 GOOD-ALL ELECTRIC CO.  
 RECTIFIER TYPE "N"

INITIAL PROJ.	DRAWN BY	CHECKED BY	DATE
	S L O	DRW	10-29-68

AMERICAN TEL. AND TEL. CO.  
 LONG LINES ENG. DEPT.  
 WESTERN AREA

WA 21168



WHERE CHANGING THE RECTIFIER ONE STEP PRODUCES TO GREAT A CHANGE IN THE TANK TO SOIL POTENTIAL, CUT STRAP IN CENTER & MOUNT A 25 Ω, 50W, NON-INDUCTIVE RESISTOR, UTILIZING MTG. SCREWS PROVIDED, AND SOLDER ENDS OF STRAP TO RES. THIS RESISTOR WILL BE THE R<sub>0</sub> RESISTOR.

100 OHM NON-INDUCTIVE RESISTORS R<sub>1</sub>' TO R<sub>10</sub>', 50 WATT, OHMITE NO. 2005, NOTE 4.

ANODE TERMINAL BOX MOUNTED ON WALL. PER DWG WA 19012.

AIR GAP PROTECTORS THESE ARE ACTUALLY LOCATED IN LOWER LEFT CORNER OF THE ANODE TERMINAL BOX. USE 26-31A BLOCKS FOR REPLACEMENT IF NECESSARY.

TABLE A  
POTENTIAL MEASUREMENTS AT ANODE TERMINAL BOX

ACROSS RESISTOR	VOLTS	ACROSS RESISTOR	VOLTS	ACROSS PROTECTOR	VOLTS
R <sub>1</sub>		R <sub>1</sub> '		1	
R <sub>2</sub>		R <sub>2</sub> '		2	
R <sub>3</sub>		R <sub>3</sub> '		3	
R <sub>4</sub>		R <sub>4</sub> '		4	
R <sub>5</sub>		R <sub>5</sub> '		5	
R <sub>6</sub>		R <sub>6</sub> '		6	
R <sub>7</sub>		R <sub>7</sub> '		7	
R <sub>8</sub>		R <sub>8</sub> '		8	
R <sub>9</sub>		R <sub>9</sub> '		9	
R <sub>10</sub>		R <sub>10</sub> '		10	
R <sub>0</sub>					

RECTIFIER TERMINAL OUTPUT — VOLTS — AMPERES

- NOTES
- SINGLE CONDUCTOR "B" OR "C" BRIDLE WIRES FROM TANK MANHOLE TO ANODE TERMINAL BOX RUN THROUGH SAME CONDUIT WITH LIQUIDOMETER CABLE. ONE WIRE FOR EACH ANODE. TERMINAL NO. 1 IN ANODE TERMINAL BOX TO ANODE #1 ETC. TERMINALS IN TANK MANHOLE ARE ELIMINATED. BRIDLE WIRE CONNECTION TO ANODE LEAD IN MANHOLE TO BE SOLDERED & WATERPROOFED WITH BUTYL RUBBER PRIMER, TWO OR THREE LAYERS OF BUTYL RUBBER MOLDING TAPE & A FINAL HALF LAPPED LAYER OF CHASEKOTE NO. 750 TAPE.
  - CURRENT IN MILLIAMPERES (MA.) IN ANODE LEAD WIRES FROM VOLTAGE "E" IN VOLTS MEASURED ACROSS RESISTORS.
 

RESIST. OHMS	MA. THRU RESIST.	RESIST. OHMS	MA. THRU RESIST.
12.5	80E	50	20E
25	40E	100	10E

 NO VOLTAGE MEASURED ACROSS EITHER RESISTOR INDICATES ANODE LEAD CIRCUIT IS OPEN.
  - FOR A SINGLE TANK INSTALLATION THE NEGATIVE WIRE TO THE FUEL OIL TANK MAY BE ARRANGED TO PASS THROUGH THE ANODE TERMINAL BOX & TO THE TANK THROUGH THE SAME TRANSITE CONDUIT AS THE WIRES TO THE ANODES.
  - WITH ISSUE 4 RESISTORS R<sub>1</sub>' TO R<sub>10</sub>' WERE CHANGED TO 100 OHMS. PREVIOUSLY THEY WERE 25 OHMS. 100 OHM RESISTORS FOR REPLACEMENT OF 25 OHM RESISTORS MAY BE OBTAINED FROM CUSTOM CONTROL INC. 5601 MERRIAM DRIVE, MERRIAM KANSAS, THE MANUFACTURER OF THE ANODE TERMINAL BOX.

ISSUE	DATE	BY
12-11-63		
NOTE 3 ADDED		
7-7-64		
ADDED TABLE A. REVISED		
NOTE 2		
2-15-65		
REVISED NOTES		
1 & 2 ADDED.		
NOTE 4		
4-19-65		
PROVIDED FOR R <sub>0</sub> RES IN SERIES WITH POS. RECT. LEAD		

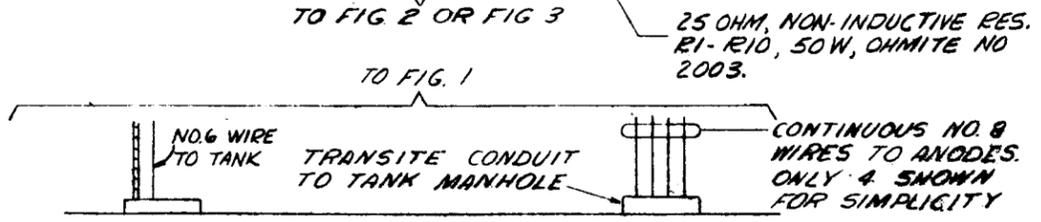


FIG. 3  
NEW INSTALLATIONS  
REF. DWG WA 19012

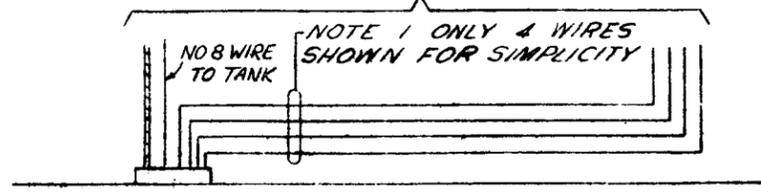


FIG. 2  
MODIFICATION OF OLD INSTALLATIONS  
ADD ANODE TERMINAL BOX PER DWG WA 19012

WA 21189

**ELECTROLYSIS PROTECTION ANODE TERMINAL BOX**

FUEL OIL TANK PROTECTION AT MICROWAVE STATIONS FOR EQUALIZING INDIVIDUAL ANODE CURRENTS

INITIAL PROJ.	DRAWN BY	CHECKED BY	DATE
	SLD	DRW	10-29-65

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