CONNECTING
COMPRESSION TOOLS AND COMPRESSION CONNECTIONS

CONTENTS

1. GENERAL

1.1 Scope
1.2 Background
1.3 Description

2. DETAILED TOOL DESCRIPTIONS

2.1 R-4135 Manual Compression Tool.
2.2 R-4198 Intermediate Size Hydraulic Head.
2.3 R-4136 Large Size Hydraulic Head
2.4 R-4143 Hydraulic Pump and R-4142 Hoses

2.41 Description
2.42 Set-Up and Accessories

3. PREPARATION OF WIRE AND CONNECTORS

3.1 Skinning Wire Midsections.
3.2 Skinning Wire Ends.
3.3 Cleaning and Protecting Copper Wire
3.4 Cleaning and Protecting Aluminum Wire
3.5 KS Parallel Taps, Lugs and Connectors

4. MAKING CONNECTIONS USING MANUAL AND HYDRAULIC TOOLS

4.1 Connecting No. 14 through No. 6 Wire.
4.2 Connecting No. 4 through 750 MCM Wire.
4.3 Insulating Connectors and Taps.

5. VERIFICATION OF KS ALUMINUM CONNECTORS

5.1 General
5.2 Extent of Verification
5.3 Verification Items Detailed

6. PREPARATION FOR SHIPMENT

6.1 Hydraulic Pump and Hoses
6.2 Large 15 Ton "C" Head
6.3 Intermediate 12 Ton "C" Head

7. NON-STANDARD TOOLS AND CONNECTORS - ESS

7.1 General
7.2 Making Connections
7.3 Insulating Connectors and Taps
7.4 Verification - Non-KS Connectors

1. GENERAL

1.1 Scope

1.11 This section reflects a recent change in the Bell System Standard for use in all systems for making connections to power wire and for terminating ends of power wire. The concept is known as "Compression" connections as compared to "pressure" or "mechanical" type connections so extensively used in the past.

1.12 The tools described herein are manufactured in accordance with Bell Telephone Laboratories KS Specifications and in turn are furnished the W.E. Installer under an "R" tool code and specification. A description of the tools and the methods for using them are provided, as well as detailed instructions for making the connections. These tool-and-die sets are for use only on KS type compression connectors. Conversely, the KS compression connectors cannot be squeezed with commercial dies of any description. When unfamiliar with these methods, it is suggested the installer read the entire text before making compression connections. Review carefully the Verification Section.

1.13 The corresponding KS connectors are listed in Section 7J. These connectors are made of tin plated aluminum and may be used either on copper wire or aluminum wire.

1.14 Aside from these standardized tools and connectors, a brief status report has been included on approved but non-standard commercial compression tools and connectors currently used in power portions of electronic offices. This will help to more completely understand the overall application of this compression concept.

1.2 Background

1.21 Until this new standard was introduced, several terminating methods have been employed. "Soldering" or "Soft Soldering" is one method and is covered in Section 7C. Another method used extensively is the "Pressure" or "Mechanical" type of connection as covered in Section 7D. The pressure type connector depends upon tightening of screws with a screwdriver, Allen wrench, etc., for a mechanically secure and electrically reliable connection.

1.22 The introduction of compression connections does not cancel previous connecting methods but supplements them and represents and improved method rather than a replacing method.

1.3 Decription

1.31 The compression type connector concept differs from the pressure type in several ways. Rather than depend on a screw or other mechanical device to secure the wire end to the lug, etc., the "Compression Connector" is squeezed or compressed onto the wire. It requires sufficient force not only to deform, mash, squeeze or compress the connector around the wire, but it must go beyond this and squeeze the connection still further until there are no air voids between connector and wire, or between strands of the wire, when similar metals are present in the wire and connector, and then squeeze beyond this point until some of the metals flow away or out from under the compressing dies. The metals in the connecotr and wire will "cold flow" under the relatively high unit pressures exerted by the compression tools and dies. By bringing the metals into intimate contact and retaining them under stress, a near homogeneous bond, and in the case of similar metals, a homogenous bond is made between connector and wire. The resulting connection is highly

reliable both from a mechanical and electrical standpoint and requires no maintenance. Once the connection is made, the connector cannot be removed aside from destructive means.

1.32 The integrity or quality of a compressed connection is insured by design of the tools and connectors when several simple instructions are carefully and consistently followed. The elements that go into making a good connection are:

1. Correct size of connector for the particular wire size involved.
2. Wire cut to extend the full length of the barrel or groove.
3. Cleaning preparation of the wire end, and connector as required.
4. Use of an inhibitor, such as R-3266 NO-OX-ID "A" Compound on the wire and in the connector.
5. Squeezing, crimping or compressing the connector the correct amount, This is insured when the correct dies are used, when the dies "home" or are fully closed each time a compression is made, and when the correct number of adjacent squeezes is completed.

1.33 The following identifies the tools in accordance with the connector wire sizes they are designed to be used with. See Table A.

TABLE A

COMPRESSION TOOLS AND DIES VERSUS WIRE SIZES

Par. 1.33

TOOLS	WIRE SIZES								
	14 12 10	8 6	4 2	1/0 2/0	4/0	350 500	750
R-4135 Manual compression including dies (One Hand Tool) KS-15976 L-1	Inner Die	Outer Die					
*R-4198 12 ton "C" Head (KS-19964 L-202 Head)			L-211	L-212	L-213		
"R" Number Die Set			R-4204	R-4205	R-4206		
*R-4136 15 ton "C" Head (KS-19964 L-102 Head			L-111	L-112	L-113	L-114	L-115
"R" Number Die Set			R-4137	R-4138	R-4139	R-4140	R-4141

*The 12 ton and 15 ton heads require, in addition to the die sets shown, an R-4143 electrically operated hydraulic pump (KS-19961 L-11), R-4142 Detail 1, 10 foot insulated hydraulic hose (KS-19961 L-23), and an R-4142 Detail 2, 6 foot insulated hydraulic hose (KS-19961 L-24).

