# SUBSCRIBER LOOPS

# FACTORS AFFECTING INSERTION LOSS

## 1. GENERAL

**1.01** This section describes the effect of loop parameters and irregularities on the insertion loss of subscriber lines.

**1.02** The data resulted from a study which preceded the establishment of requirements for the J94024 Loop Checking System.

**1.03** Insertion-loss measurements (between 900-ohm terminations) were made using artificial cable to simulate selected nonloaded and H-88 loaded loops. Table 1 summarizes the detailed results shown on Figs. 1 through 11 for H-88 loaded loops and Figs. 12 through 14 for nonloaded loops.

**1.04** In general, the insertion-loss characteristic of a properly loaded loop exhibits a slight dip at about 2800 CPS. This is due to a very rapid change in the driving point impedance of the loop in this frequency range. In one particular case this change was from 2100-j1200 ohms at 2600 CPS to 800 + j0 ohms at 2850 CPS. This dip, therefore, is due to the higher transfer of energy from the 900-ohm oscillator to the loop at this frequency.

## TABLE 1

### LOADED LOOPS

| FIGURE | LOOP PROPERTY VARIED | LOOP PROPERTIES HELD CONSTANT | EFFECT ON INSERTION LOSS |
|---|---|---|---|
| 1 | Resistance | Length<br>Loading coil spacing<br>End section | Increase of 0.5 db per 100 ohms increase in resis. below 3 KC |
| 2 | Length | Resistance<br>Loading coil spacing<br>End section | No uniform effect on loss below 3 KC |
| 3 | Position of gauges in loop | Resistance<br>Length<br>Loading coil spacing<br>End section | No uniform effect on loss |
| 4 | Length of end section | Resistance<br>Length<br>Loading coil spacing | Loss increases for added end section by about 0.2 to 0.6 db per KFT below 3 KC |
| 5 | Length of bridged tap | Resistance<br>Length<br>Loading coil spacing<br>End section | About same effect as Fig. 4 |
| 6 | Bridged tap and end section length; sum of two held constant | Resistance<br>Length<br>Loading coil spacing | No uniform effect on loss below 3 KC |
| 7 | Internal loading coil mis-spacing | Length<br>Resistance<br>Sum of end section and bridged tap | Faster Cutoff.<br>Wobbulations below 2.5 KC |
| 8 | Added or missing loading coils | Length<br>Resistance<br>End section | About same effect as Fig. 7 |
| 9 | Position of 6 KFT bridged tap in loop | Length<br>Resistance<br>End section<br>Loading coil spacing | Taps between loading coils produce wobbulation and faster cutoff |
| 10 | Subscriber position in loop | Sum of length of loop plus bridged tap | Severe Wobbulation |
| 11 | Length of loaded bridged tap | Length<br>Resistance<br>End section<br>Loading coil spacing | Severe Wobbulation |

### NONLOADED LOOPS

| FIGURE | LOOP PROPERTY VARIED | LOOP PROPERTIES HELD CONSTANT | EFFECT ON INSERTION LOSS |
|---|---|---|---|
| 12 | Length of bridged tap | Resistance<br>Length | Loss increases about 0.2 to 0.4 db per added KFT bridged tap |
| 13 | Resistance | Length<br>Bridged tap | Loss increases about 0.5 db per added 100 ohms resistance |
| 14 | Length | Resistance<br>Bridged tap | Loss increases about 0.2 to 0.4 db per added KFT length |

## LOADED LOOPS

### Fig. 1 — Effect of Change of Loop Resistance

For a 36 KFT loop with a 9 KFT end section, the resistance was varied from 625 ohms to 1211 ohms by varying the gauge. Generally for frequencies below 2800 CPS, the loss increased by 0.5 db per 100-ohm increased loop resistance, when all other parameters were held constant. Above 2800 CPS, no pattern existed and cutoff was hardly affected.

### Fig. 2 — Effect of Change of Loop Length

For an 865-ohm loop with 9 KFT end section, the length was varied from 18 KFT to 48 KFT by varying the gauge. In the range 2500-3300 CPS, the loss varied by as much as 1.6 db and below 2500 CPS by as much as 1 db between different loops, but no pattern was observed. However, the longer loops tend to cut off more rapidly. At about 3500 CPS, the loss increased by as much as 0.3 db per KFT added length.

### Fig. 3 — Effect of Changing Gauge-Position in the Loop

For an 1139-ohm loop 36 KFT long, the makeup of the loop was varied by switching the gauge positions. Below 2500 CPS, the change in insertion loss was not very large, the maximum being about 0.7 db at 2500 CPS. Above 2500 CPS, the difference increased to about 1 db at 3300 CPS and 3 db at 3500 CPS. This is examined in more detail in Section AB22.090.12.

### Fig. 4 — Effect of Change in Length of End Section

For an 865-ohm loop 36 KFT long, the end-section length was varied by adding loading coils and by varying the office end section. Given a 3 KFT office end section, adding subscriber end section increased the loss by about 0.2 db/KFT at 1500 CPS, 0.2 to 0.4 db/KFT at 2000 CPS, 0.4 db/KFT at 2500 CPS and about 0.6 db/KFT above 2500 CPS. Thus, long end sections contribute to faster cutoff. Comparison of Curves (c) and (d) indicates that increasing the office end section 1.5 KFT and decreasing the subscriber end section 1.5 KFT made about 0.2 db loss difference below 2500 CPS and about 0.6 to 1 db above 2500 CPS.

### Fig. 5 — Effect of Change in Length of Bridged Tap

For an 865-ohm 36 KFT loop, the bridged tap length was varied. The bridged tap was lumped and placed 3 KFT from the subscriber since, as a result of other measurements, this appeared to give the greatest loss for a given length. The added insertion loss per KFT of added bridged tap was about 0.2 db at 1000 CPS, 0.4 db at 1500 and 2000 CPS, and 0.6 db at 2500 CPS and above.

### Fig. 6 — Effect of Varying Both End Section and Bridged Tap but Keeping Their Sum Constant

Again for an 865-ohm 36 KFT loop, the lengths of bridged tap and end section were both changed, but their sum was maintained constant at 15 KFT. These variations produced no discernible pattern in the insertion loss characteristic, although below 2500 CPS, there was a 1 db variation at some one frequency between different conditions. Cutoff occurred more rapidly for loops with the longer bridged tap and shorter end section. More thorough investigation indicated that, in general, bridged tap adds more loss than end section.

### Fig. 7 — Effects of Internal Loading Coil Mis-Spacing

For the 865-ohm 36 KFT loop, the loading coil spacing for the coils between the first and last was varied. The number of loading coils was kept constant at 5 and the end section plus bridged tap sum was kept constant to minimize variations due to changes in total wire beyond last loading coil (see Fig. 6). Using Curve (a) of Fig. 7 as the standard, misplaced loading coils produced wobbulations in the insertion loss curve below 2500 CPS and generally caused a much faster cutoff.

### Fig. 8 — Effects of Added or Missing Loading Coils

The subscriber end section was kept constant on the 865-ohm 36 KFT loop while loading coils were added and removed from the loop. Wobbulation was more pronounced below 2500 CPS and cutoff occurred at a lower frequency than for the variations of internal loading coil mis-spacing of Fig. 7.

### Fig. 9 – Effects of Bridged Tap Position

For the 865-ohm 36 KFT loop, a 6 KFT 19 gauge bridged tap was placed at various points in the loop. The solid curve represents the average of the losses caused by placing the bridged tap at the subscriber, at the midpoint of the end section, and at the last loading coil. There was little difference in the loss caused by this variation, but the greatest loss occurred for the bridged tap placed at the midpoint. Bridged tap placed between loading coils caused either wobbulation below 2500 CPS or faster cutoff or both.

### Fig. 10 – Effects of Subscriber Position in the Loaded Loop

Again for the 865-ohm 36 KFT loop, the detector was placed at various points which yielded loaded bridged taps. Each loading coil in the bridged tap produced one loss peak between 300 and 3500 CPS. The cutoff frequency increased as the detector was moved closer to the oscillator. This was due in part to shorter length loops having higher cutoff frequencies as was shown in Fig. 2.

