LOOP CHECKER GENERATOR
APPLICATICN TO NONLOADED LOOPS

1. GENERAL

1.01 The reasons for using a swept band of frequencies were discussed in Section AB22.090.1. In Section AB22.090.12, the frequency weighting of this swept band required for measuring loaded loops was derived. There is also the need for measuring nonloaded loops. This section discusses application of the shaped sweep-frequency generator output to measurement of nonloaded loops.

1.02 Nonloaded loops do not have the same loss vs. frequency characteristic as loaded loops. Nonloaded loops also ordinarily do not have as many types of irregularities as loaded loops. The most probable irregularity is excess bridged tap which degrades the transmission over the whole band, becoming more evident at the higher frequencies (see Section AB22.090.11, Fig. 12).

1.03 In applying the shaped generator output to nonloaded loops, it was recognized that the slope of the loss vs. frequency characteristic of nonloaded loops with the allowed 6 KFT of bridged tap is less than that of the ***limiting*** loaded loop.* This can be seen from observing Curves (a) and (b) on Figs. 1, 2, and 3 where the losses on nonloaded and loaded loops of the same resistance are compared. In most cases, the loss of the nonloaded loop is greater than the loss of a limiting loaded loop with the same resistance over part or all of the frequency band, but the slope of the loss vs. frequency characteristic is less.

1.04 Further examination of Figs. 1 through 3 shows that the loss of the nonloaded loop can be made equal to the loss of the limiting loaded loop at one frequency in the band or, to put it another way, the loss curves can be made tangent at one frequency by inserting a flat-gain or loss device in the loop. The gain or loss of this device depends on the length of the loop. As discussed below, the additional gain required is about equal to the actual length of the loop less 6 KFT times 0.25 db, i.e.,

$$G = (L-6)\ (0.25)\ \text{db}$$

(Note that for loop lengths less than 6 KFT, the gain will be negative, i.e., a loss.) This gain is provided in the Loop Checker through the use of the length adjustment. For example, consideration of Fig. 1 reveals that a negative gain (loss) of 0.75 db added to the loss of a 3 KFT nonloaded loop will make its loss curve tangent to the loss curve of the same resistance limiting loaded loop at 1 KC. This 0.75 db loss is calculated from

$$G = (3-6)(0.25) = -0.75\ \text{db gain}$$

Similarly, the gain required for the case of Fig. 3 is

$$G = (18-6)(0.25) = 3\ \text{db}$$

As shown on the figure, this amount of gain added to the loss of the 18 KFT nonloaded loop will make its loss curve tangent to the loss curve of the same resistance limiting loaded loop at 2 KC.

Previous discussion and consideration of Figs. 1, 2, and 3 shows that the tangent frequency varies with the length of the loop from about 1 KC at 3 KFT to 2 KC at 18 KFT. This tangent frequency depends on the length only and not on the gauge or resistance of the loop. The measurement of the transmission performance of the loop is made at the tangent frequency. At all other frequencies, the loss of the limiting loaded loop exceeds that of the nonloaded loop with its associated length gain adjustment. Since the generator shaped output is based on the limiting loaded loop loss, this means that the relative output power of the generator exceeds the loss of the nonloaded loop except at the tangent frequency. This can perhaps be clarified by referring to Fig. 7.

* See Section AB22.090.12, Paragraph 1.02, for the definition of the limiting loaded loop.

This figure demonstrates application of the shaped output of the generator to a loop. The loss of the nonloaded loop is greater than the loss of the loaded loop over most of the band, but its loss vs. frequency slope is less. Thus, the received power at point B is generally less for a nonloaded loop than that for a loaded loop. The length-sensitivity adjustment of the Loop Checker is represented by the variable amplifier, and the meter represents only the indicating portion of the Loop Checker. Assume for the moment that the amplifier is a part of the loop during the measurement. By applying the length-sensitivity adjustment, i.e., adjusting the amplifier gain, the loss of the nonloaded loop is made equal to the loss of the limiting loaded loop at the tangent frequency. The needle pattern at point C results. If the nonloaded loop has excess bridged tap (over 6 KFT) its loss will be greater than that allowed, and the needle will deflect into the FAIL region in the vicinity of the tangent frequency.

1.05 Working with maximum allowed losses at the varying tangent frequencies is difficult. A more convenient and simpler method is to designate a measurement or "allowed loss" frequency, and derive constants relating the various tangent frequencies to this designated frequency.

The "allowed loss" frequency was arbitrarily selected to be 2000 CPS. Plotted on Fig. 4 are the measured 2000 CPS insertion losses of a number of nonloaded loops having 6 KFT of bridged tap. Straight lines plotted to fit the data points exhibit the same 0.5 db/100 ohm slope discussed in Section AB22.090.12.