2. DETAILED TOOL DESCRIPTIONS

2.1 R-4135 Manual Compression Tool

2.11 R-4135 is a small hand compression tool held and operated by one hand. See Figure 1. The tool is 10" long by 3-3/4" wide, is electrically insulated and weighs approximately 3 pounds. It has an internal pawl-actuated-cam which operates the movable jaw and dies toward the fixed jaw and dies. The jaws have two die set openings. The die set nearest the jaw opening or nearest the outside of the tool accommodates connectors for wire sizes No. 6 & No. 8 gauge while the inner die set accepts connectors for wire sizes No. 10, No. 12 and No. 14 gauge. The outer die opening is identified as No. 12 and the inner die opening as No. 11. These dies are an integral part of the jaws and cannot be removed.

2.12 Because of the amount of manual work necessary to crimp or compress a No. 8 and 6 wire with one hand, multiple squeezes are required to complete each crimping cycle.

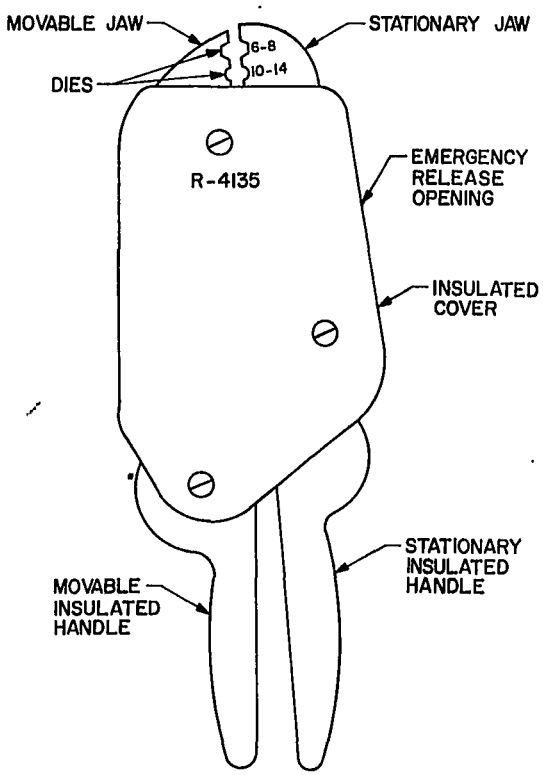

FIGURE 1

R-4135 MANUAL COMPRESSION TOOL

PARS. 2.1 & 4.17

(KS-15976)

2.2 R-4198 Intermediate Size Hydraulic Head

2.21 The R-4198 is a hydraulically operated "C" shaped compression head used with the mid range of wire sizes. See Figure 2. It has a stationary die half in the top of the "C" and the barrel shaped portion on the bottom of the "C" contains a cylinder and movable piston to which the corresponding die half attaches. The hydraulic hose attaches to the bottom of the piston and the pressurized fluid operates the piston and die half. A return spring inside of the cylinder retracts the piston and opens the dies when the pressure is relieved on the hydraulic fluid. The head is furnished with an outer coating of electrical insulation and is filled with hydraulic fluid. The tool is 10-1/2" long, 5-1/4" wide and weighs 8-1/2 pounds.

2.22 When equipped with a die set (two corresponding die halves) and attached to the R-4143 Hydraulic Pump operating at a nominal pressure of 10,000 pounds per square inch, the head is capable of delivering 12 tons of pressure on the compression connector and wire. By design, all sizes of connectors are fully crimped (die halves fully closed) before the full 12 tons of pressure is developed.

2.23 Do not operate the piston without one of the die sets in the tool, and do not allow the die halves to close and a full build-up of pressure without a proper size connector in the dies.

2.24 Do not disassemble the head.

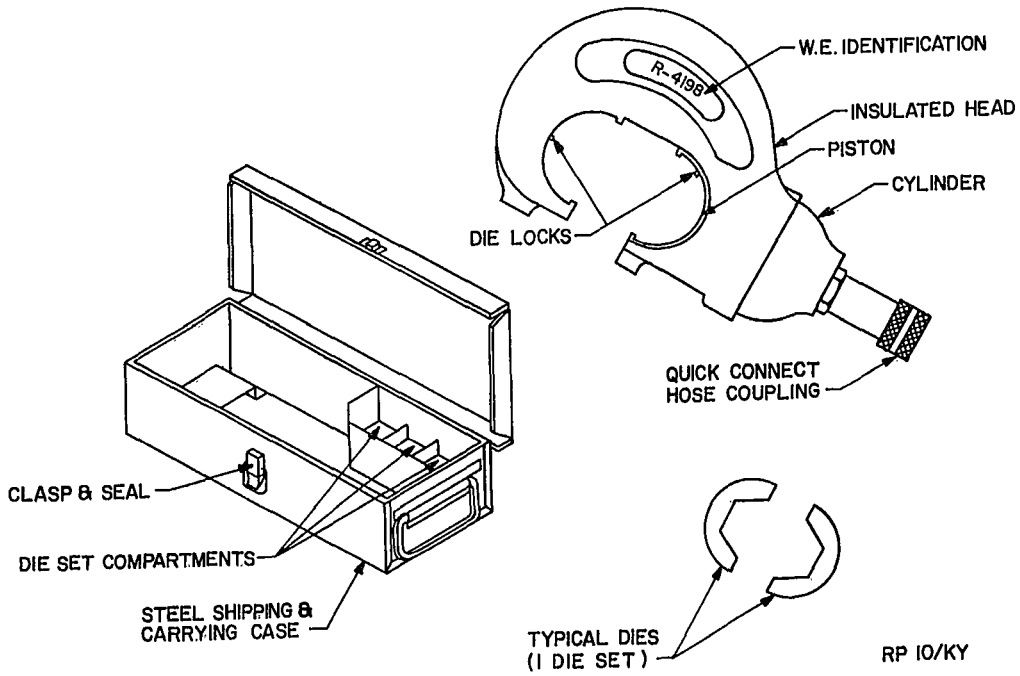

FIGURE 2

R-4198 INTERMEDIATE TWELVE TON POWER-WIRE-CONNECTOR COMPRESSION TOOL

(KS-19964)