### Fig. 11 – Effects of Adding Loaded Bridged Tap

In this figure, the basic 865-ohm, 36 KFT loop was kept constant while loaded bridged tap was added beyond the subscriber. In this manner, the change in loss due to change in loop resistance and length was nullified. Connection of the loaded bridged tap did not necessarily produce the same number of discernible loss peaks as loading coils in the bridged tap. The cutoff was not effected appreciably because the length of the loop was held constant.

## NONLOADED LOOPS

### Fig. 12 – Effect of Change in Length of Bridged Tap

The bridged-tap length on an 18 KFT 22 gauge loop was varied between zero and 6 KFT. The insertion loss of the loop increased by about 0.2 db at 1000 CPS to 0.4 db at 3000 CPS for each added KFT of bridged tap. The bridged tap was lumped and placed at the midpoint of the loop since this appeared to give the greatest loss.

### Fig. 13 – Effect of Change of Loop Resistance

The resistance of a constant length loop was changed by changing the gauge. The loss of the loop increased by about 0.5 db for each 100 ohms added resistance.

### Fig. 14 – Effect of Change of Loop Length

The length of a relatively constant resistance loop was changed by changing the gauge. The loss of the loop increased by about 0.2 db at 1000 CPS to 0.4 db at 3000 CPS for each added KFT of length. Note that this is about the same effect as that produced by adding bridged tap (see discussion of Fig. 12 above).
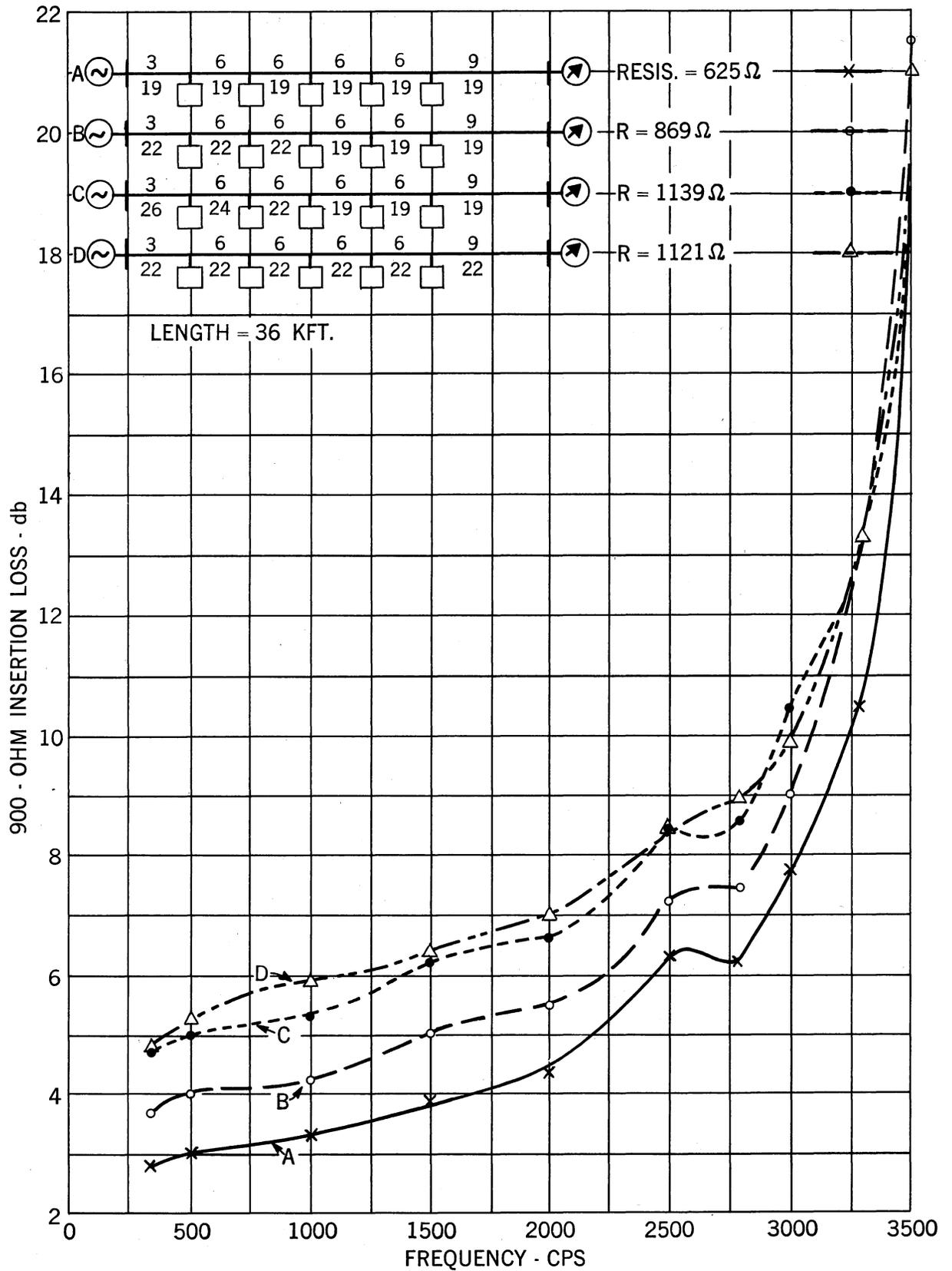
**Fig. 1 – Variation of Insertion Loss as a Function of Loop Resistance**
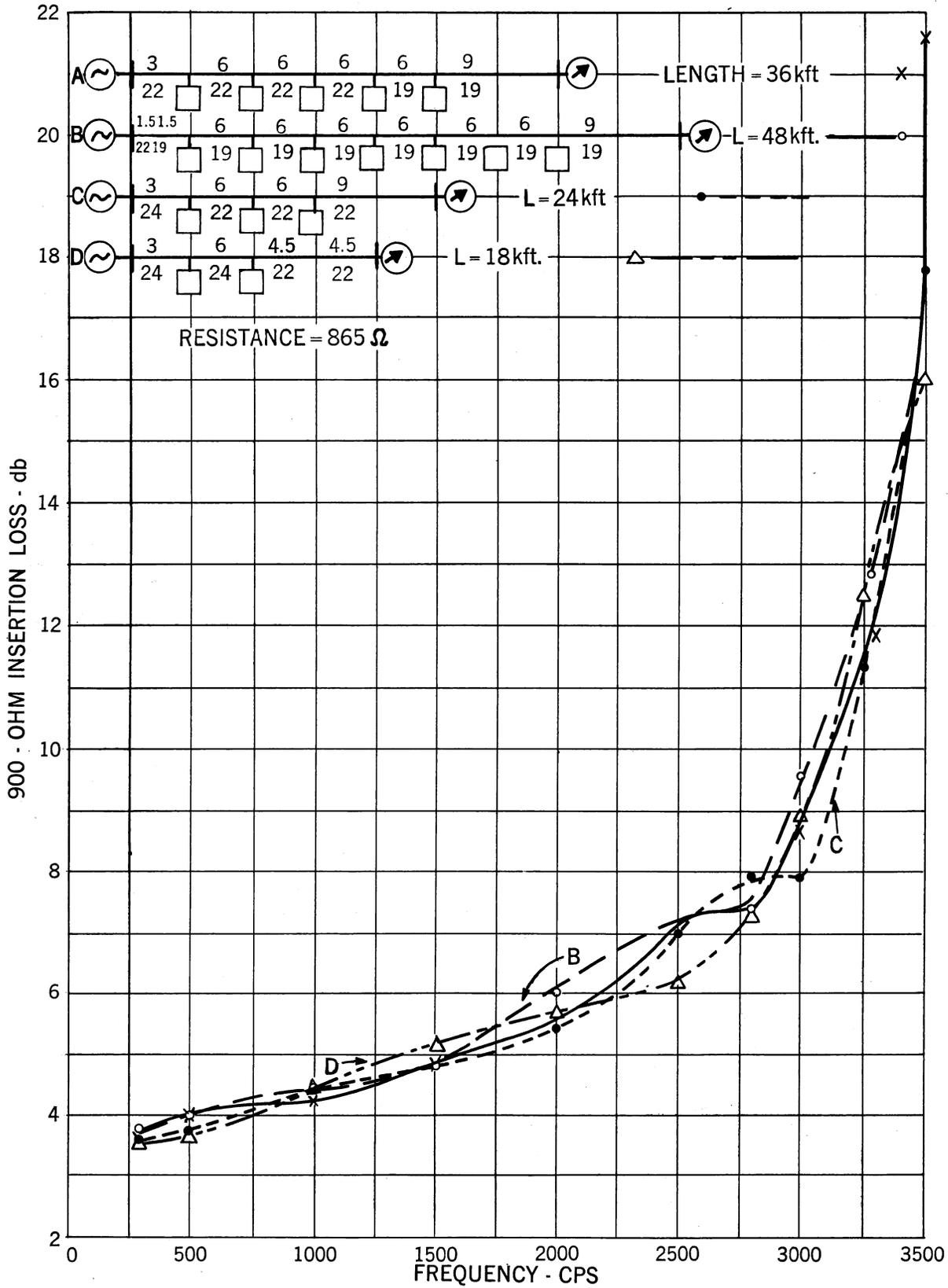
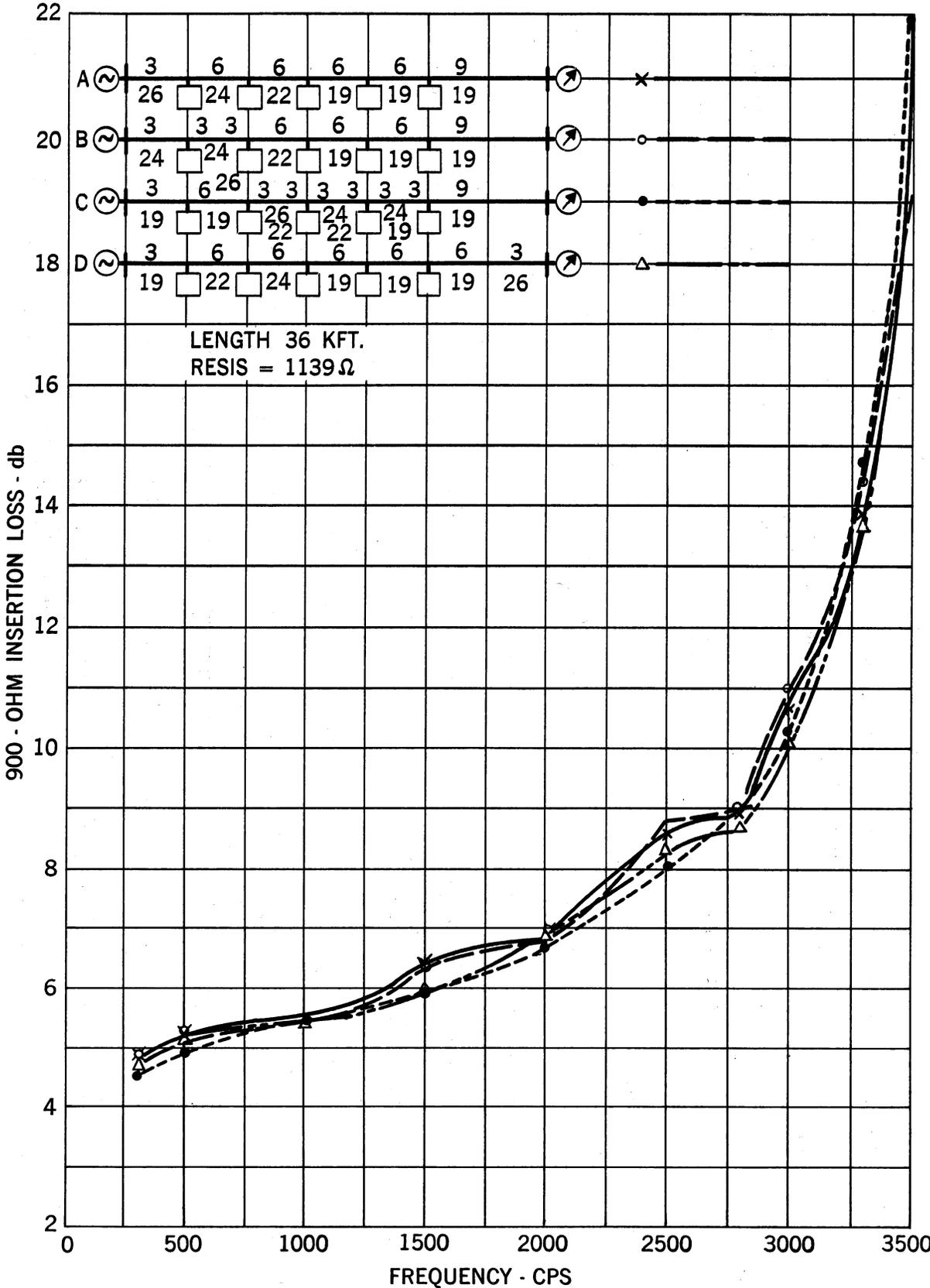Fig. 2 — Variation of Insertion Loss as a Function of Loop Length