1.06 As discussed earlier, a length-sensitivity adjustment must be made in the Loop Checker to produce the loss tangent points which vary in frequency from about 1 KC to 2 KC, depending on the length of the loop. In order to set a 2 KC "allowed" loss value, some adjustment must be made for those loops whose tangent frequency is not 2 KC. The loss of the 3 KFT 250-ohm loop of Fig. 1 should not exceed 2.25 db loss at 1 KC and 3.8 db loss at 2 KC. When the sensitivity adjustment of 0.75 db added loss is made to achieve tangency, the combined loss of the loop plus length-sensitivity adjustment should not exceed 3 db at 1 KC and 4.55 db at 2 KC. The loss of the equal resistance (250 ohms) limiting loaded loop is about 6.05 db at 2 KC. Thus, in terms of the "allowed loss" frequency (2 KC), the 3 KFT 250-ohm nonloaded loop plus length-sensitivity adjustment should not have a loss greater than 6.05 db. This is 1.5 db greater than the 4.55 db mentioned above and is shown in Fig. 1.

1.07 Following the same procedure, correction factors derived using Figs. 2 and 3 were 0.6 db for a 9 KFT loop and zero db for an 18 KFT loop. These correction factors are plotted as a smooth curve for loops of all lengths up to 18 KFT long on Fig. 5.

1.08 Application of the correction factors to the curves of Fig. 4 produces the curves of Fig. 6 which shows the permissible losses for nonloaded loops in terms of the "allowed loss" frequency. Some smoothing has been applied in the derivation of Fig. 6 to provide for uniform loss steps of 0.25 db KFT between loops of different length. Also shown is the 2 KC allowed loss of the limiting loaded loop. The correction factors of Fig. 5 plus the smoothing have moved the 2 KC loss curves up from Fig. 4 until the 6 KFT nonloaded loop curve corresponds to the loaded loop curve. These curves show why the sensitivity adjustment of the Loop Checker is the same at the "OVER 18" and the 6 KFT positions of the "LENGTH" dial.

Two things must be remembered. First, although the Loop Checker sensitivity adjustment is based on the 2000 CPS "allowed" losses, the measurement of the transmission performance of the nonloaded loop actually takes place at the tangent frequency. Second, the "allowed" 2000 CPS losses are only a means of working with losses at one frequency when designing the Loop Checker, and are applicable only to the Loop Checker. They cannot be used as objectives or requirements for any other type of measuring procedure.