PAR. 2.2

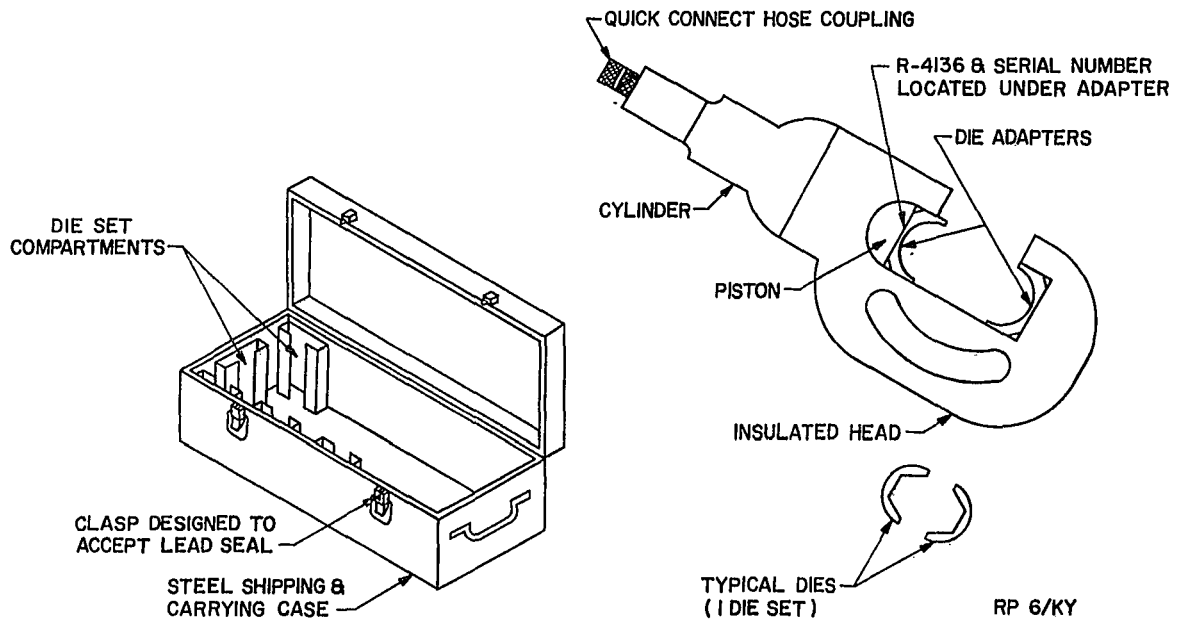

FIGURE 3

R-4136 LARGE FIFTEEN TON POWER-WIRE-CONNECTOR COMPRESSION TOOL
(KS-19964)

PAR. 2.3

2.3 R-4136 Large Size Hydraulic Head

2.31 This large size hydraulically operated "C" shaped compression head is constructed similar to and operates the same way as the twelve ton "C" head. See Figure 3. With 10,000 P.S.I. hydraulic fluid from the R-4143 pump this insulated head is capable of compressing the largest of the available wire sizes and develops a maximum of 15 tons of pressure. It is 13" long, 6-1/4" wide and weighs 16 pounds.

2.311 The fifteen ton head manufactured by the Thomas and Betts Company will not accommodate any die set without first installing the adapter set. This adapter set is identified as an R-4136 Det. 2 (T & B Part Number 15500). The adapters are furnished in the head in place and should not be removed except for R No. & Serial No. identification.

2.32 Do not operate the head unless properly fitted with the adapter set, die set, connector and wire.

2.33 Do not disassemble the head.

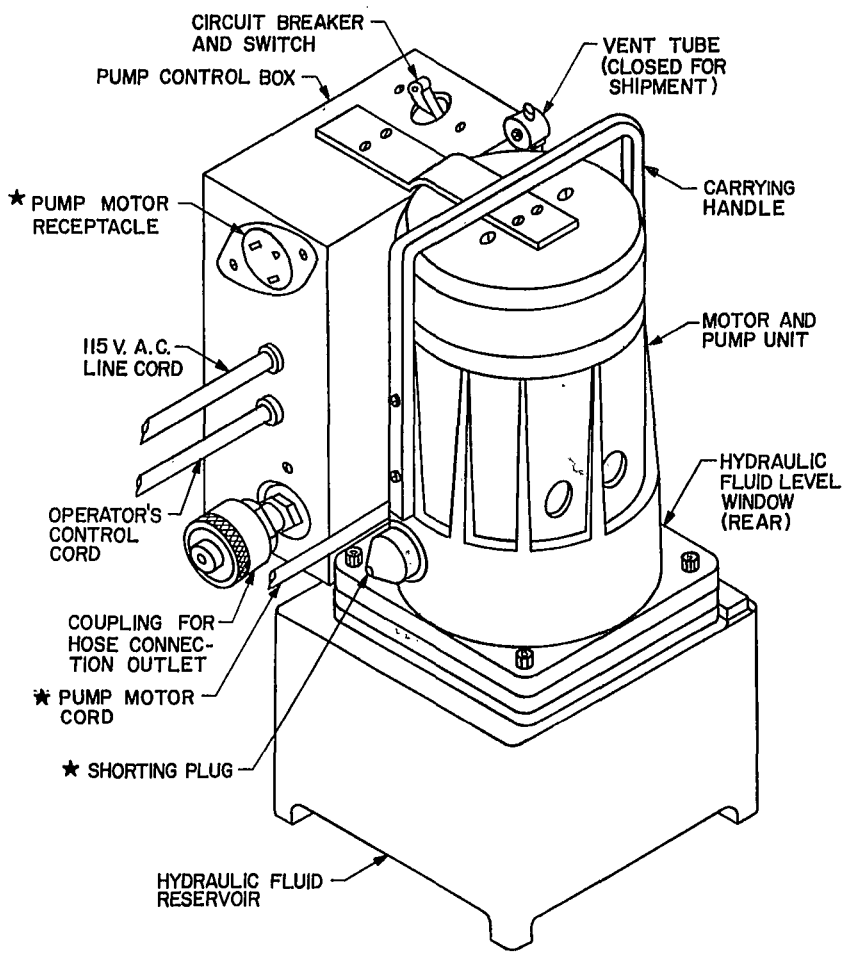

FIGURE 4
R-4143 HYDRAULIC PUMP
(KS-19961)
PAR. 2.4

★ On more recent models, the Pump Motor Receptle, Pump Motor Cord and Shorting Plug is eliminated.

2.4 R-4143 Hydraulic Pump and R-4142 Hoses

2.41 Description

2.411 The R-4143 Hydraulic Pump is a 115V ac motor-operated pump that delivers hydraulic fluid at a pressure upwards to 10,000 pounds per square inch. See Figure 4. Equipped with 3 conductor line cord, control cord, operator's control box and filled with hydraulic fluid, the unit weighs 35 pounds. It measures approximately 9-1/4" square and stands 14-1/2" high.

