Section 431
Issue No. 2
Addendum No. 1
April 1975

VOICE FREQUENCY LOADING FOR TRUNK CABLES

Purpose: This addendum clarifies the application of D-66/H-88 junction impedance compensators to insure that the best return losses are achieved.

Deletions: Delete paragraph 7 in its entirety. Make a notation stating: "See Addendum No. 1."

Delete Illustrative Examples 10, 17, 18, 19, and 20. Make a notation stating: "See Addendum No. 1."

Additions: Add new paragraph 7 and Illustrative Examples 10, 17, 18, 19, and 20 to read as follows:

7.0 THE D-66/H-88 JUNCTION IMPEDANCE COMPENSATOR AND APPLICATIONS

7.1 A device used to match the impedance of an H-88 loading system to that of a D-66 loading system when it is inserted at a junction point between the two loading systems is termed a "D-66/H-88 junction impedance compensator," or simply "junction compensator." Use of a junction impedance compensator permits a company utilizing the D-66 loading system to provide both subscriber and trunk facilities within the same sheath with the same loading scheme. A connecting company with H-88 loaded cable system will also have the same advantage.

7.2 H-88 and D-66 loaded cables have, by design, the same nominal 1000 Hz impedance but as the cutoff frequency of the H-88 loaded cable is approached its impedance increases in magnitude more rapidly than that of D-66 loaded cable. Therefore, at frequencies higher than approximately 2500 Hz the impedance match between D-66 and H-88 loaded cable facilities becomes progressively poorer when the two systems are directly interconnected. Performance of voice frequency repeaters may be expected to be impaired due to the poor return loss resulting at the point of such direct interconnection. To obtain acceptable return losses at these higher frequencies it is necessary that the rising impedance of the H-88 be modified to match the flatter impedance of the D-66. The device which makes possible this matching, thereby improving the return loss, is the junction compensator.

7.3 A junction impedance compensator consists of a loading coil with a capacitor in parallel with each winding of the loading coil. Depending on cable length to the next loading coil location, there may be one or two build out capacitors in shunt with the tip and ring conductors of the cable pair. The shunt capacitors build out the D-66 and H-88 natural cable end sections respectively to 0.8. This results in a 3600' effective end section for the D-66 and 4800' for the H-88 loading system. The characteristic impedances of both D-66 and H-88 loaded cables at 0.8 end sections have nearly constant and approximately equal resistive components and negative reactive components non-linear with frequency. The objective is to annul the non-linear negative reactances. Since the positive linear reactance of a simple loading coil in the compensator is not sufficient to cancel the total of the negative reactances the series capacitors are added. Addition of these capacitors helps in reducing this reactance disparity and the impedances of the D-66 and H-88 loaded systems become better matched.

7.4 Component make-up of the D-66 and H-88 junction impedance compensator is shown in Figure 1. It should be noted that the loading coil and series capacitors (capacitors C_3 and C_4 in Figure 1) have different values for 19 and 22 gauge cables. The shunt or building out capacitors, however, (capacitors C_1 and C_2 in Figure 1) are the same for either 19 or 22 gauge, since their value depends solely on the cable length at the end section.

7.41 Impedance compensators designed for 22 gauge cable may be used with 24 gauge cable. While not of optimum design for this application, resulting circuit performance will meet REA return loss objectives.

7.42 Where mixed gauges such as 19 and 22 gauge are used at the junction point, the configuration of the junction compensator should be computed for the gauge having the greater 1000 Hz loss.

7.5 Application of the D-66/H-88 junction impedance compensator requires careful design to insure full utilization of its capabilities. Where the distance from the junction between the D-66 and H-88 loaded facilities and the central office is less than 18 kilofeet with a cable used only for trunks, consideration should be given to extending the H-88 loading scheme to the office. A good terminal impedance cannot be achieved with less than 18 kilofeet of cable. Consideration may also be given to extension of the H-88 loading scheme to the office with junction to office distances exceeding 18 kilofeet when such construction proves most economical. Return losses are better (higher) when the end sections of both facilities at the junction are longer than when they are short. Following are basic design rules which should be adhered to so as to obtain impedance matching of maximum efficiency.

7.51 Combined end sections (length of actual junction cable) of the two facilities (D-66 and H-88) should be not less than 3901 feet or more than 8400 feet.