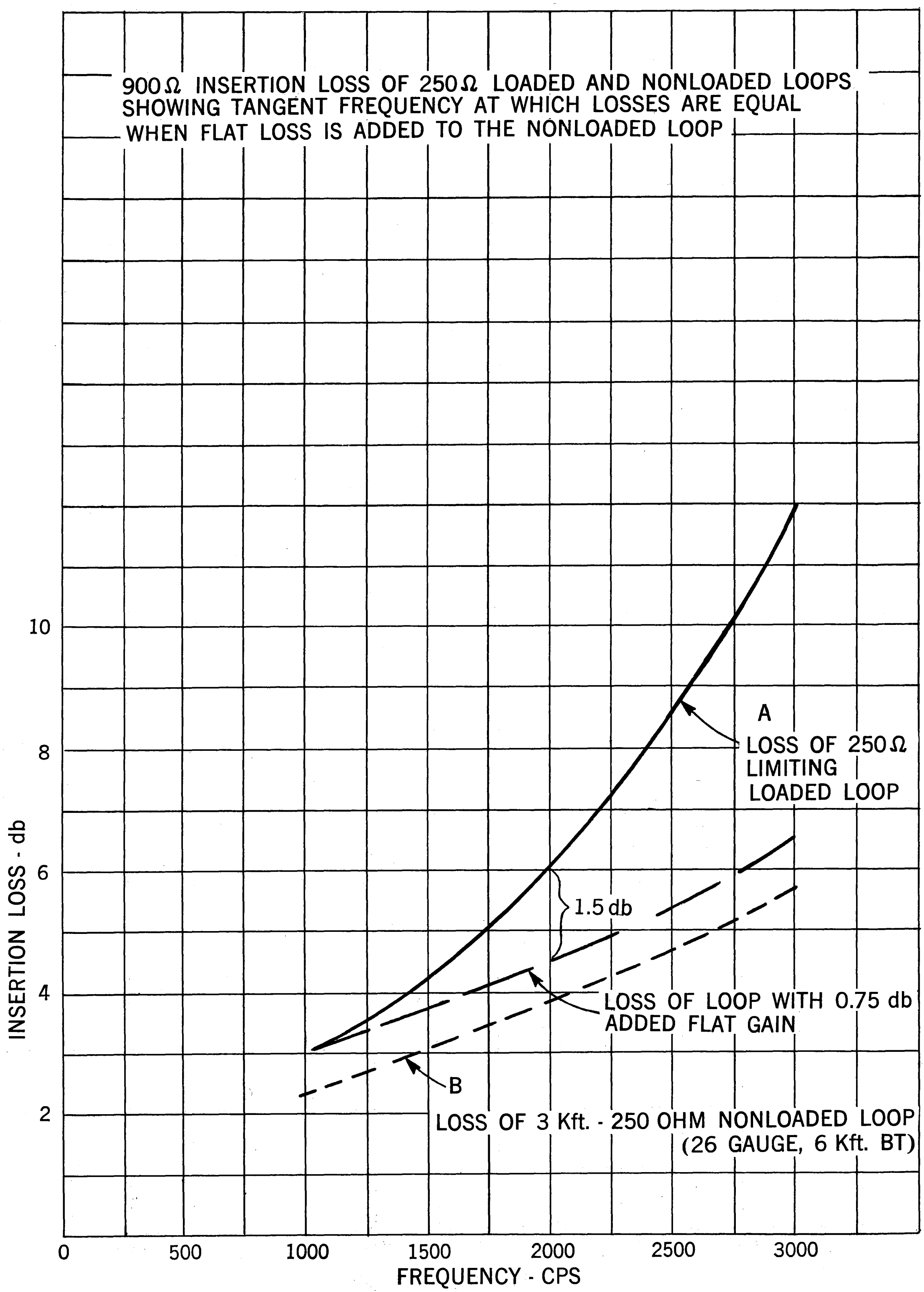

900Ω INSERTION LOSS OF 250Ω LOADED AND NONLOADED LOOPS SHOWING TANGENT FREQUENCY AT WHICH LOSSES ARE EQUAL WHEN FLAT LOSS IS ADDED TO THE NONLOADED LOOP
A
LOSS OF 250Ω LIMITING LOADED LOOP
1.5 db
LOSS OF LOOP WITH 0.75 db ADDED FLAT GAIN
B
LOSS OF 3 Kft. - 250 OHM NONLOADED LOOP (26 GAUGE, 6 Kft. BT)
INSERTION LOSS - db
10
8
6
4
2
0
500
1000
1500
2000
2500
3000
FREQUENCY - CPS