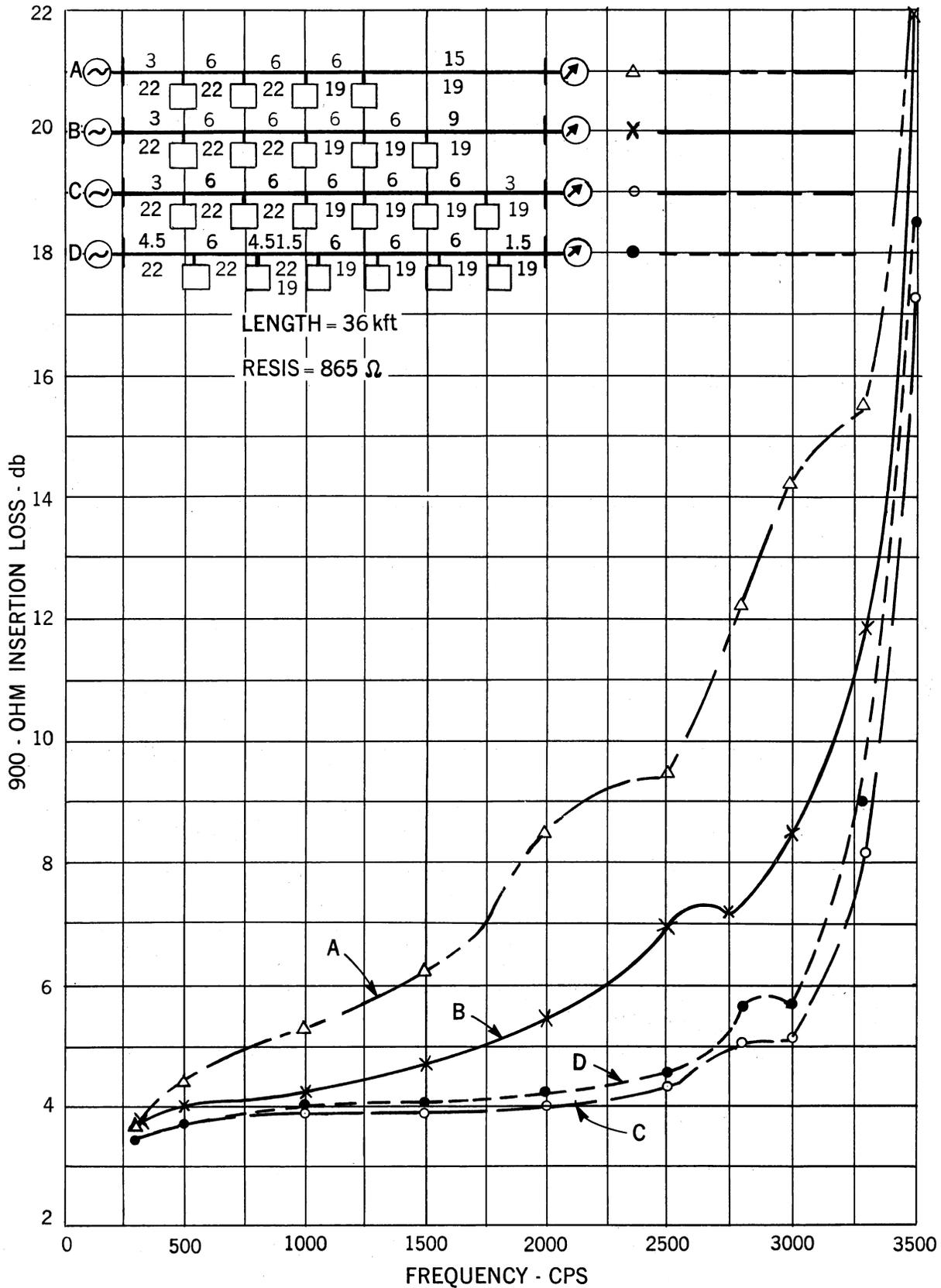Fig. 3 — Variation of Insertion Loss as a Function of Loop Gauge Position