7.511 When the length of actual junction cable between the last D-66 and H-88 loading coils is less than 3901 feet, omit the last D-66 loading point and design to the new length.

7.512 Should the combined end section length be more than 8400 feet, add a D-66 loading point and complete the design to the new length.

7.513 Where length of actual junction cable between the last D-66 and H-88 loading points is 5400 to 8400 feet, locate the compensator 3600 feet of actual cable from the D-66 loading point (0.8 section) with $C_1 = 0$. Set C_2 equal to 0.083 (4800-feet of remaining junction cable)/ 5280.

7.514 For actual junction cable lengths of 3901 to 5399 feet between the last D-66 and H-88 loading points, locate the compensator X feet of actual cable from the D-66 loading coil, where X equals actual junction cable/2.33. Set C_1 equal to 0.083 (3600 - X)/5280. Set C_2 equal to 0.083 (4800 - (total length of actual junction cable/1.75))/ 5280.

7.515 Illustrative examples pertaining to the application of the junction impedance compensator for various D-66 and H-88 natural end sections are shown in examples 17 to 20. It should be noted that there is no requirement to place the junction compensator at the precise point where the D-66 and H-88 loaded cables meet (boundary). From the transmission standpoint, the junction compensator should be physically located at the point determined by the design rules above. Shunt capacitors are not required when total footage of actual junction cable is 8400 feet.

7.5151 Example 17 illustrates a cable layout in which the length of actual junction cable is almost exactly 8400 feet. The best solution is to locate the junction impedance compensator at the point where no capacitor build out is required. This can be determined by locating the compensator X feet from the last H-88 loading point where X equals actual junction cable length/1.75.

7.5152 Another cable layout is shown in Example 18 with 5800 feet of junction cable. The application rule cited in Paragraph 7.513 applies to this example. The compensator should be placed 3600 feet (0.8 section) from the last D-66 loading coil. C_1 will equal 0 and C_2 will be for 4800 - 2200 = 2600 feet. In this example the compensator should be placed on the H-88 side of the cable junction at the boundary to achieve maximum return loss.

7.5153 Example 19 shows an example with 5110 feet of actual junction cable. The application rule cited in Paragraph 7.514 applies. Compensator should be located X feet of actual cable from the D-66 loading point where X equals 5110/2.33 = 2190 feet. Distance from compensator to the H-88 loading point will be 5110 - 2190 feet = 2920 feet. C_1 and C_2 can then be computed as shown in the example.

7.5154 Example 20 shows two possible solutions for a cable layout with 10,100 feet of actual junction cable. Since 10,100 feet of cable exceeds the 8400 foot maximum in Paragraph 7.512, a loading coil should be added to the cable. Solution B shows a 66 mH coil and solution C a 88 mH coil added. The best solution is B since with solution C there is less actual cable at the junction and two capacitor build outs are required. Solution B sets $C_1 = 0$ and C_2 for 4800 - 2000 = 2800 feet.

7.6 Junction compensators should be installed on both repeatered and non-repeatered plant. When ordering the compensator a sufficient number of compensator units should be specified for spares as part of the normal circuit requirements.

7.7 The D-66/H-88 junction impedance compensators and all application examples shown herein require the use of exchange type cables (0.083 uF/mi.) for both the connecting company and the REA borrowers portion. It is the exchange type cable which makes interconnection of D-66 and H-88 loaded cables possible and further, for the reason discussed in Paragraph 7.3, requires the use of the junction impedance compensator. Where the connecting company provides 19 gauge H-88 loaded cable facilities using low capacitance cable, it is not possible for the REA borrower to use D-66 loading for connecting to it. In this situation the REA borrower portion must consist of D-88 loading. This special case is discussed in Paragraph 8.

7.8 To insure proper voice frequency repeater performance, it is imperative that the following steps be taken during the engineering, construction, and installation of the junction compensator.