2.412 Its initial application is to furnish the power for operating the R-4198 12 ton head and the R-4136 15 ton head.

2.413 Also shipped with the pump is one 10' length and one 6' length of insulated hydraulic hose equipped with quick connect couplers and filled with hydraulic fluid. Insulating boots are furnished on one end of the 6' hose for use in insulating the coupling.

2.414 The 15 foot control cord is attached to the pump control box and the operator's low voltage control box. See Figure 5. The operator's control box is equipped with a 3 position rocker type momentary-on switch. Either end of the switch may be pressed to operate but returns to the normal position when released.

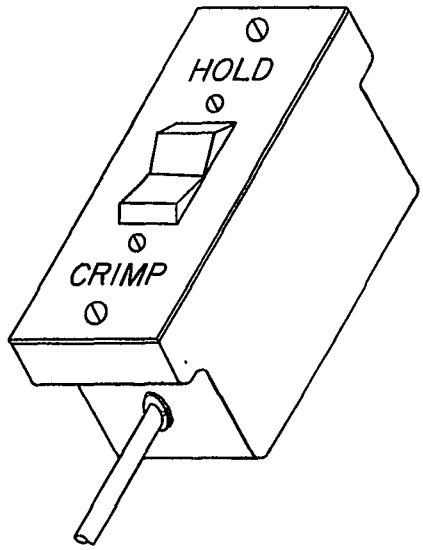

FIGURE 5.

OPERATOR'S CONTROL BOX

PAR. 2.414

2.42 Set-Up And Accessories

2.421 Remove the hoses, pump and cords from the carrying and shipping case. Examine to ascertain absence of shipping damages. Open the pet-cock on the reservoir extension tube to allow the reservoir to vent. The open position can be determined by viewing the open end of the pet-cock, not by the position of the pet-cock handle. Determine if sufficient hydraulic fluid is available by observing through the window that the level is within view. It need not be at the indicating line on the window. If the level is below the bottom of the window, remove the pet-cock from the long tube into the reservoir and bring level up to the top of the window with any good grade of Type "A" Automatic Transmission Fluid. When the pump is equipped with a shorting plug and motor line cord make sure the shorting plug is in place in the side of the motor housing and the pump motor cord is plugged into the pump control box.

2.422 Examine and wipe clean as necessary, all hose connections to prevent dirt from entering the hydraulic system. Attach to the pump control box the 6' hose, the 10' hose or both hoses in series with the boots on the extreme end of the hose or hoses (away from the pump). Attach the 12 ton head or the 15 ton head to the hose with the quick connect coupler and slip the correct insulating boot over the coupler at the head. No insulating boot is furnished for over the hose-to-hose coupling. This coupling is insulated from the grounded pump and from the head, however, since it is metal it must be temporarily protected when working around live equipment to prevent it from causing a short circuit.

2.423 Coupling the two hoses together allows for the pump to be left on the floor and an installer to work on the cable rack at the 11 foot level. For bench work or work near the floor such as at the rear of power boards and BDFB's the 6' or 10' length of hose can be used individually.

2.424 Should one hose become damaged, work at the cable rack level can still be accomplished by taking the pump up the ladder and adequately securing it to the superstructure or on the cable rack with trunk straps, etc. When securing the pump on the cable rack, always provide protection under the pump to prevent damage to the cable by weight and damage from minimal hydraulic fluid leaks. Make sure the pump cannot become dislodged when using it off of the floor.

2.425 Plug the line cord from the control box into a 115 volt ac 3 wire "U" grounding type receptacle. If an extension cord is required, make sure a reliable three conductor cord is used. Otherwise, it is necessary to furnish a separate grounding conductor between the pump or motor housing and a framework or ground bus bar in the office. Use No. 14 gauge wire or larger equipped with alligator clips or lugs as required. Verify that the pump and motor are grounded using a voltmeter, or a bulb and waterproof socket. See Section 7A. The heads and dies will be insulated from the grounded pump when specified hydraulic fluid is used and when the plastic insulating hoses are used.

2.426 Do not operate the pump without a head and dies.

2.427 Do not disassemble the pump.

3. PREPARATION OF WIRE AND CONNECTORS

3.1 Skinning Wire Midsections

3.11 Prepare midsections of wire for connecting to parallel taps by removing enough insulation for the wire to fit into the connector groove or hole. Use the R-2884 Power Wire Stripper or the R-2761 Wireman's Skinning Knife. Exercise care to avoid scoring the strands by proper adjustment of the cutting blade on the stripper or by not forcing the knife blade into the insulation any harder than necessary to cleanly remove the insulation.

3.12 On wire sizes 14, 12 and 10 do not cut the insulation with the wireman's skinning knife. Crush the insulation between the smooth jaw surfaces of the R-2291 Short Nose Pliers or the R-2120 Long Nose Pliers and trim off the insulation to the butt with the R-6433 Diagonal Cutter.

3.2 Skinning Wire Ends

3.21 Prepare the insulated wire by forming and dressing it so that it lies without strain or stress in the exact location it will terminate if the lug were there. Place the lug adjacent to the wire, align the mounting holes and mark the butt location on the wire insulation. On wire sizes No. 4 and larger, beyond the portion of insulation to be removed, place a mark along the wire insulation to indicate the top of the lug.

3.22 Stress the wire away from its termination sufficiently to cut, strip and crimp. Do not bend the wire unless absolutely necessary. Determine the internal depth of the barrel as far as the full diameter of the hole exists. Do not measure into the distorted or tapered portion of the hole. Measure this distance from the butt mark toward the end of the wire and cut. BE CAREFUL NOT TO CUT THE BUTT MARK. Also refer to Section 6B.

3.23 With the R-2884 Power Wire Stripper or the R-2761 Wireman's Skinning Knife, butt and strip the insulation from the wire.

3.24 On wire sizes 14, 12 and 10 do not cut the insulation with the wireman's skinning knife. Crush the insulation between the smooth jaw surfaces of the R-2291 Short Nose Pliers or the R-2120 Long Nose Pliers and trim off the insulation to the butt with the R-6433 Diagonal Cutter.