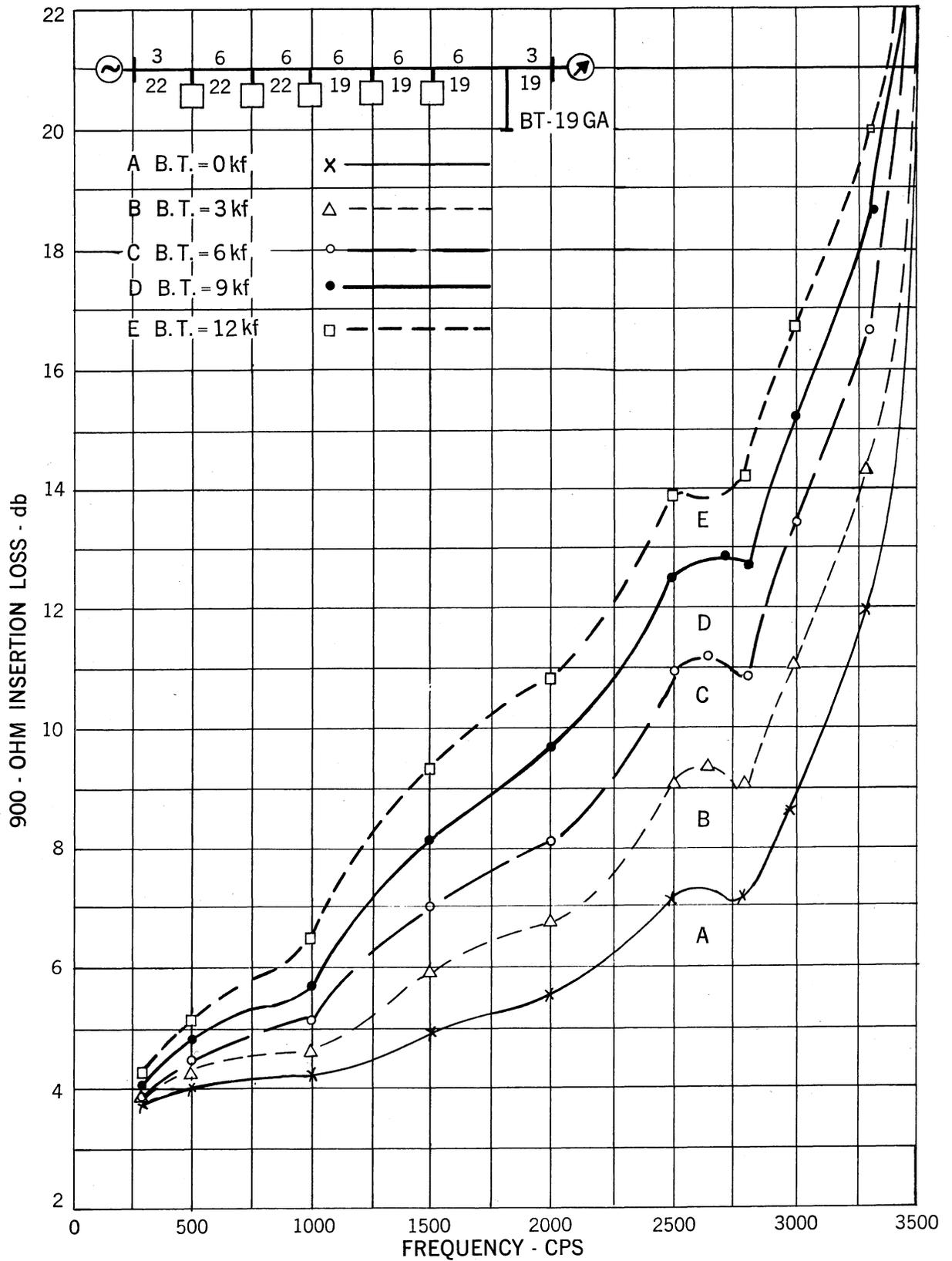Fig. 4 — Variation of Insertion Loss as a Function of End Section Length

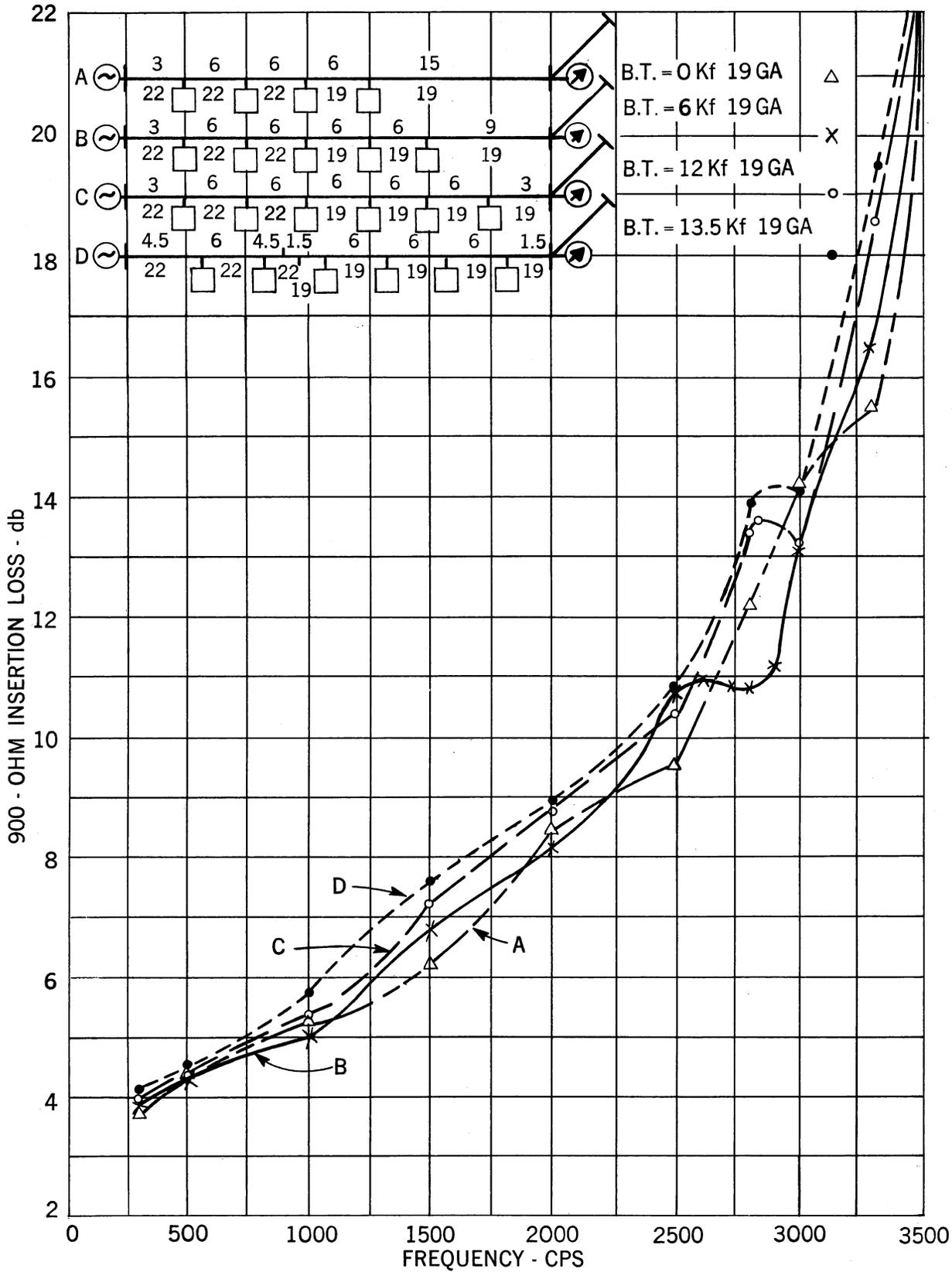Fig. 5 – Variation in Insertion Loss as a Function of Bridged Tap Length