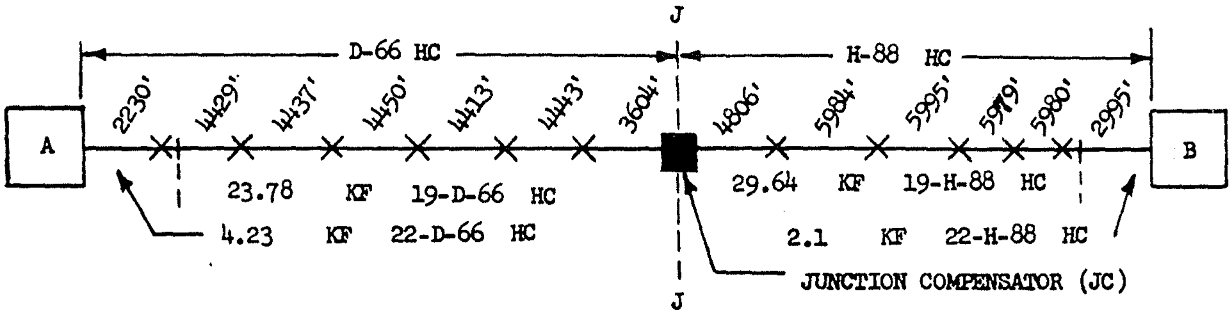
7.81 Compute the building out capacitors required (capacitors C_1 and C_2 in the compensator) only when the lengths of the natural D-66 and H-88 end sections at the junction are firmly known. Changes, if any, in the end sections due to re-staking, relocation, or other factors which entail a change in shunt capacitors C_1 and C_2, should be reflected in the actual capacitor values of the junction compensator procured.

7.82 Ascertain that the junction impedance compensator assembly is spliced correctly, that is, the D-66 side of the unit is connected to the D-66 portion of the trunk and the H-88 side is connected to the H-88 portion of the trunk. A reversed compensator may adversely affect the performance of voice frequency repeaters operating over the circuit in question.

7.9 To assure proper compensator performance the units should be ordered in accordance with REA Specification PE-31, latest issue, which covers all pertinent transmission, protection, and physical characteristics. External protection for the compensator is not required.

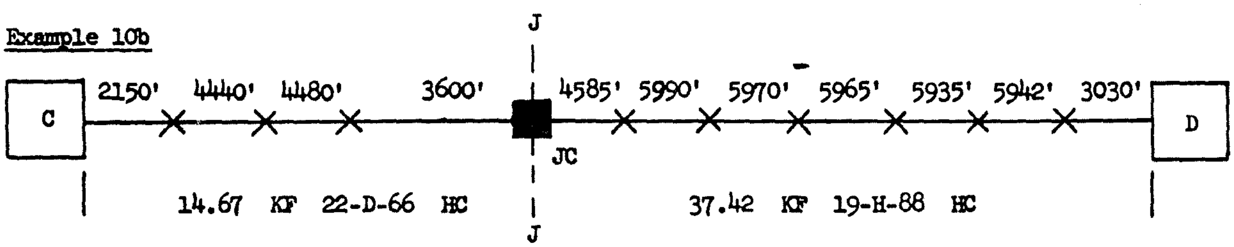
__Illustrative Example 10__ To show how to compute the attenuation of a loaded trunk cable similar to the one shown below at 1000 cps and 68°F.

__Example 10a__



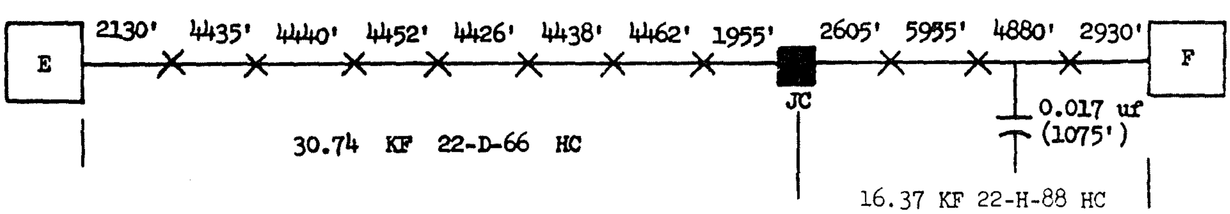
Procedure	Answer
Cable Attenuation + JC Loss (4.23 + 2.1) x 0.15 + (23.78 + 29.64) x 0.081 + 0.3	5.58 db