3.25 All wire contact surfaces shall be clean.

3.3 Cleaning And Protecting Copper Wire

3.31 KS-5482-01 Copper wire is tinned, however, if the wire shows any signs of corrosion or oxidation, clean with a wire brush or fine abrasive paper and dust as necessary with a dry cloth. If the rubber should adhere to the wire or strands, scrape clean with the skinning knife.

3.32 Apply a small amount of R-3266 NO-OX-ID "A" Compound to clean and cleaned wire sections. With stranded wire, work as much compound in between the strands as possible and remove excess around the insulation butt.

3.4 Cleaning And Protecting Aluminum Wire

3.41 All KS-20189 aluminum wire must be cleaned. After removing insulation, clean No. 12 to No. 6 aluminum wire with a wire brush or abrasive paper. Clean No.4 and larger with a wire brush. Immediately coat the wire end with NO-OX-ID "A" Compound. Work as much compound in between the strands as possible.

3.42 On all wire sizes, break up oxides that reform instantly after cleaning by wire brushing thoroughly with the compound in place. Do not remove the compound. Following this procedure is essential to making reliable low resistance connections.

3.5 KS Parallel Taps, Lugs And Connectors

3.51 The contacting surfaces of all connectors shall be clean.

3.52 These KS taps, lugs and connectors are made of tin plated aluminum. They shall not be sanded or wire brushed. Any dirt or contaminant can be removed with a dry cloth.

3.53 Coat all wire contacting surfaces in the main and branch opening of the tap with R-3266 NO-OX-ID "A" Compound. On lugs, apply a small amount of compound (about 1/4 full) to the inside surfaces of the barrel. Use sufficient compound to thoroughly coat the surfaces but not an excess especially near the openings for the wire. It will not be necessary to add NO-OX-ID "A" Compound to any connector that has been supplied by the factory with protective compound in place.

4. MAKING CONNECTIONS USING MANUAL AND HYDRAULIC TOOLS

NOTE: A fact that must be recognized and should be appreciated is that the compression process is irreversible. Therefore, it is of the utmost importance that the correct size wire, connector and dies are used together, and that the dies are properly and proportionally spaced on the connector barrel. Read the Verification Items before proceeding with the crimping operation.

4.1 Connecting No. 14 through No. 6 Wire

4.11 Lugs and connectors for No. 14 through No. 6 are crimped with the R-4135 Manual Compression Tool.

4.12 Hold the tool in either hand with the fingers extended around and well back on the movable handle. Make sure the connector size agrees with the die opening as the tool is equipped with an interlock feature which prevents removal from the connector until all of the multiple squeezes are made.

4.13 Place the connector in the proper die opening with the tang extending from either side of the tool and with the dies on top and bottom of the connector. All crimps shall be confined to the crimping area on the barrel. The crimps shall not extend onto the tang, shall not extend beyond the end of the connector and multiple crimps shall not overlap unless the barrel is not long enough. When more than one crimp is called for, they shall not be made in the same location.

4.14 Squeeze the handles together until the connector is held but not distorted by the dies. The first squeeze is a connector-holding-stroke and provides a fast jaw advance for this purpose. Insert and hold the previously prepared wire end fully into the connector and complete the multiple squeezes.

4.15 On the last squeeze, the dies come fully together on the connector and then the tool automatically releases and recycles ready for the next connection.

4.151 If the die halves or jaws do not fully close (touch) the tool shall be returned to the Regional Service Center for arrangements for an internal adjustment by the factory.

4.16 Wipe with a dry cloth to remove any excess inhibitor that may have been forced out of the connector.

4.17 If the crimping strokes have been started and it is discovered that a No. 8 or 6 connector was accidentally placed in the 14, 12 and 10 die, DO NOT ATTEMPT TO COMPLETE THE CONNECTION. An attempt to do so may very well break the jaws. In such an emergency it will be necessary to obtain a small piece of stiff wire, such as an opened paper clip, and insert it in the Emergency Release Opening. Squeeze slightly on the handles to relieve the pressure on the pawl. Press the pawl with the wire to release the jaws and recycle the tool. This is strictly an emergency measure and shall never be employed when the tool is being properly used. See Figure 1.

4.18 Do not disassemble this tool.

4.2 Connecting No. 4 through 750 MCM Wire

4.21 Connections to these wire sizes are made with a hydraulic pump, hose and one of several compression heads.

4.22 The R-4198 intermediate head will squeeze wire sizes No. 4 through No. 4/0. The R-4136 large head will squeeze wire sizes from No. 4 through 750 MCM. The number of compressions per connector is not necessarily the same with both heads and their respective dies.

4.23 Since the pump and heads are self lubricating there is a slight wetting by the hydraulic fluid around the pump, hose fittings and heads. The floor under and around the pump should be protected from any small seepage of fluid. Wipe up any fluid immediately with a dry cloth. Cease using any hose that shows signs of leakage along its length or at the point where the coupling is attached to the hose.

4.24 When using the heads at elevated locations, arrange for temporary but substantial restraining support with trunk straps or equivalent. Secure the head to superstructure or cable rack allowing sufficient slack so as not to interfere with its use or operation.

4.25 Assuming all hose and cord connections are made, the head is attached and the proper dies inserted, the compression connection is ready to be made.

4.251 The preparation of the wire and the connector has been previously covered.

4.252 Do not run dollies, rolling ladders, etc., over the hose. Do not drop heavy items on the hose. MAKE SURE THERE ARE NO SHARP BENDS OR KINKS IN THE HOSES. Protect the line cord and control cord from damage.

4.253 On the pump, operate the Circuit Breaker Switch to the "ON" position. Provide protection under the head against hydraulic fluid seepage as required. With one hand, place the connector between the dies and against the fixed die in the exact location to be crimped. Hold the lug by the tang or the connector by one end well back from the area to be crimped. Place the lug in the correct die opening with the tang extending from either side of the head and with the dies on top and bottom of the lug when alignment with the wire permits. On parallel taps, slip the head's open "C" over the connector.

4.2531 All crimps shall be confined to the crimping area on the connector when possible, but they shall not extend on the tang of the lugs. Some dies are slightly wider then the barrel and will extend onto the wire insulation before the crimp is started. The insulation will yield and no damage will result since the barrel elongates slightly as it is squeezed. Multiple crimps may overlap slightly when it is necessary to prevent the dies from extending onto the tang or the wire insulation. This may be necessary since the length of the barrel on crimping area is not always a multiple of the width of the die.