Fig. 6 — Variation of Insertion Loss as a Function of Bridged Tap and End
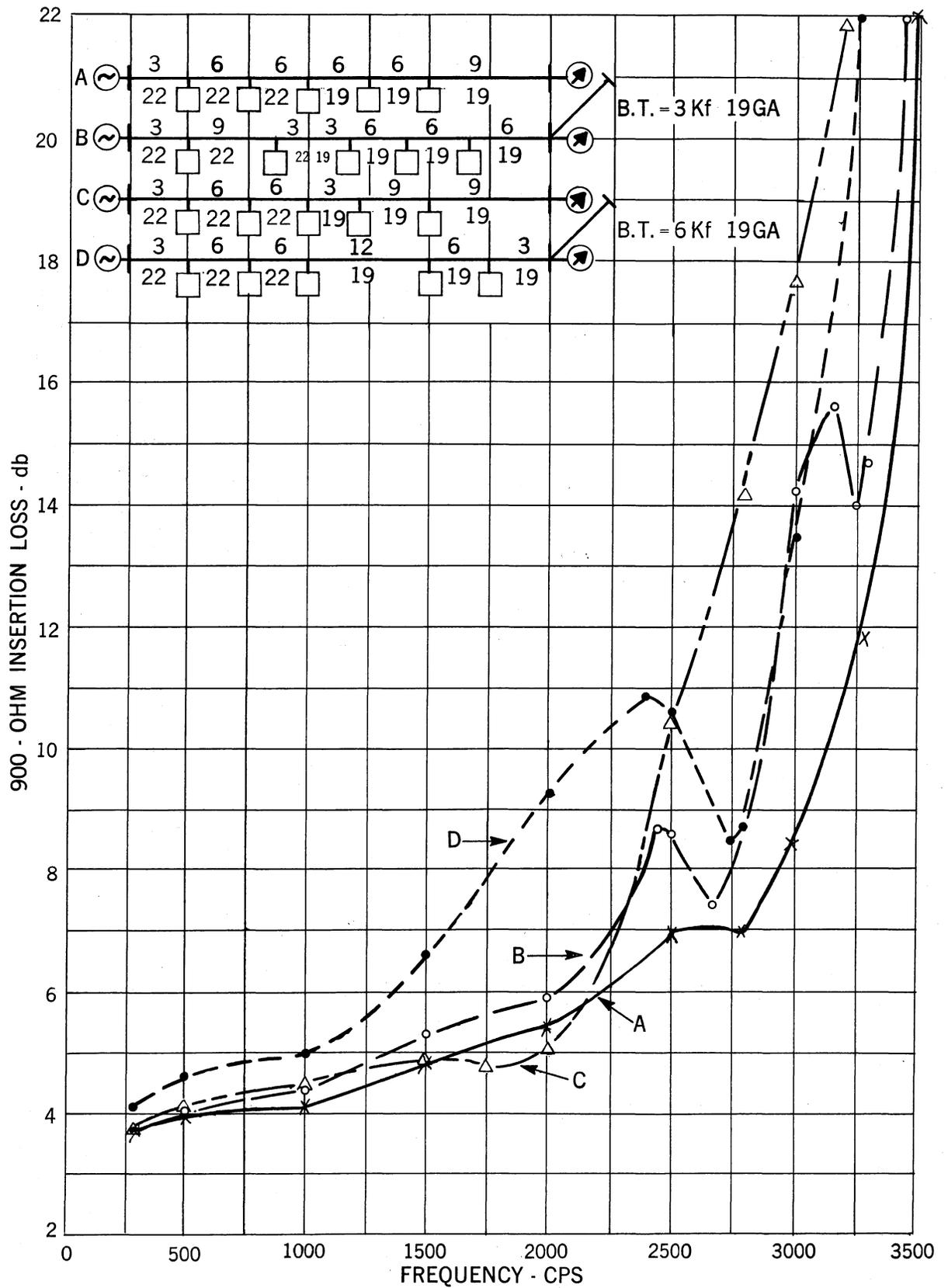Section Length with Their Sum a Constant