Fig. 1

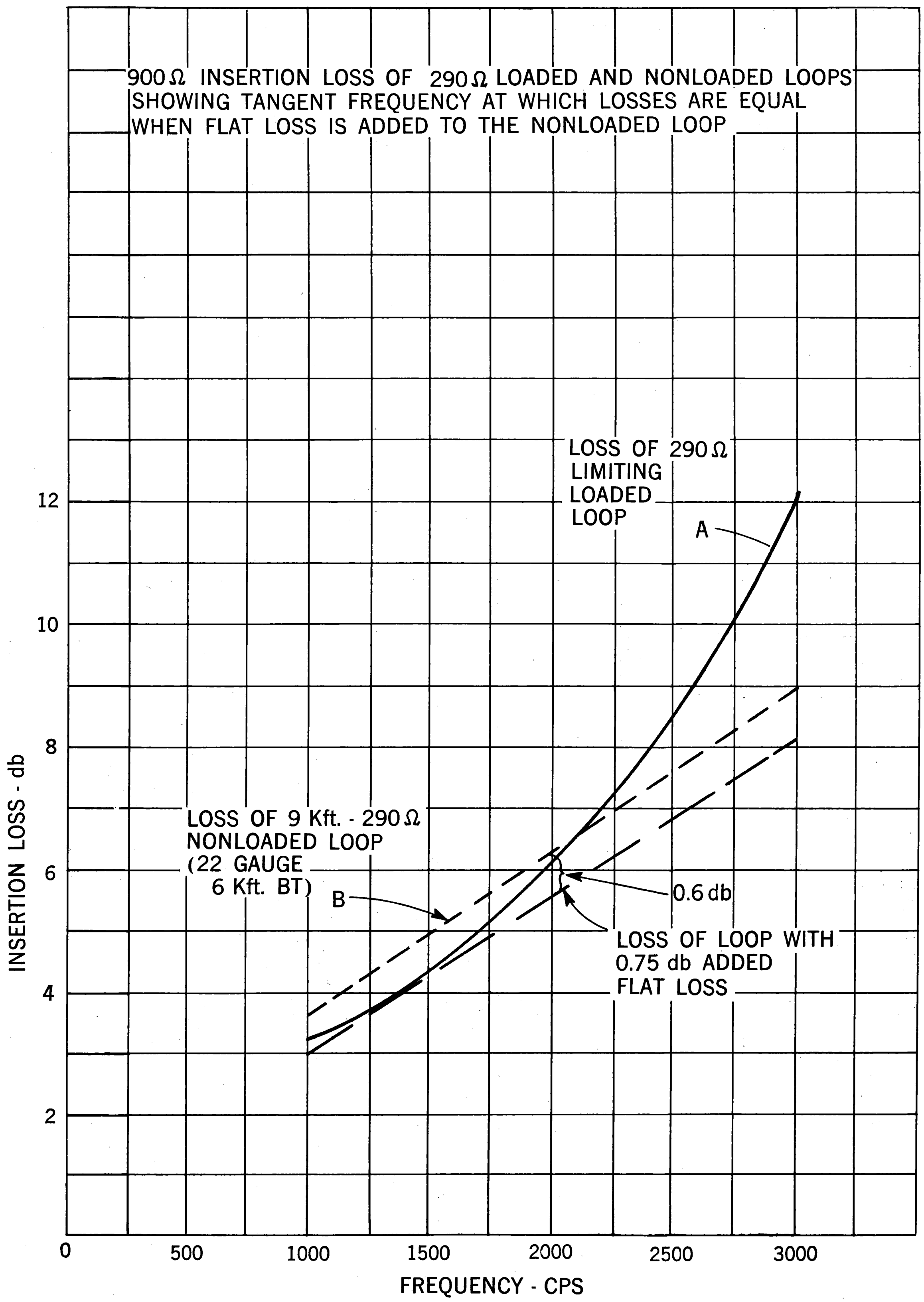

900Ω INSERTION LOSS OF 290Ω LOADED AND NONLOADED LOOPS SHOWING TANGENT FREQUENCY AT WHICH LOSSES ARE EQUAL WHEN FLAT LOSS IS ADDED TO THE NONLOADED LOOP
LOSS OF 290Ω LIMITING LOADED LOOP
A
LOSS OF 9 Kft. - 290Ω NONLOADED LOOP (22 GAUGE 6 Kft. BT)
B
0.6 db
LOSS OF LOOP WITH 0.75 db ADDED FLAT LOSS
INSERTION LOSS - db
2
4
6
8
10
12
0
500
1000
1500
2000
2500
3000
FREQUENCY - CPS