4.2532 When more than one crimp is called for, they shall not be made in the same location but adjacent to each other. When making multiple crimps over a wire section, crimp the barrel nearest the end of the wire first, (nearest the tang of the lug). This will insure that the first crimp will be over a full section of wire and not just over part of the wire end. Since the aluminum connector extrudes at a faster rate than copper wire, additional crimps may crowd the end of the barrel tight against the insulation butt. Experience will determine if removal of additional insulation will result in a more acceptable looking job even though subsequent trimming is not required.

4.254 Hold operated the "HOLD" button or switch and the motor and pump should start. The movable die should advance until the connector is trapped and self supported between the dies but not deformed. This normally occurs when 120 pounds of fluid pressure has been developed. At this time, the "HOLD" button may be released. The pump will continue to operate and maintain this holding force.

4.2541 At this point while in the holding position, if it is determined the connector is not properly positioned, or the wrong size connector or dies are in use, or if for any reason it is decided not to complete the crimping operation, operate and release the "CRIMP" button quickly and the pump control will recycle and release the connector. The pump will stop.

4.255 Place the connector (held by the hydraulic head) over the prepared wire or place the prepared wire into the connector and align the previously marked wire with the top of the connector.

4.2551 On short wire ends of the larger sizes, if the lug or connector is not positioned axially, difficulty may be experienced in twisting the lug so it will lie flat on the surface to which it will attach.

4.256 With the wire fully inserted, hold operated the "CRIMP" button until the dies fully home or fully touch, then release the "CRIMP" button. If there is any doubt or if it cannot be clearly seen that the dies have fully homed, continue to hold the "CRIMP" button operated until the motor and pump unit stops automatically at 9,800 P.S.I., then release the "CRIMP" button. The pump control will recycle and the dies will open to release the connector.

4.2561 If it is decided, at any time during the crimping operation not to complete the cycle, release the "CRIMP" button. The dies will release and the tool will recycle. To resume crimping, it is necessary first to operate the "HOLD" button and secondly the "CRIMP" button.

4.257 When hexagonal shaped dies are used, closing of the dies fully sometimes shears off but usually kicks up a thin fin or flashing on either side of the connector where the die halves meet. These ridges or fins should be carefully bent back-and-forth with the fingers and broken off. With an R-1482 file, remove sharpness to the touch only as necessary to prevent persons from getting cut when brushing along the fin. If the fin does not exist on a hexagonal crimp, there should appear a thin line or very narrow ridge on both sides of the connector where the two die halves meet.

4.258 With a dry cloth remove any excess inhibitor that may have been forced out of the connection and onto the insulation.

4.3 Insulating Connectors and Taps

4.31 When connectors and "C" taps require insulation (connectors on conductors operating at other than ground potential, and connectors on conductors at ground potential that require insulation in accordance with job information) they shall be taped. On "C" taps, place rubber tape between the main and branch wires and on all taps and connectors apply rubber tape over the entire unprotected area to a minimum thickness of the rubber on the insulated

conductors. Usually this amounts to four or six thicknesses, i.e., two or three layers applied in a half-lapped manner. Finish with a minimum of 2 layers of friction tape applied in a half-lapped manner, i.e., four thicknesses. Extend the friction tape beyond the rubber tape and apply one coat of shellac. Plastic tape shall not be used.

5. VERIFICATION OF KS ALUMINUM CONNECTORS

5.1 General

5.11 Aside from a greater degree of reliability, one of the outstanding advantages of the KS compression connection is the fact that it requires no maintenance. Therefore, these connections need not be left accessible for subsequent inspection and maintenance as did the KS-5517 lugs and the KS-5537 parallel taps. This does not excuse an initial verification, however, and says nothing of the verification of the bolting material when securing lugs to details and bus bars. Section 7E.

5.12 One of the criteria in developing this program was to produce a connection that would require no tools or gauges for verification, i.e., connections that could be verified wholly by observation.

5.2 Extent of Verification

5.21 The universe of principle items to be checked consists of the following:

(1) Proper connector, wire and die association

(2) Position of crimp and number of crimps.

(3) Degree or amount of crimp.

(4) Use of an inhibitor.

(5) Absence of excessive shiners.

5.3 Verification Items Detailed

5.31 Verification is required on every connection and is required only once. The verification may be made at any time, i.e., before or after lugs are mounted but preferably before the circuitry is made alive and before the lug is mounted, since the bolting material may cover the KS-15977 list number. The detailed items to be checked visually are listed below:

5.32 Determine that the wire size stamped on the wire agrees with the wire size stamped on the connector.

5.321 If the wire size is not indicated on the connector, the KS List number on the connector can be referred to in the table in Section 7J for the associated wire size. If the size of the wire cannot be determined by tag markings or markings on the insulation the dimensions may be referred to Table 1 in Handbook 22 Section 91.

5.33 Determine that the proper dies were used by comparing the list number embossed on the lug by the squeezing of the dies, with the wire size shown in Section 7J.

NOTE: On the first shipment of die sets for the 12 ton "C" head, the manufacturer inadvertently omitted engraving the list number on the dies. This oversight is being corrected on future orders.

5.34 Ascertain that the dies were fully homed and crimped the correct number of times.

5.341 The detachable steel dies used with the hydraulic heads may be designed to kick up a thin fin or flashing on both sides of the connector where the dies come together. This fin of metal should be very thin. If the fin does not exist on a hexagonal crimp, there should appear a thin line or very narrow ridge on both sides of the connector where the two die halves meet. Either would indicate the dies were fully homed.

5.342 If the dies used with the hydraulic heads do not produce a fin by design, such as an oval crimp, the fully crimped condition can be determined by the appreciable working or necking down of the metals in the general area of 15% to 25% reduction in cross section. The general shape of the area where the dies came together is the indication of a fully crimped connection and is insured by design of the tool. No gauging is necessary nor recommended. An insufficiently crimped connection can be corrected by squeezing over the crimp the second time in the exact same location.

5.343 The connector shall be crimped the correct number of times as indicated in TABLE "A" of Section 7J.

5.35 On all connectors with inspection holes, it should be determined that all compressions were made within the wire area or even with the end of the wire. No die marks should extend into the area of the tang.