Fig. 7 — Variation of Insertion Loss as a Function of the Internal Load Spacing
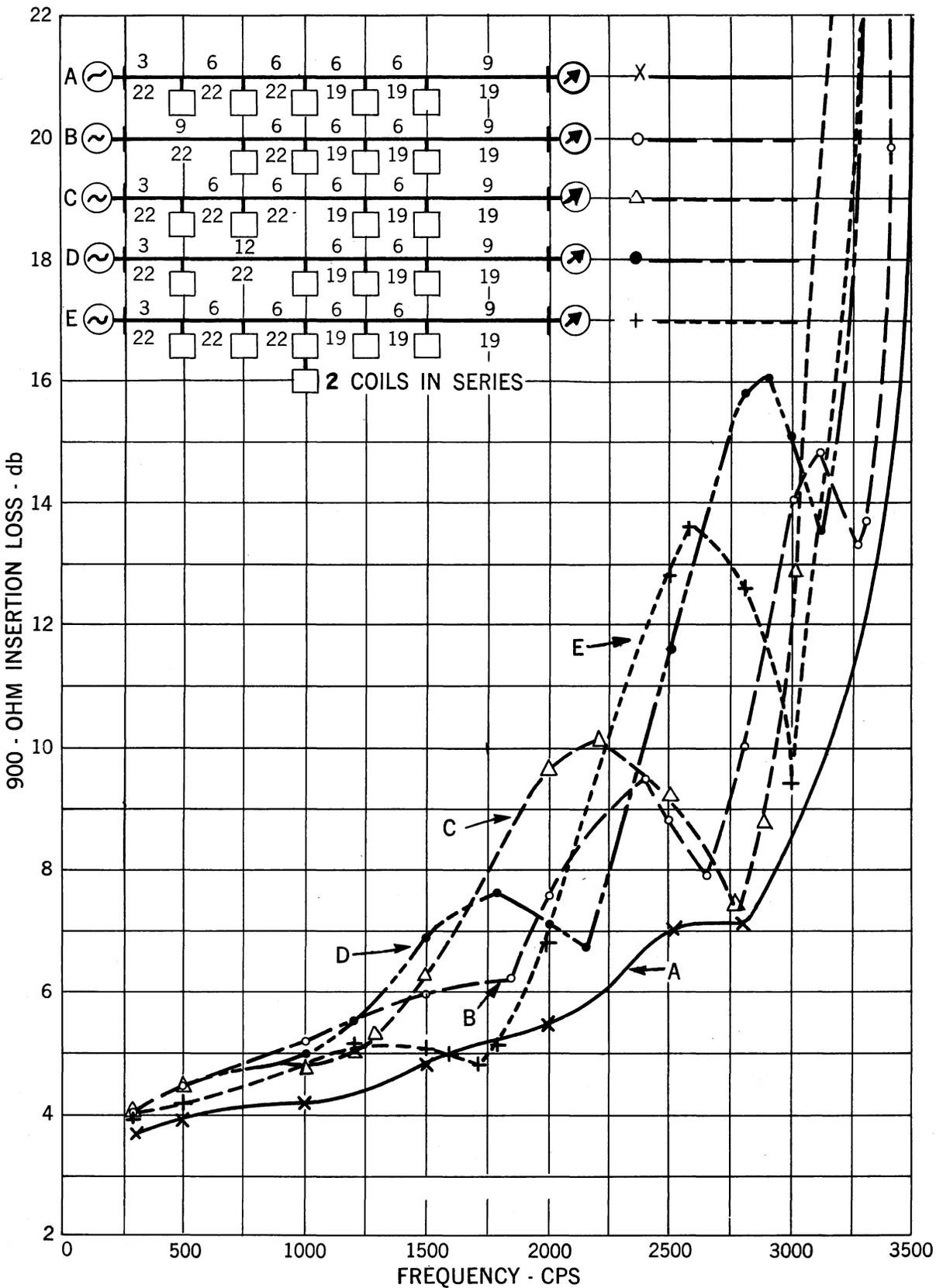
Fig. 8 — Variation in Insertion Loss Due to Added or Missing Load Coils
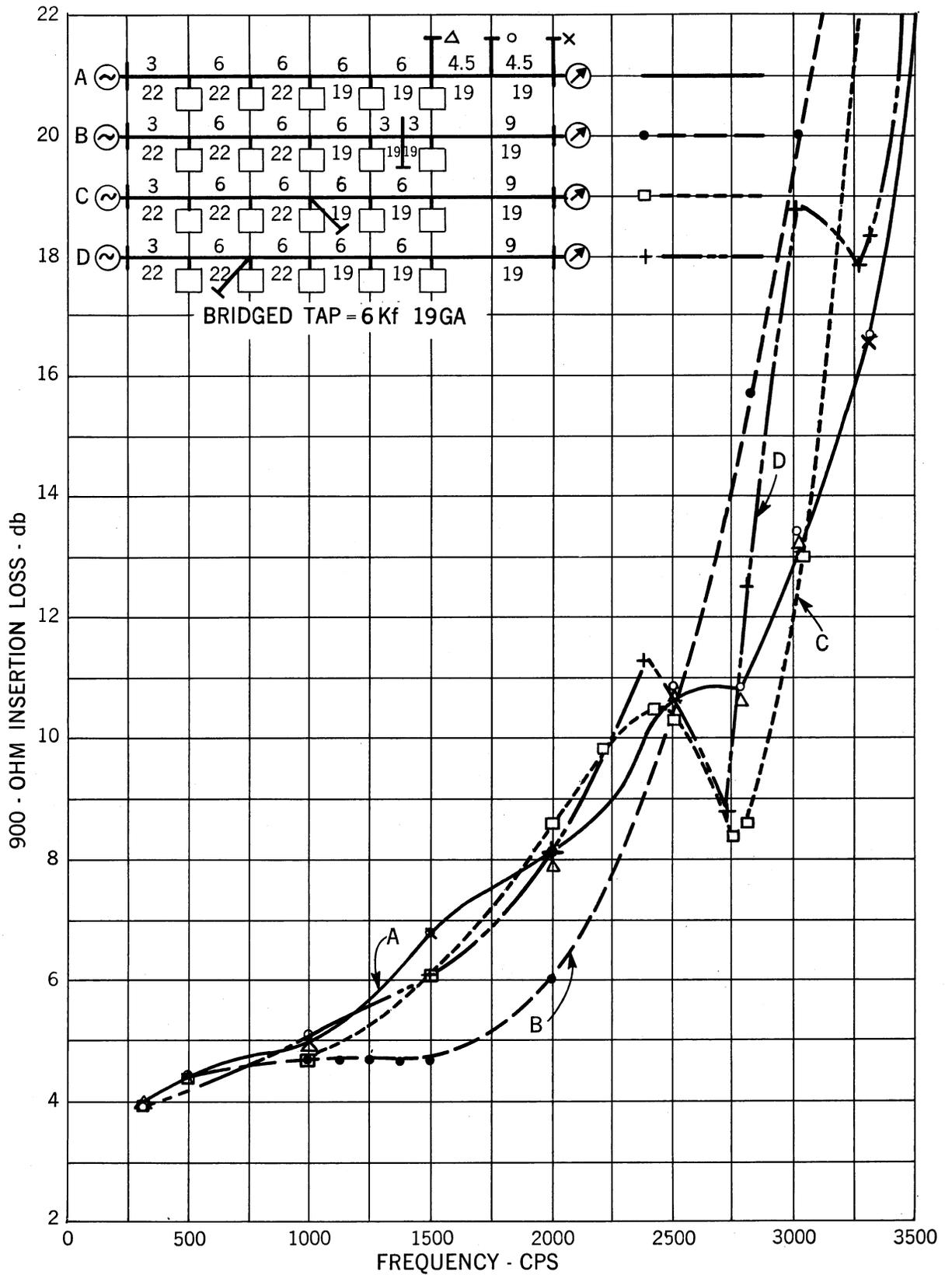
**Fig. 9 — Variation in Insertion Loss as a Function of the Position of the Bridged Tap in the Loop**
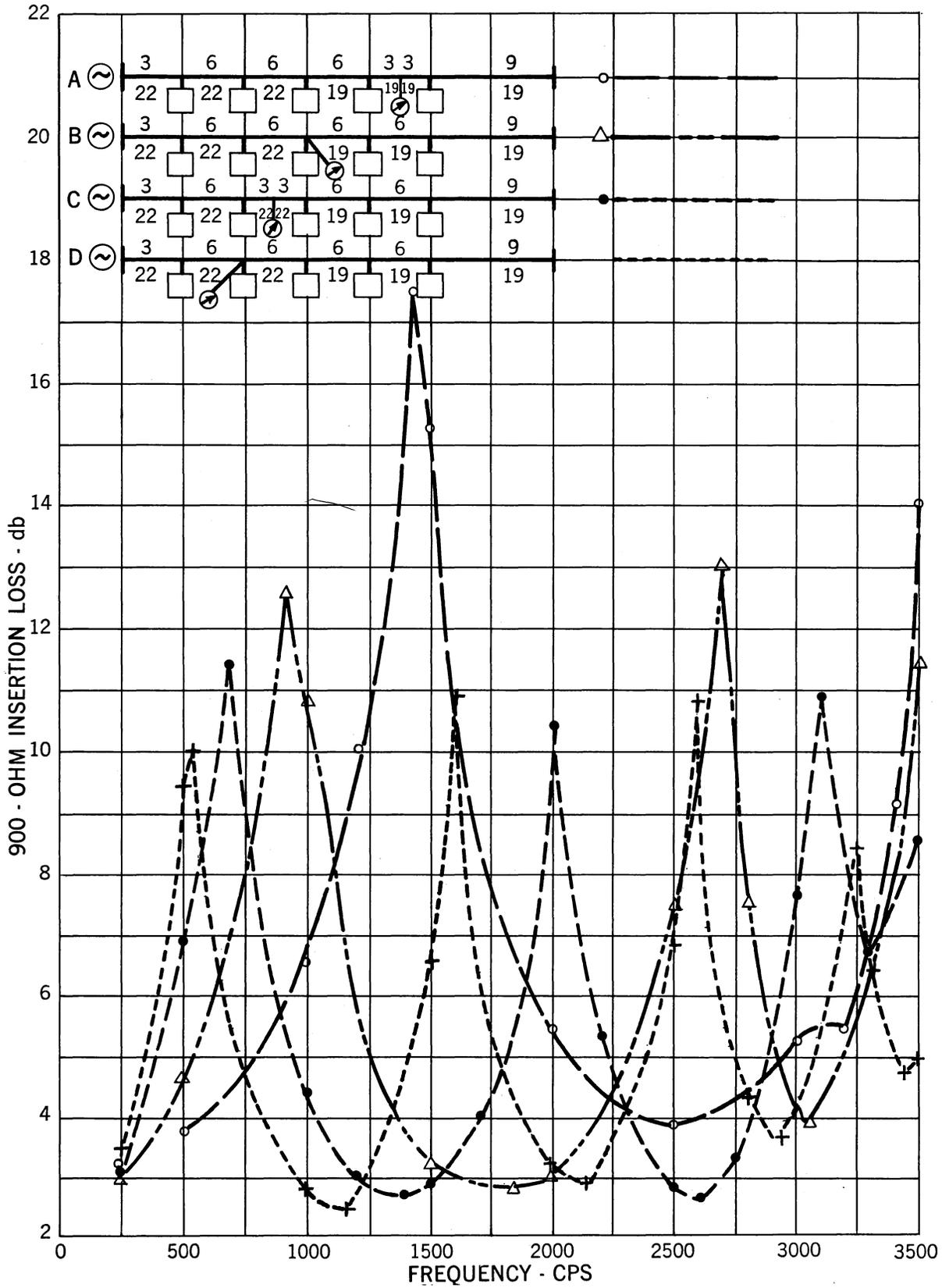