Fig. 2

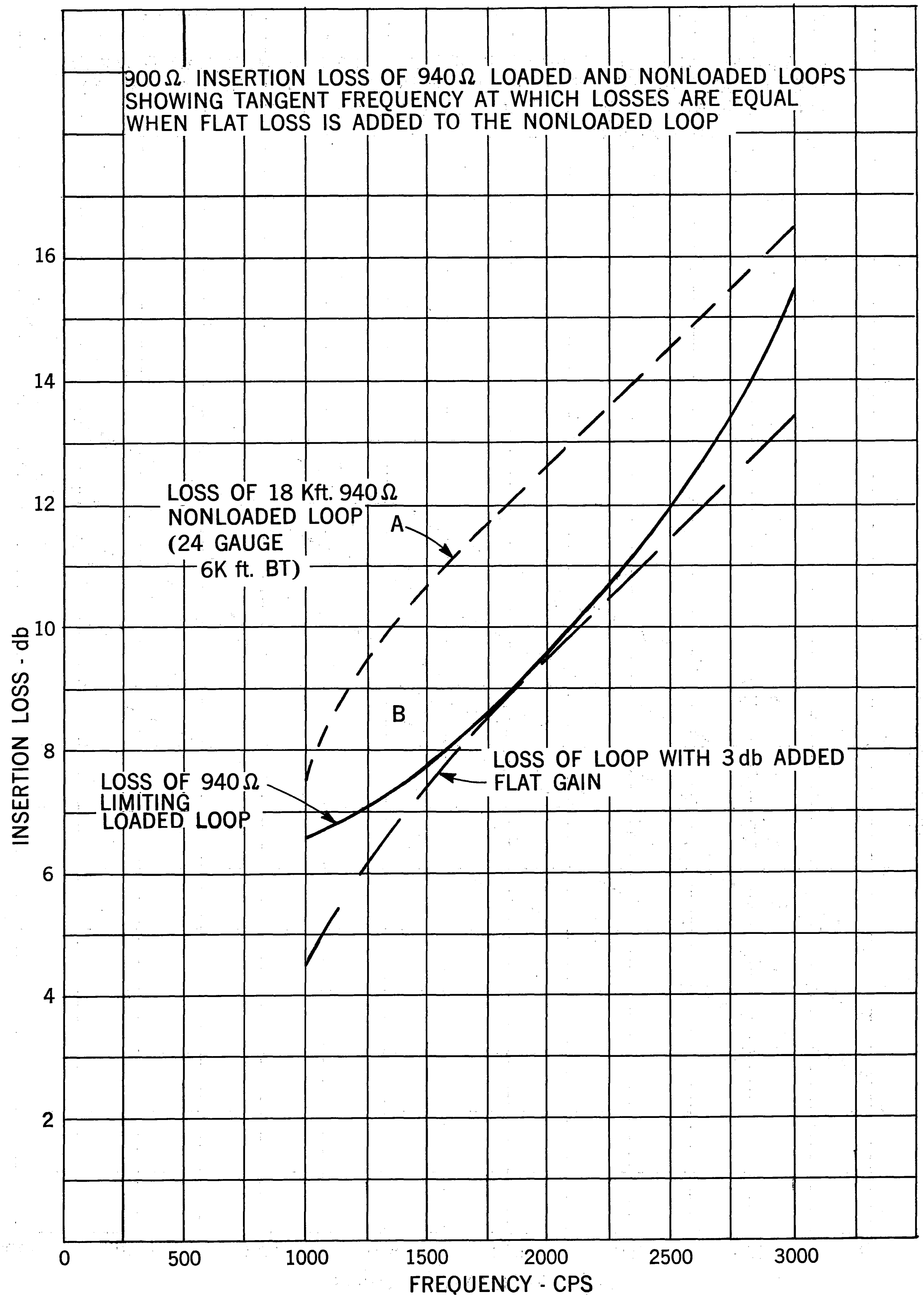
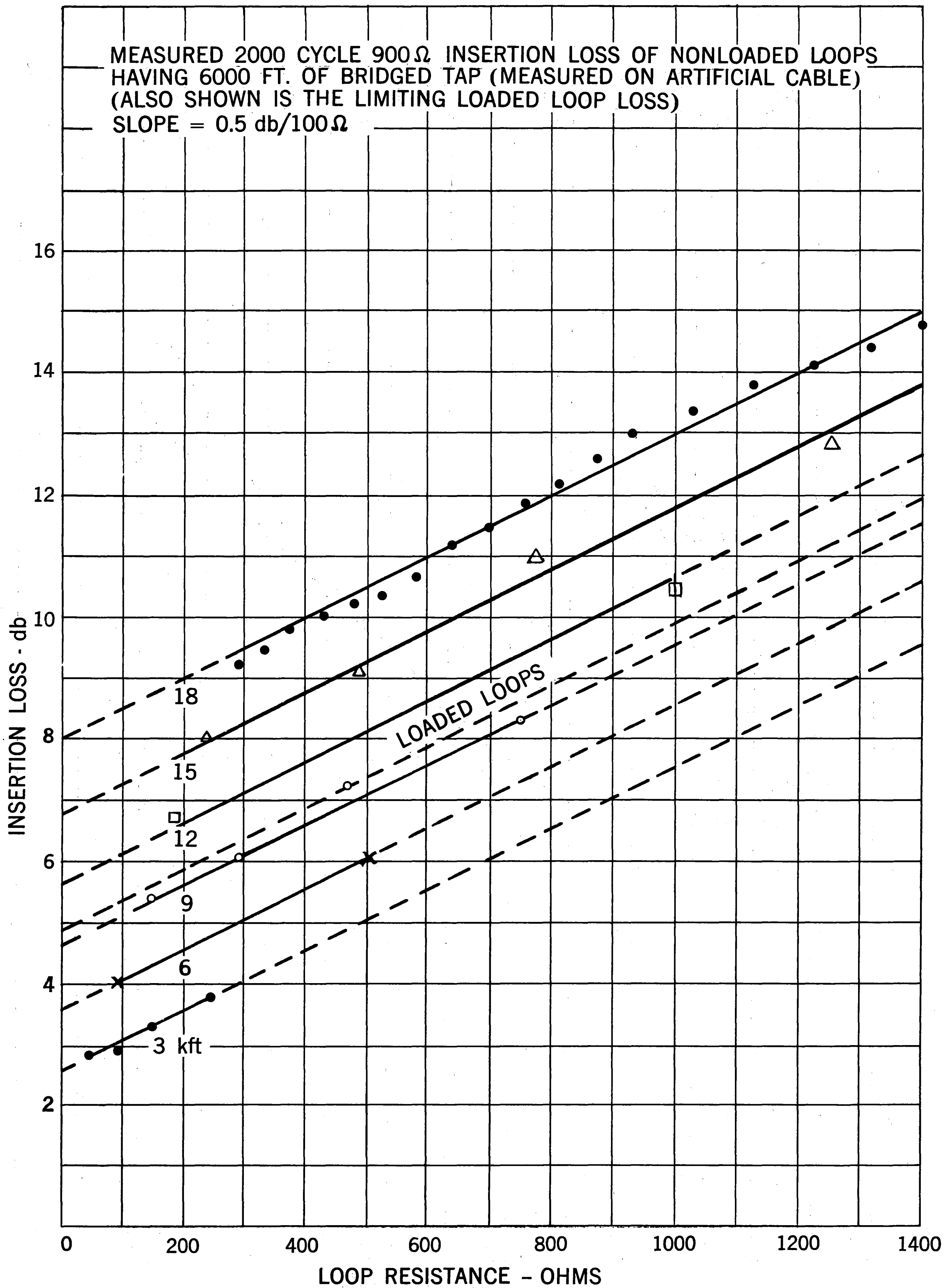