5.36 The total travel of the dies on the manual tool may safely be assumed adquate and satisfactory to produce a fully crimped connection as this is determined and insured by design of the tool. The tool can not be released from the connector until the dies have fully homed.

5.37 Although the use of an inhibitor is mandatory it would be difficult to determine if it had been used properly since it requires the conscientious effort on the part of the installer to do a good workman like job and involves a non-verifiable procedure. It is even more difficult to establish that it was used if the installer had earlier corrected a shiner with friction tape. Otherwise, good penetration of NO-OX-ID "A" Compound between the strands at the insulation butt may possibly be determined, and when this is evident, it should be assumed the inhibitor was properly used.

5.38 The maximum shiner is 1/16". Areas between the insulation butt and the edge of the connector when greater than 1/16" shall be filled in with friction tape and finished off with a minimum of 2 turns of 3/4" friction tape. Apply a coat of shellac.

6. PREPARATION FOR SHIPMENT

6.1 Hydraulic Pump and Hoses

6.11 Close the pet-cock vent. Disconnect the hose from the pump. Wipe the small amount of oil lost when separating the hoses and when separating them from pump and head. Replace all dust caps as they are essential for keeping dust and dirt from entering the hydraulic system and they also prevent the threads from being damaged. Place the pump in the R-4208 Shipping Case and coil the hoses around and beside the pump in such a manner as not to interfere with the closing of the lid. Avoid making any sharp bends in the hoses while packing. If it is felt advantageous, because of the length and rigidity of the couplings, the two hoses may be separated. Coil the line cord and control cord in the shipping case and secure the lid with the two hasps. Slip the R-3348 Lead Seal wire through the back of one of the hooks on the lid and through the bale on the hasp. Draw the seal up close and press with the R-2560 Sealing Press.

6.2 Large 15 Ton "C" Head

6.21 Disconnect the hose and wipe up the small amount of oil lost. Replace the dust cap and place the head in the R-4214 Shipping and Carrying Case. Verify the presence of all five die sets in the labeled compartments. The sixth compartment is a spare. The Thomas and Betts Co. Catalog No. 15500 die adapter set should remain in the tool at all times. Close the lid and seal as described in Paragraph 6.11.

6.3 Intermediate 12 Ton "C" Head

6.31 Disconnect the hose and wipe up the small amount of oil lost. Replace the dust cap and place the head in the R-4215 Shipping and Carrying Case. Verify the presence of all three die sets. Close the lid and seal as described in Paragraph 6.11.

7. NON-STANDARD TOOLS AND CONNECTORS - ESS

7.1 General

7.11 At the inception of ESS it was agreed to use compression connectors for all field installed power wire connections within the ESS equipment room. This practice has been rigidly followed and application has been extended to some degree in power rooms associated with electronic offices.

7.12 Extensive delays in developing KS tools and connectors forced Installation Engineering to furnish nonstandard, commercial tools for associated commercial connectors during this interim period. These tools were not listed in Handbook 250 for control purposes. When commercial T & B connectors are furnished for Electronic Switching jobs, the installer should order tools as follows: "One collection of power wire compression tools for Electronic job at _____,

Order_____."

7.13 Until the complete conversion to KS aluminum connectors is accomplished, it will be necessary to continue using the commercial tools listed in this part of the section when any commercial copper connectors are furnished on electronic jobs. During the interim, electronic jobs may be furnished both KS connectors and commercial lugs and connectors. In such a case, both KS and commercial dies will be required.

7.14 To obviate the need for both complete sets of hydraulic tools, it is planned to: (1) Add five KS die sets to the existing R-3799 to compress KS connectors (wire sizes No.4 through 750 MCM), (2) commercial dies will be retained with this commercial head as long as any commercial connectors are furnished on electronic jobs, (3) the hose attachment coupling will be changed and, (4) if possible, the heads will be insulated to make them over into KS-19964 L-302 and a new number R-4228 will be assigned.

7.15 At some future date, it is planned to modify the R-3701 Pumps furnished only by ALCOA (manufactured by Brock Equipment Company) to make them over into R-4143 (KS specification) Pumps. Basically; (1) the low voltage control circuit will be added (2) the hose coupling will be changed and (3) new serial numbers will be assigned.

7.16 Manufacturers of connectors will only guarantee the completed connection when they are made with their own tools. To obviate duplication of tools, Standards Engineering approved through EIM 6567 only the Thomas & Betts line of connectors and only certain connectors. This does not license line engineering to indiscriminately select any connector from any T & B catalogue.

7.17 The "T & B Method" associates dies with lugs and connectors by color. The same colors may be reused when there is a great disproportion in sizes and it would be obvious to the user that the die set and connector could not be used together. The number of crimp per connector is self evident. Either the width of the die will be a multiple of the length of the connector barrel, dictating the number of crimps, or, the barrel will be marked with bands corresponding to the area and number of crimps. Some dies are only half as wide as each band and must be squeezed twice, side-by-side, over each band.

7.18 Commercial copper connectors can be squeezed only on copper wire. (KS Tin Plated Aluminum Connectors may be used either on aluminum or copper wire).

7.2 Making Connections

7.21 Skinning insulation from the wire is covered elsewhere in this section.

7.22 The length of the wire should be such as to extend even with or beyond the crimping area and the insulation butt should be against, but not more than 1/16" from the edge of the connector. Shiners out of limits should be corrected by filling in with friction tape and finishing with 1-1/2 to 2 turns of the full 3/4" width of the tape over the fill-in. Complete with one coat of shellac.

7.23 Although there is a measure of improvement gained by using an inhibitor on the 1/0 and larger connector wire sizes, NO-OX-ID "A" Compound is not required on these copper lugs and connectors.

7.24 Always crimp or compress fully. Make sure dies home or fully close on each crimp. When more than one crimp is indicated they should not be made in the same location but should be made adjacent to each other. They should be distributed side by side over the barrel of the connector so as not to overlap where possible and not extend over the end of the barrel, or onto the tang in the case of a lug.

7.25 Table B tabulation will assist in identifying connectors, in determining the required tools and will indicate when more than one crimp is required.

7.26 The WT-105M is a Thomas & Betts hand operated plier type tool. Its use is not recommended since it does not contain a device to insure complete closure. It requires a strong grip and depends on the installer's deliberate effort to perform good workmanship. Consequently, the quality of the connection would vary with the installer. It must be used, however, when RAA21, RBB21, and RCC21 connectors are specified since the Thomas & Betts Company has no tool available.