Fig. 10 — Variation in Insertion Loss as a Function of the Subscribers Location
in a Particular Loaded Loop
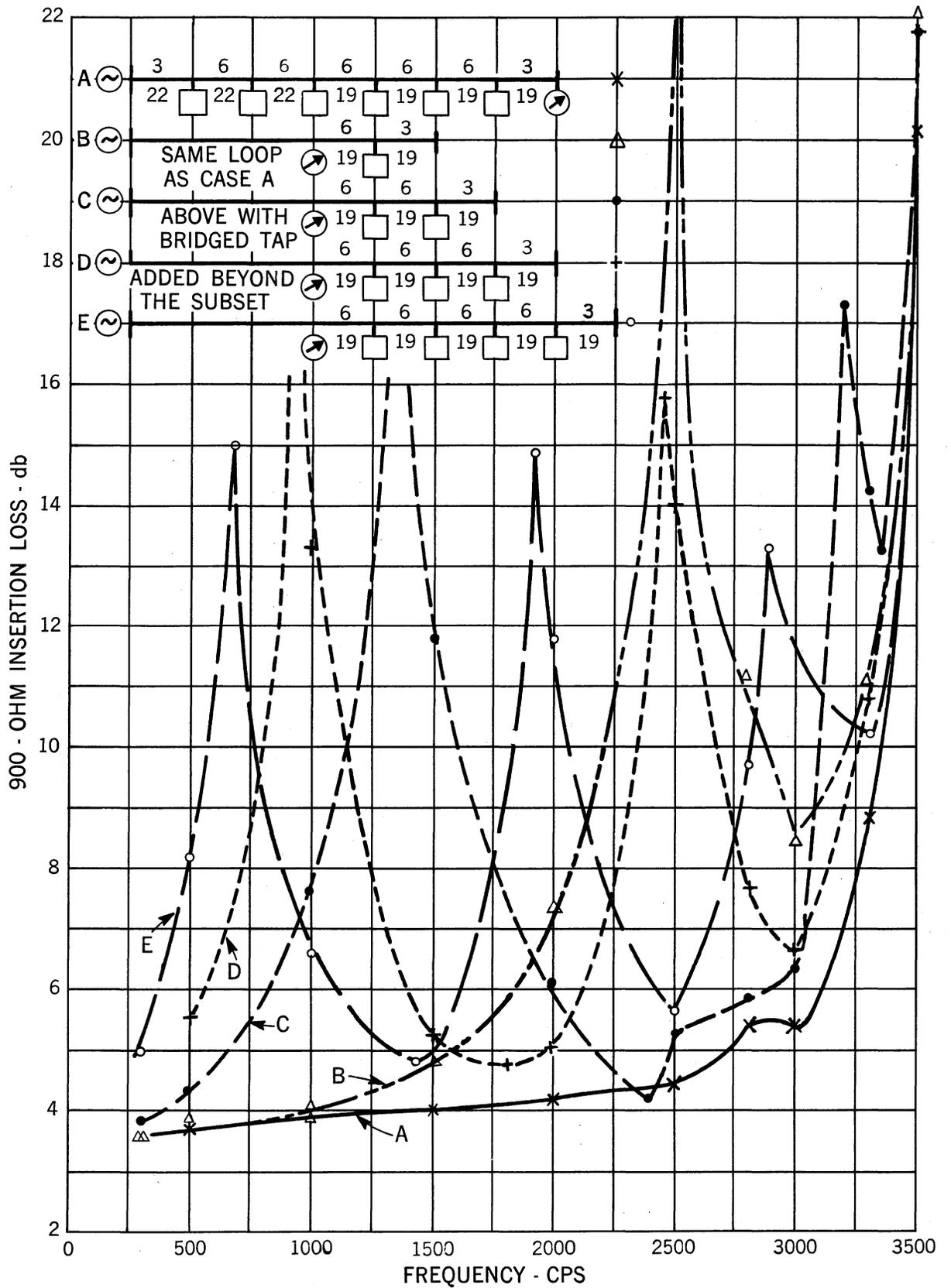
Fig. 11 – Variation in Insertion Loss Due to the Addition of Loaded Bridged Tap
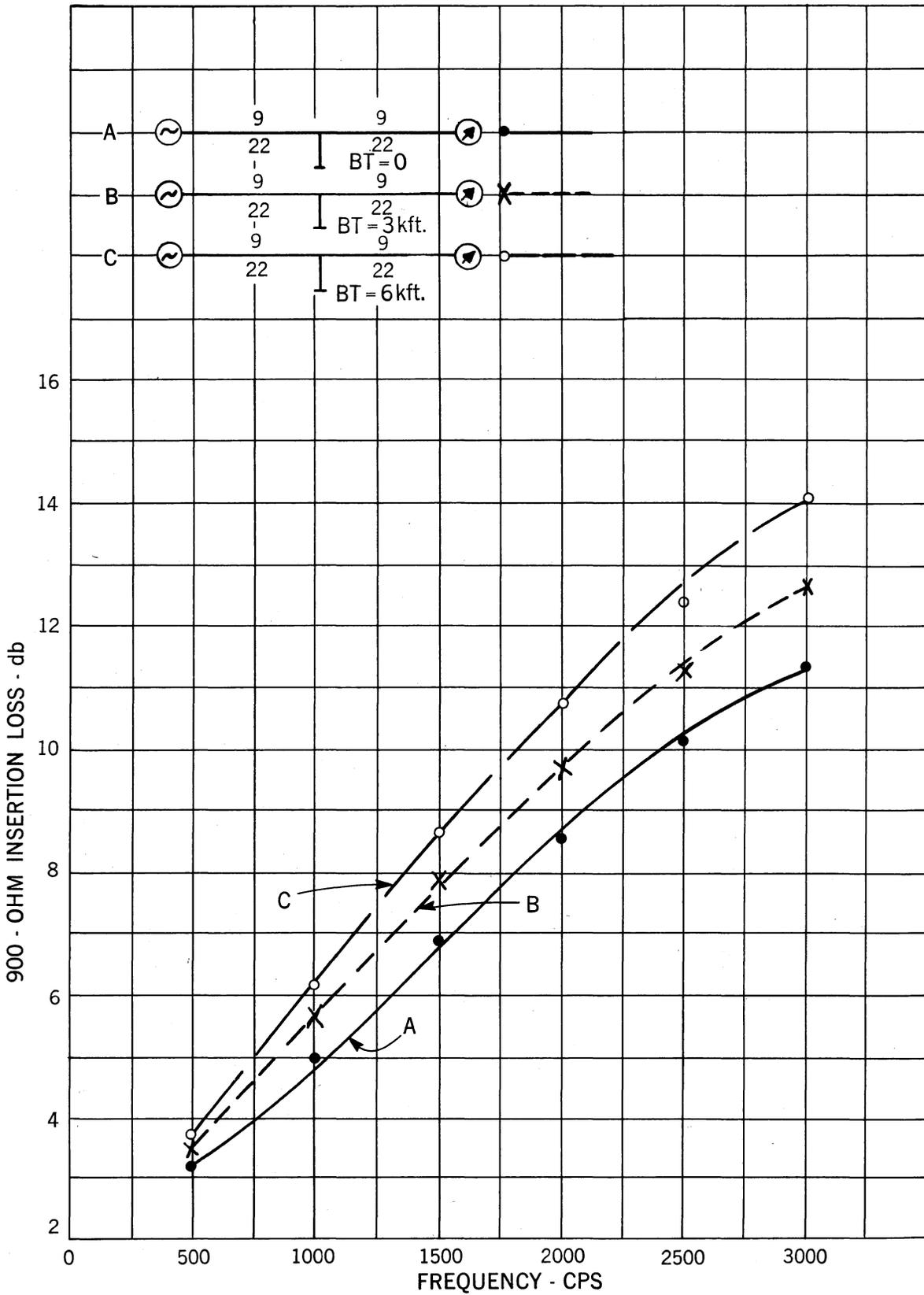
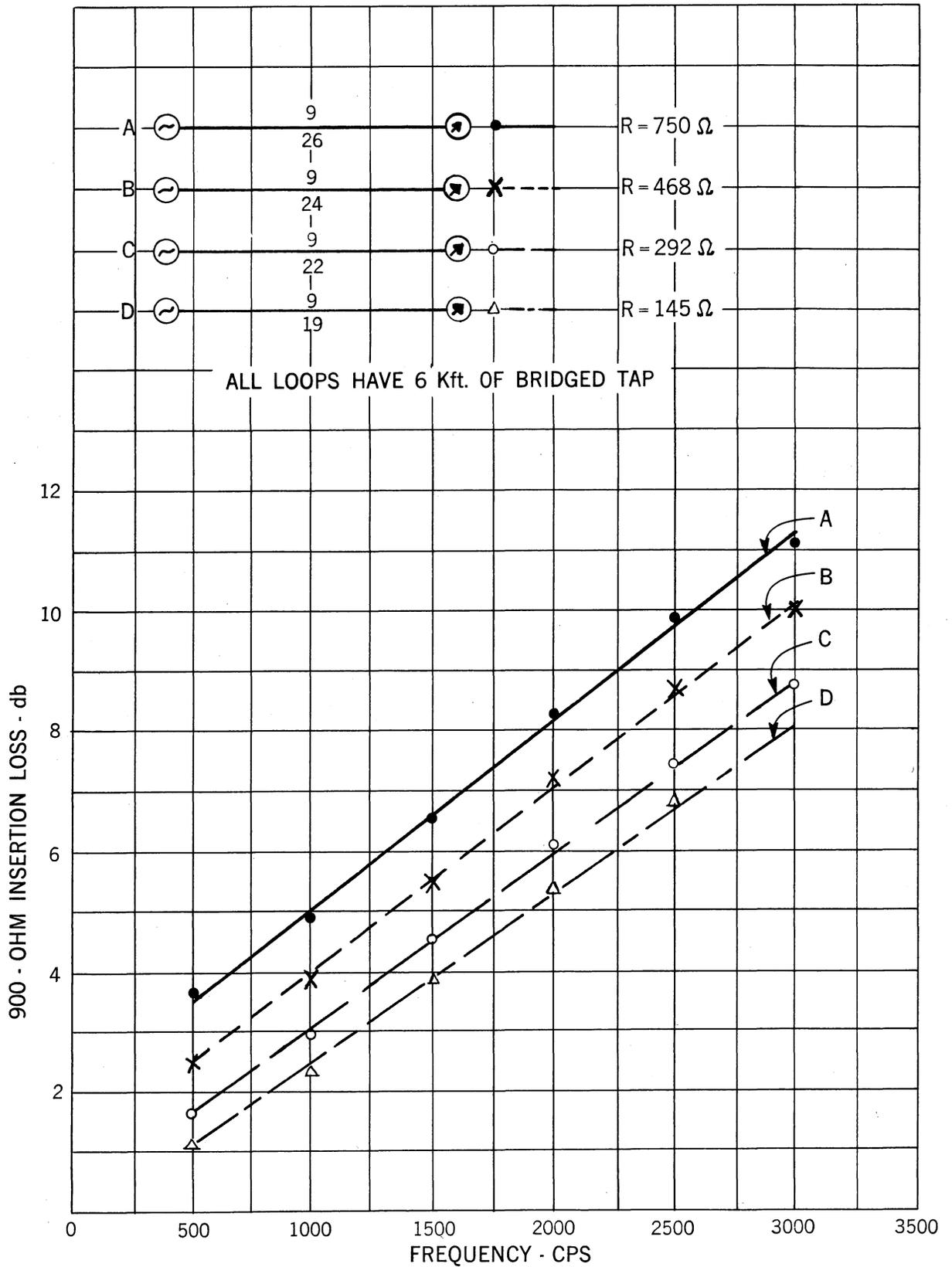Fig. 12 — Variation of Insertion Loss as a Function of Bridged Tap Length