900Ω INSERTION LOSS OF 940Ω LOADED AND NONLOADED LOOPS
SHOWING TANGENT FREQUENCY AT WHICH LOSSES ARE EQUAL
WHEN FLAT LOSS IS ADDED TO THE NONLOADED LOOP
LOSS OF 18 Kft. 940Ω
NONLOADED LOOP
(24 GAUGE
6K ft. BT)
A
B
LOSS OF 940Ω
LIMITING
LOADED LOOP
LOSS OF LOOP WITH 3 db ADDED
FLAT GAIN
INSERTION LOSS - db
2
4
6
8
10
12
14
16
0
500
1000
1500
2000
2500
3000
FREQUENCY - CPS

Fig. 3



MEASURED 2000 CYCLE 900Ω INSERTION LOSS OF NONLOADED LOOPS HAVING 6000 FT. OF BRIDGED TAP (MEASURED ON ARTIFICIAL CABLE)
(ALSO SHOWN IS THE LIMITING LOADED LOOP LOSS)
SLOPE = 0.5 db/100Ω
INSERTION LOSS - db
16
14
12
10
8
6
4
2
18
15
12
9
6
3 kft
LOADED LOOPS
0
200
400
600
800
1000
1200
1400
LOOP RESISTANCE - OHMS

Fig. 4

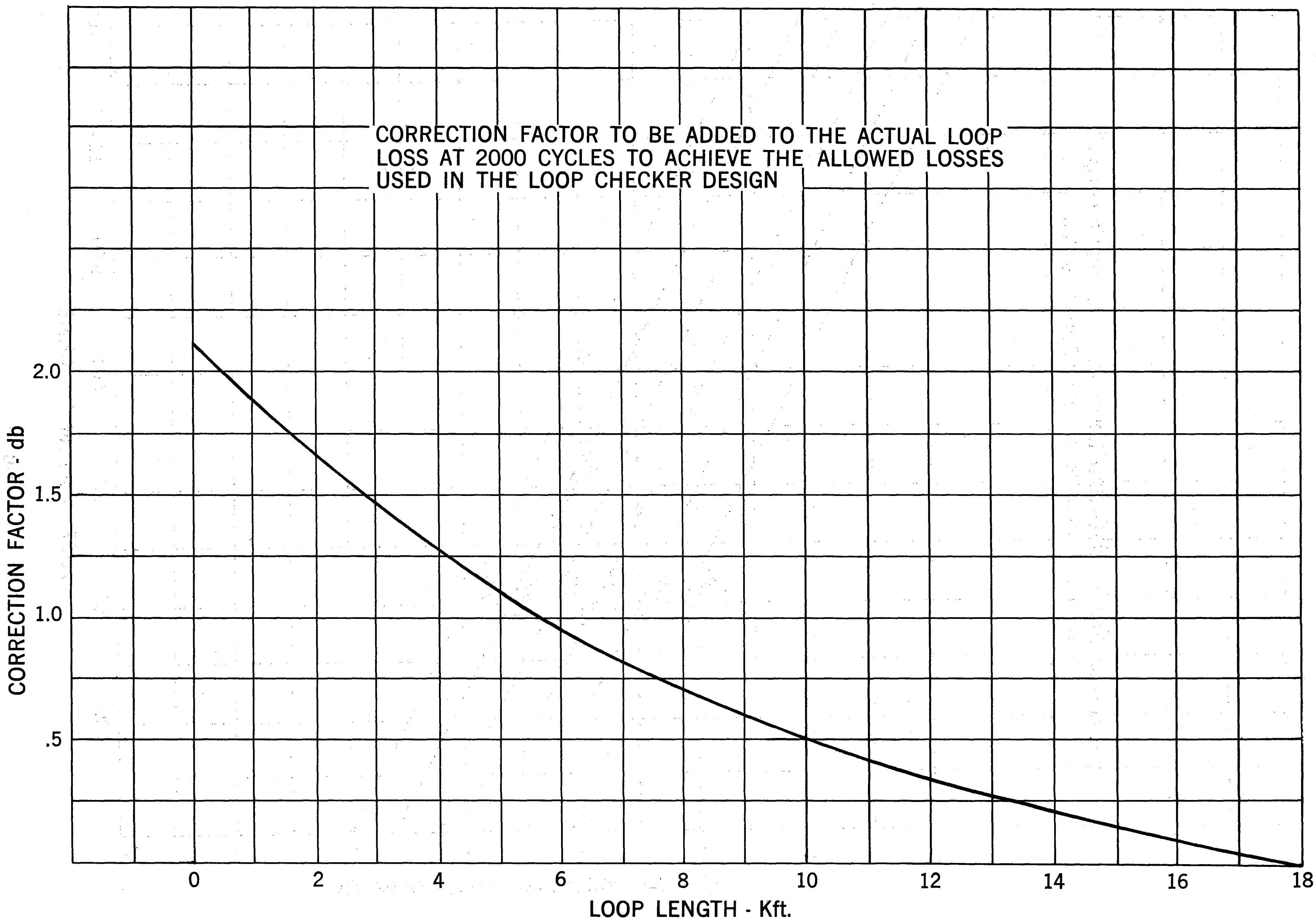

CORRECTION FACTOR TO BE ADDED TO THE ACTUAL LOOP LOSS AT 2000 CYCLES TO ACHIEVE THE ALLOWED LOSSES USED IN THE LOOP CHECKER DESIGN
CORRECTION FACTOR - db
2.0
1.5
1.0
.5
0
2
4
6
8
10
12
14
16
18
LOOP LENGTH - Kft.

Fig. 5

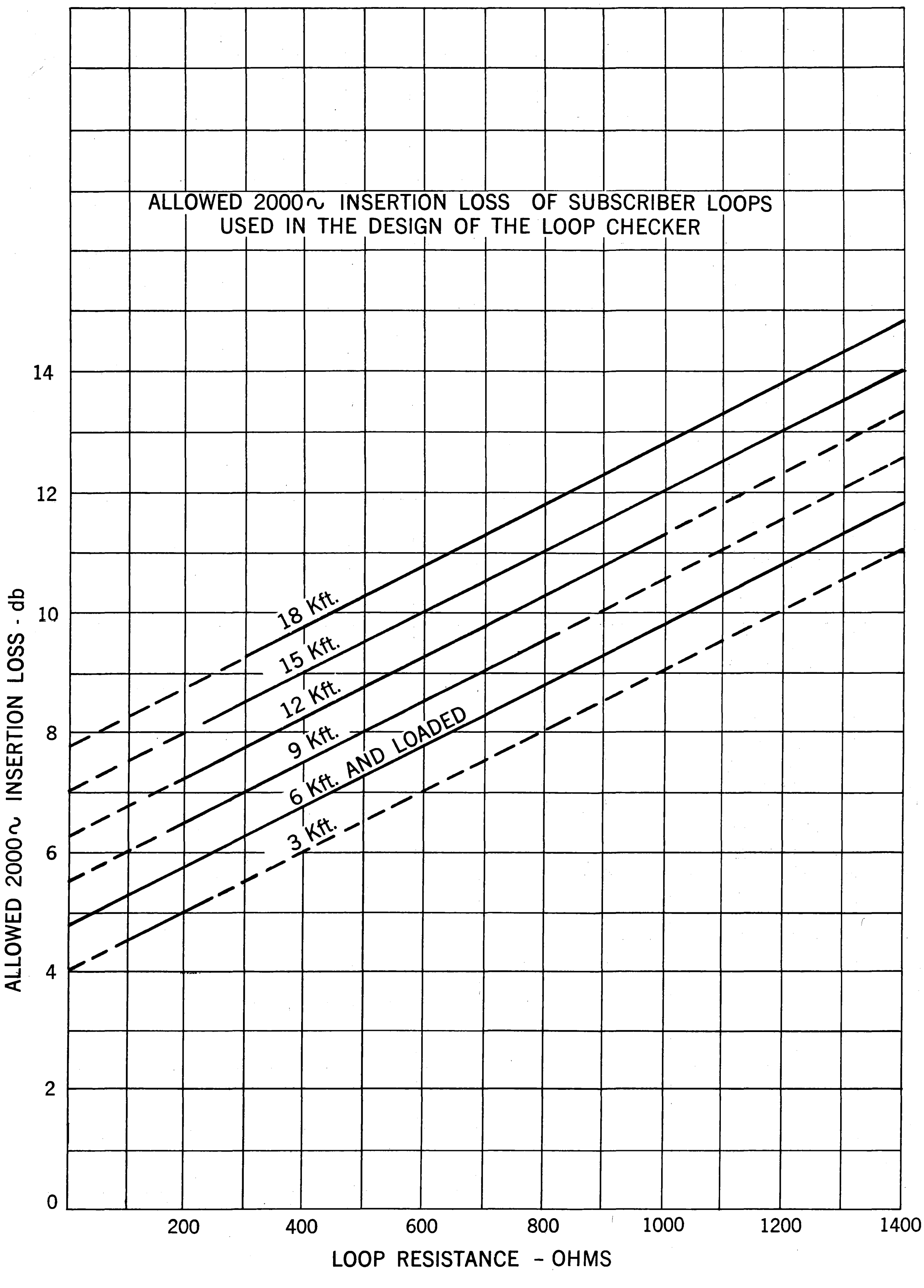

ALLOWED 2000∿ INSERTION LOSS OF SUBSCRIBER LOOPS
USED IN THE DESIGN OF THE LOOP CHECKER
18 Kft.
15 Kft.
12 Kft.
9 Kft.
6 Kft. AND LOADED
3 Kft.
ALLOWED 2000∿ INSERTION LOSS - db
0
2
4
6
8
10
12
14
200
400
600
800
1000
1200
1400
LOOP RESISTANCE - OHMS