__Example 10b__

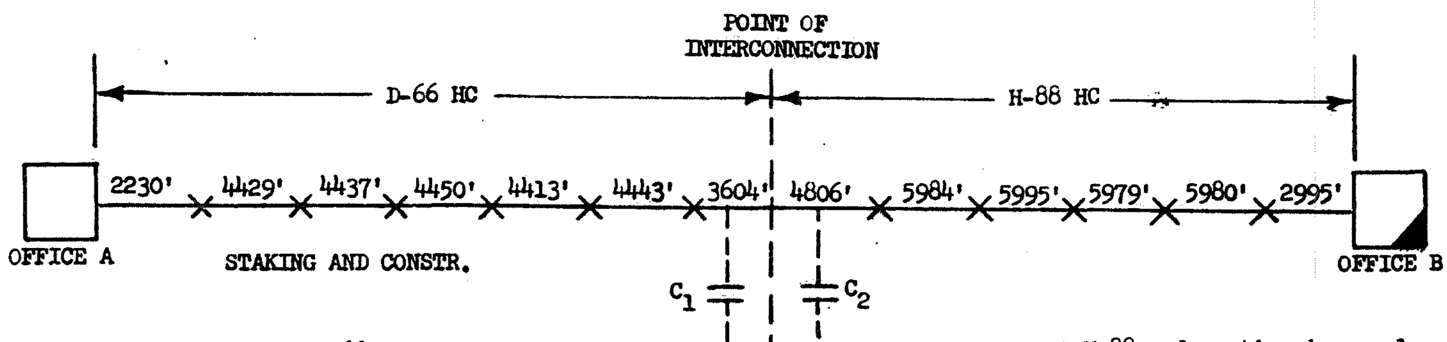


(14.67 x 0.15) + (37.42 x 0.081) + 0.3	5.53 db

__Example 10c__



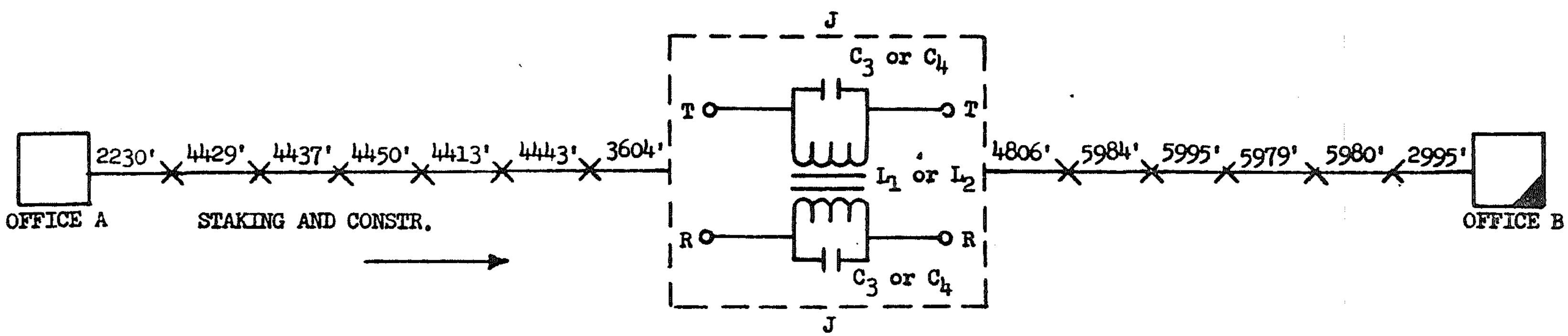
47.11 KF x 0.15 db/KF + 0.3	7.37 db



Since the natural D-66 end section is nearly 0.8 (3600') no CBO is required in the junction compensator. Therefore, capacitor $C_1 = 0$.

Since the natural H-88 end section is nearly 0.8 (4800') no CBO is required in the junction compensator. Therefore, capacitor $C_2 = 0$.