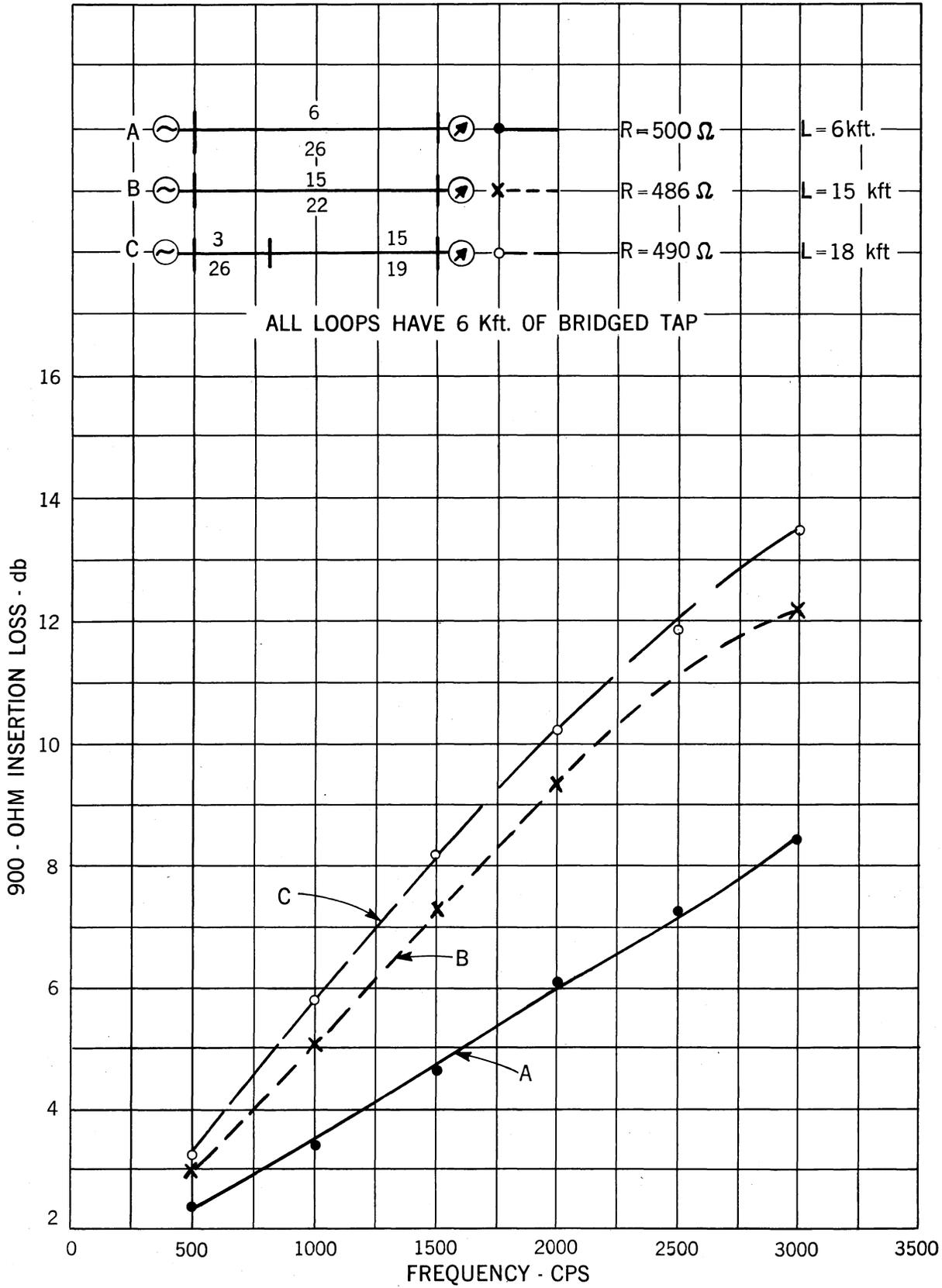**Fig. 13 — Variation of Insertion Loss as a Function of Resistance**

Fig. 14 – Variation of Insertion Loss as a Function of Length