Fig. 6

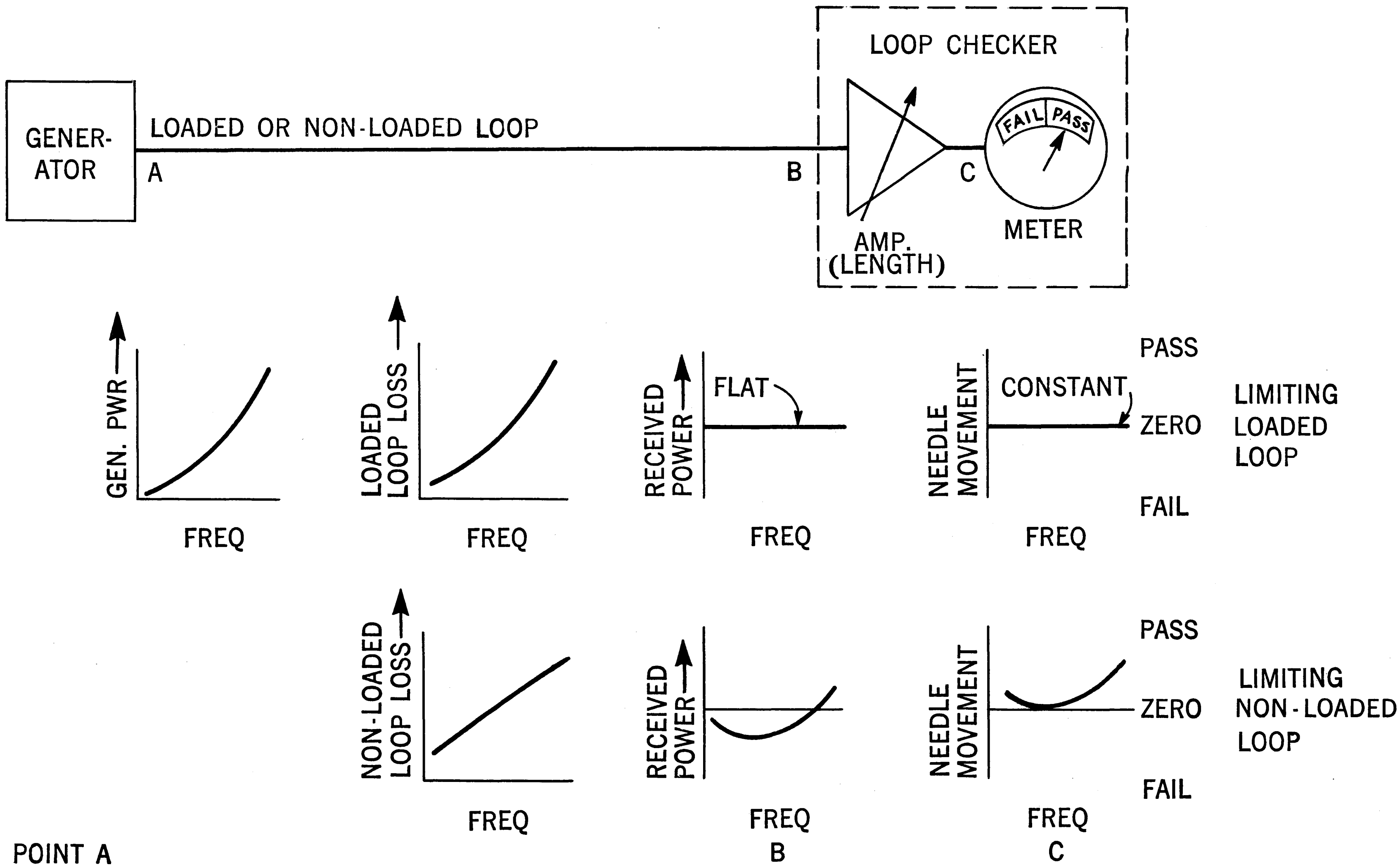

LOOP CHECKER
GENER-
ATOR
LOADED OR NON-LOADED LOOP
A
B
C
FAIL
PASS
METER
AMP.
(LENGTH)
GEN. PWR
FREQ
LOADED
LOOP LOSS
FREQ
RECEIVED
POWER
FLAT
FREQ
NEEDLE
MOVEMENT
CONSTANT
PASS
ZERO
FAIL
FREQ
LIMITING
LOADED
LOOP
NON-LOADED
LOOP LOSS
FREQ
RECEIVED
POWER
FREQ
B
NEEDLE
MOVEMENT
PASS
ZERO
FAIL
FREQ
C
LIMITING
NON-LOADED
LOOP
POINT A

Fig. 7