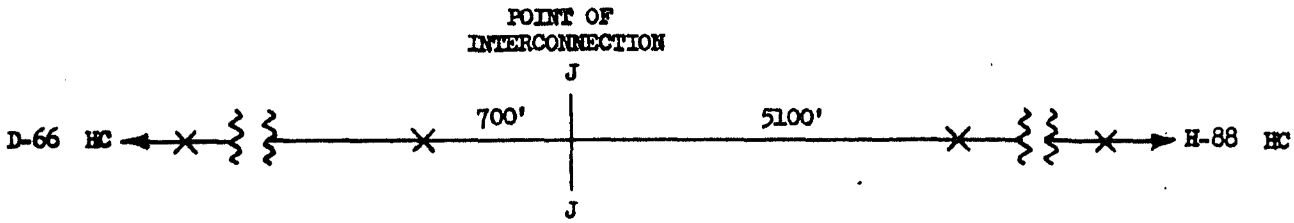
A. CABLE LAYOUT UNDER CONSTRUCTION



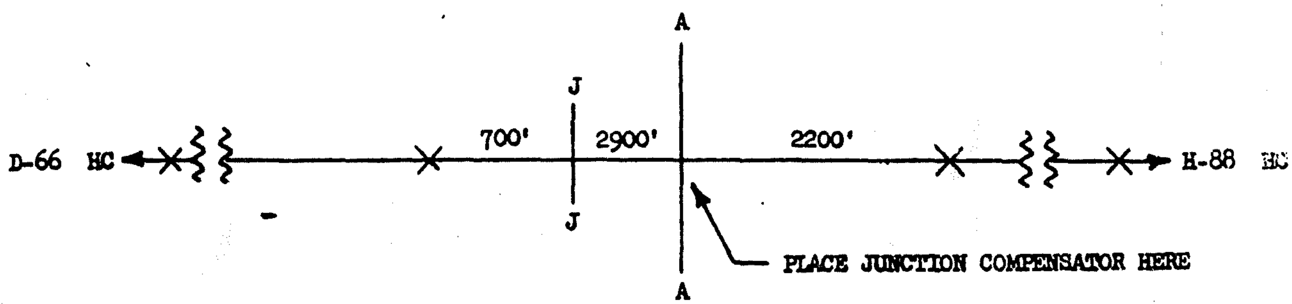
B. RESULTING APPLICATION OF JUNCTION COMPENSATOR

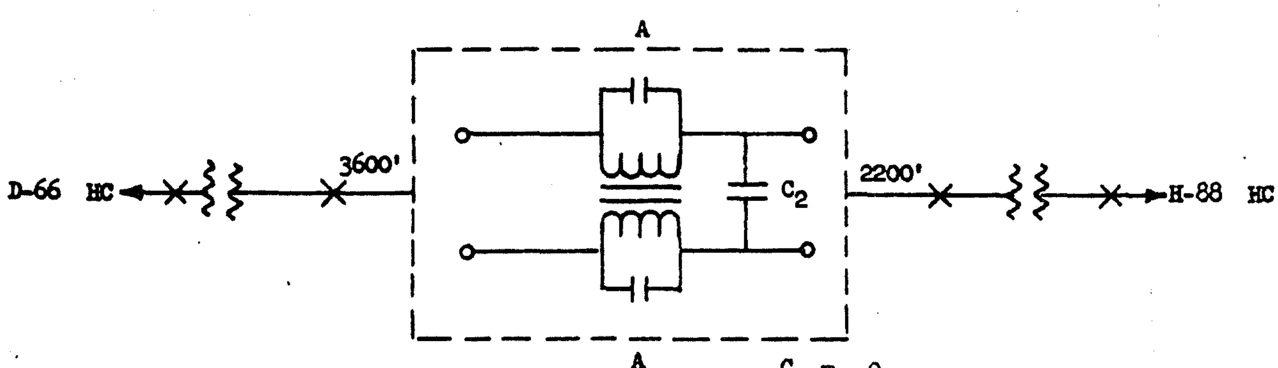
Notes:
1. In Examples 17 to 20, refer to Figure 1 for values of L_1 or L_2 of loading coil inductance and values of capacitance for C_3 or C_4 "series" capacitors in the compensator.
2. "T" and "R" designations in compensator refer to tip and ring conductor identification.
3. Office B is office of the connecting company.