TABLE B

Commercial Connectors and Tools used in Electronic Offices

Par. 5.25

T&B Co. Identification	Code Size and Color Code	Wire Size	W.E. "R" No.
WT-140	C Yellow	12&10 For Flag Type Lugs	R-3698
WT-129	D Red	8 For Flag Type Lugs	R-3699
	E Blue	6 For Flag Type Lugs	
	F Grey	4 For Flag Type Lugs	
	G Brown	2 For Flag Type Lugs	
	Upper Nest (Farthest from Pivot)		
WT-145A	RZ Yellow	26-24 For Insulated Lugs	R-3700
	RA Red	22-18 For Insulated Lugs	
	RB Blue	16-14 For Insulated Lugs	
	Lower Nest (Nearest to Pivot)		
	RC Yellow	12-10 For Insulated Lugs	
WT-131	Same as WT-130 Except for Stranded Wire Only (This tool not required when WT-130 is available)		R-3697
WT-130	A Red	22-18 Solid or Stranded For small Uninsulated Lugs	R-3798
	B Blue	16-14 Solid or Stranded For small Uninsulated Lugs	
	C Yellow	12-10 Solid or Stranded For small Uninsulated Lugs	

T&B Co. Identification	Code Size and Color Code	Wire Size		W.E. "R" No.
TBM-2 (Furnished with Dies)	D Red	9,8,7	For Barrel Type Lugs. 2 Crimps ★	R-3695
	E Blue	6,5	For Barrel Type Lugs. 2 Crimps ★	
	F Grey	4	For Barrel Type Lugs. 2 Crimps ★	
	G Brown	2	For Barrel Type Lugs. 2 Crimps ★	
TBM-5 (Furnished with Dies)	D Red	9,8,7	For Barrel Type Lugs. 1 Crimp ★	R-3696
	E Blue	6,5	For Barrel Type Lugs. 1 Crimp ★	
	F Grey	4	For Barrel Type Lugs. 1 Crimp ★	
	G Brown	2	For Barrel Type Lugs. 1 Crimp ★	
	Green	1	For Barrel Type Lugs. 1 Crimp ★	
	Pink	1/0	For Barrel Type Lugs. 1 Crimp ★	
	Black	2/0	For Barrel Type Lugs. 2 Crimps ★	
	Orange	3/0	For Barrel Type Lugs. 2 Crimps ★	
	Purple	4/0	For Barrel Type Lugs. 2 Crimps ★	
	Yellow	250 MCM	For Barrel Type Lugs. 2 Crimps ★	

Various Manufacturers	Electrically operated hydraulic pump and hose.	R-3701
Cat. 13642	Twelve ton yoke type hydraulic compression head.	R-3799

Die Set Code	Wire Size	
71H	350 MCM Dies for use with R-3799 2 Crimps ★	R-3702
87H	500 MCM Dies for use with R-3799 2 Crimps ★	R-3703
106H	750 MCM Dies for use with R-3799 2 Crimps ★	R-3704
107H	800 MCM Dies for use with R-3799 2 Crimps ★(This die not furnished unless ordered separately.	R-3705

WT-105M	Plier Type Hand Tool for RAA21, RBB21 and RCC21 Connectors	(Not a recommended tool and not normally furnished) See Par. 7.26	R-3741

★ = NUMBER OF CRIMPS PER DESIGNATED CRIMPING AREA

7.3 Insulating Connectors and Taps

7.31 When coneactors and "C" taps require insulation (connectors on conductors operating at other than ground potential, and connectors on conductors at ground potential that require insulation in accordance with job information) they shall be taped. On "C" taps, place rubber tape between the main and branch wires and on all taps and connectors apply rubber tape over the entire unprotected area to a minimum thickness of the rubber on the insulated conductors. Usually this amounts to four or six thicknesses, i.e., two or three layers applied in a half-lapped manner. Finish with a minimum of 2 layers of friction tape applied in a half-lapped manner, i.e., four thicknesses. Extend the friction tape beyond the rubber tape and apply one coat of shellac.

7.4 Verification - Non-KS Connectors

7.41 The proper selection of connector, dies and tool is a prime requirement for high quality. Verification consists of checking the connection for the following points:

(1) The wire size must agree with the connector size. The wire size is marked on KS-5482-01 wire and the range of wire sizes the connector is designed to accommodate is marked on the connector, however, this marking may be on the tang and covered with the bolting material.

(2) Proper tool and die must have been used. Only T & B tools and dies can be used to compress T & B connectors. On the 12 ton hydraulic head, TBM 5 two-hand tool and TBM 2 one-hand tool, the die size is color keyed to the connector, i.e., a grey die for a grey lug.

(3) For all tools and dies, whether or not the proper tool and dies were used and whether or not the connector was fully compressed, may be determined by going through the motion of making the crimp. After carefully fitting the dies into the same indents, repeating the operation should not further distort or compress the metals. In the case of the 12 ton head it will only be necessary to hand fit the two die halves around the connector (in the last indent made when more than one compression is called for) to determine that the die halves touch or very nearly touch as gauged by eye. After mechanically squeezing the connector, it relaxes a very small amount accounting for the fact that the die halves may not touch completely.

(4) Determine that the proper number of adjacent crimps were made on each connector. Where more than one squeeze is required, the connector will be marked or embossed to indicate the adjacent areas to be squeezed. It is desirable but not required that the compressions not overlap nor extend beyond the barrel onto the wire. Proper positioning of the dies is considered an item of good workmanship on these commercial connectors.

(5) The wire end in those connectors with inspection holes should be even with or extend beyong the last crimp. This too is an item controlled by good workmanship.

(6) "Shiners" or space between the end of the barrel and the insulation should not exceed 1/16". This workmanship item may be corrected by filling in the space with friction tape. Except on insulated connectors, filling in shiners is an appearance item only. After filling to the thickness of the insulation, finish with a minimum of 1-1/2 turns of friction tape over the outer wire covering and tape, and apply one coat of shellac.

(7) Verification of tightness of the bolt or fastening hardware is covered in Section 7E.

Manager, Product Engineering

Vertical lines at side of paragraphs indicates requirement.

This section replaces Preliminary Section 7G. The Preliminary Section 7G was not included in Handbook 18 nor was it shown in the Table of Contents.