ILLUSTRATIVE EXAMPLE 17
APPLICATION OF THE JUNCTION COMPENSATOR



A. CABLE LAYOUT UNDER CONSIDERATION





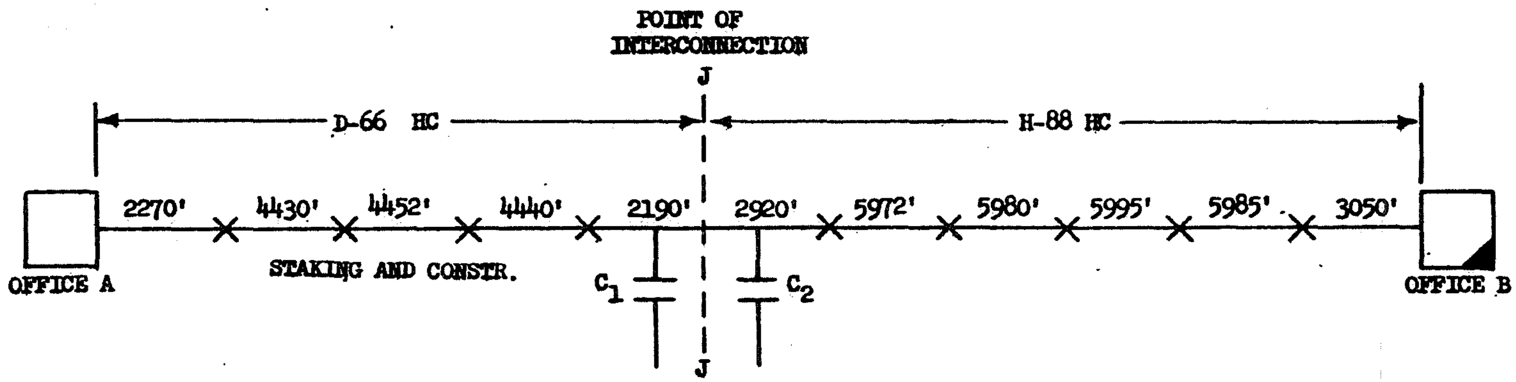
$C_1 = 0$

$$C_2 = \frac{(4800' - 2200')}{5280} \times 0.083 = 0.041 \text{ [illegible]}$$

B. RESULTING APPLICATION OF JUNCTION COMPENSATOR

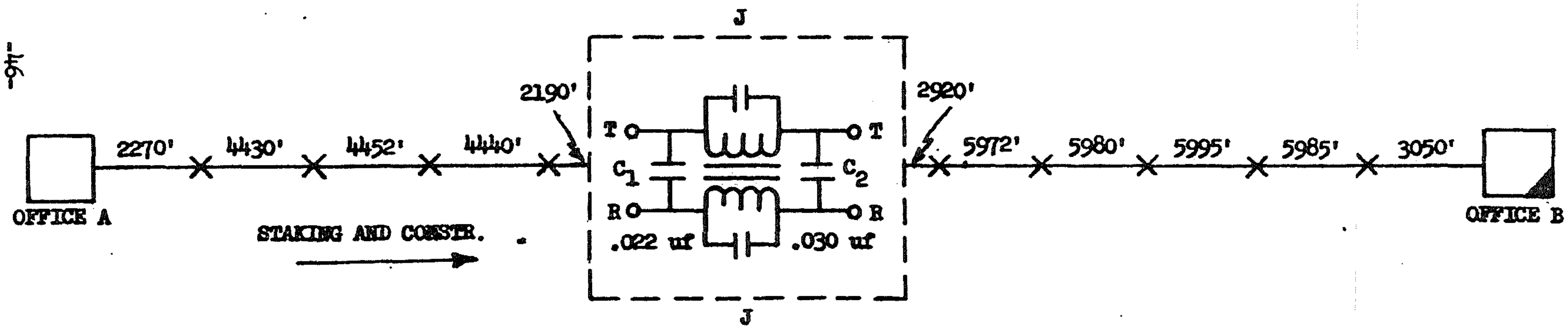
ILLUSTRATIVE EXAMPLE 18

APPLICATION OF THE JUNCTION COMPENSATOR



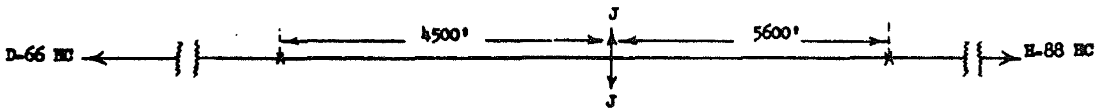
$$C_1 = \frac{(3600' - 2190')}{5280} \times 0.083 = 0.022 \text{ uf} \qquad C_2 = \frac{(4800' - 2920')}{5280} \times 0.083 = 0.030 \text{ uf}$$

A. CABLE LAYOUT UNDER CONSTRUCTION

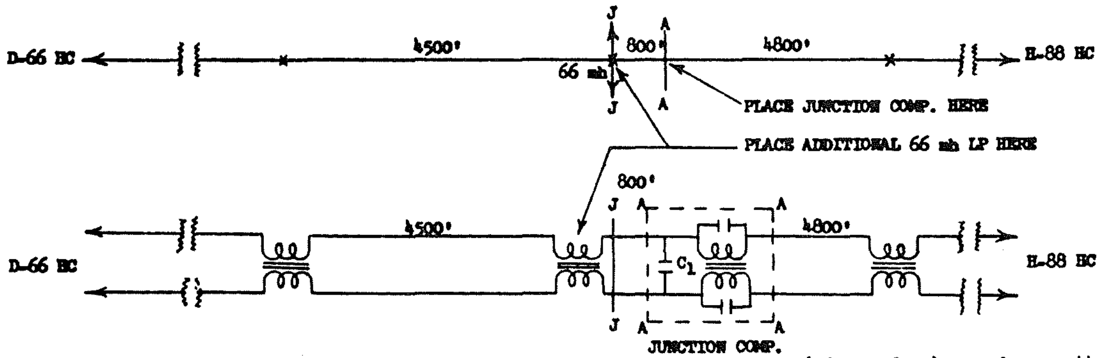


B. RESULTING APPLICATION OF JUNCTION COMPENSATOR

ILLUSTRATIVE EXAMPLE 19
APPLICATION OF THE JUNCTION COMPENSATOR



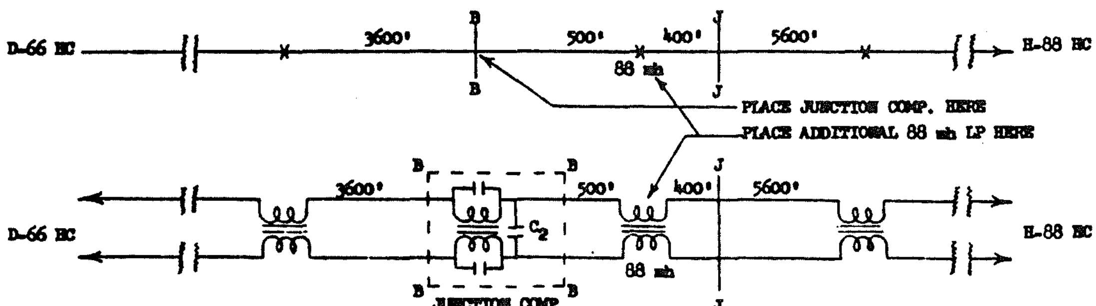
A. CABLE LAYOUT UNDER CONSIDERATION



$C_1 = \frac{(3600' - 800')}{5280} \times 0.083 = 0.044\ \mu f$

$C_2 = 0$

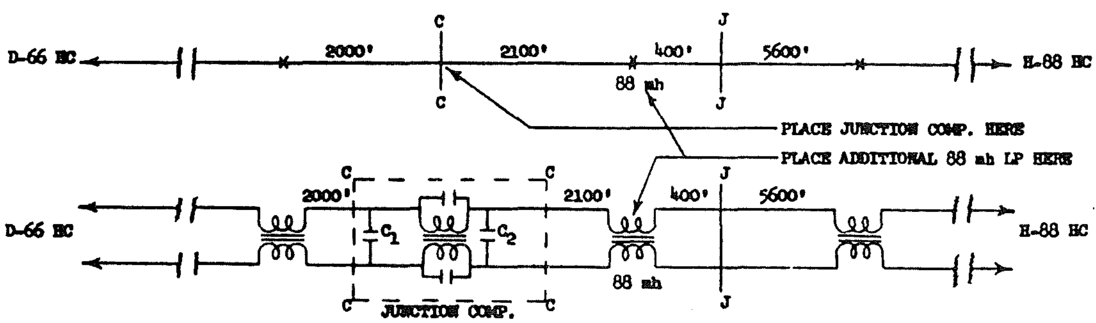
B. ONE POSSIBLE SOLUTION AND RESULTING JUNCTION COMP. CONFIGURATION



$C_2 = \frac{(4800' - 500')}{5280} \times 0.083 = 0.068\ \mu f$

$C_1 = 0$

C. ANOTHER POSSIBLE SOLUTION AND RESULTING JUNCTION COMP. CONFIGURATION



$C_1 = \frac{(3600' - 2000')}{5280} \times 0.083 = 0.025\ \mu f$

$C_2 = \frac{(4800' - 2100')}{5280} \times 0.083 = 0.042\ \mu f$

D. ANOTHER POSSIBLE SOLUTION AND RESULTING JUNCTION COMP. CONFIGURATION

ILLUSTRATIVE EXAMPLE 20
APPLICATION OF THE JUNCTION COMPENSATOR