LOOP CHECKER GENERATOR
DETERMINATION OF OUTPUT SHAPE

1. GENERAL

1.01 The need for a sweep-frequency generator was discussed in Section AB22.090.1. Section AB22.090.11 showed that below 1000 CPS the effect of loaded loop irregularities is not too noticeable while above 3000 CPS the loss of properly loaded loops cannot be predicted because of the approach of cutoff. This dictated the decision to limit the range of the swept-band oscillator to 1000-3000 CPS.

1.02 The discussion also suggested that this swept band of frequencies should be shaped to compensate for the loss vs. frequency shape of a limiting loaded loop. A limiting loaded loop is one which has (1) 9 KFT of subscriber end section, (2) 6 KFT of bridged tap in the end section and (3) loading coil spacing of 6000 ± 500 feet. Since this is the maximum allowed by design rules, the loop checker was designed to pass this loop.

Obviously, limiting loaded loops can be any length, any resistance, and be composed of any combination of cable gauges. Preliminary studies, summarized in Section AB22.090.11 indicated that all limiting loaded loops should have generally the same loss vs. frequency shape. The purpose of this section is to show how this general shape was obtained.

1.03 Two methods were used to determine the general loss vs. frequency shape. Insertion-loss measurements (between 900-ohm terminations) were made on 44 H-88 loaded loops, at a number of frequencies. These loops, simulated in the laboratory with artificial cable, varied in length from 18 to 78 KFT and in resistance from 400 to 1424 ohms. As a check on the measurements, these same 44 loops were set up on the IBM 7090 computer and the 900-ohm insertion losses were computed at the same frequencies.

In picking the sample of 44 loops, no attempt was made to get a random sample. Rather, the intent was to obtain a range; some loops were maximum in length or resistance or both; the remainder were in between. The results show, however, that a fairly normal distribution of insertion losses resulted.

The measured insertion losses are plotted on Fig. 1. Also shown are lines which define loss boundaries containing all the measured losses at the various frequencies. These lines have a slope of 0.5 db/100 ohms. The resistance sensitivity adjustment discussed in Section AB22.090.1 is based on this slope.

The slope of this line can also be computed from the approximate relationship for the attenuation of loaded lines in the mid-band frequencies.

$$\alpha = \frac{R}{2}\sqrt{\frac{C}{L}} \text{ nepers/mile}$$

For a difference in resistance ΔR

$$\Delta\alpha = \frac{\Delta R}{2}\sqrt{\frac{C}{L}} \text{ nepers}$$

$$= 8.686\,\frac{\Delta R}{2}\sqrt{\frac{C}{L}} \text{ db}$$

For H-88 loaded cable

$$C = 0.086 \text{ MF/mile}$$

$$L = 78.3 \text{ MH/mile}$$

$$\sqrt{\frac{C}{L}} = 0.00105$$

For ΔR = 100 ohms

$$\Delta\alpha = (8.686)\left(\frac{100}{2}\right)(0.00105)$$

$$= 0.46 \text{ db}$$

which is about the same as the slope of the lines shown in Fig. 1.

1.04 The preceding discussion suggests that the insertion loss-frequency characteristic of a loop with a particular resistance can be used to derive the characteristic for another loop having a different resistance by applying this factor. For instance, if an 800-ohm loop had a 1000-CPS loss of 5 db, increasing the resistance of the loop by 200 ohms would require adding 1 db, resulting in a 6 db 1000-CPS loss for the 1000-ohm loop. In this way the losses for the 44 loops, having a resistance range of 400-1424 ohms, can all be adjusted to represent 44 1000-ohm loops. Then the sample means and sample deviations can be computed for the insertion losses at the various frequencies for the 44 loops. This method was used in the computer program to determine the distribution parameter.

1.05 Returning to Fig. 1, there is about 95% probability that the loss boundary lines passing through the maximum and minimum sample losses include between them more than 90% of the population of losses for the various frequencies.* The loss boundary lines were assumed, therefore, to represent the 2σ points, and the mean was assumed midway between the lines. These assumed values for a 1000-ohm loop taken from Fig. 1 are listed in Table 1 along with the values from the computer program. Note the close correlation between the assumed and computed values. Also listed in Table 1 are the computed values for H-44 loaded loops.

The approximate upper 2σ values of the losses at the five frequencies were taken as the allowed losses for the limiting loaded loop (see Fig. 2). This determined the shape of the output power vs. frequency of the generator. The right-hand ordinate values are the result of the sensitivity requirements of the Loop Checker — for a "ZERO SET" setting of 1 kilo-ohm and a length setting at "OVER 18," this is −13.8 dbm at the input of the Loop Checker to have the needle read at the ZERO point.

TABLE 1

Insertion Losses of 1000 Limiting Loaded Loops (Between 900)

FREQUENCY	H-88 LOADING				H-44 LOADING	
	MEASURED		COMPUTED		COMPUTED	
(CPS)	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
1000	6	.36	6	.32	7	.24
1500	7.5	.33	7.4	.32	8.1	.38
2000	9.2	.33	9	.33	9.2	.41
2500	11.3	.63	10.8	.72	10.4	.42
3000	14.1	.7	14	.95	11.7	.41

There is a small percentage of H-44 loaded cable in the subscriber loop plant. The losses of the 44 loops were recomputed with H-44 loading in place of H-88 to determine the insertion loss distribution of these loops. Results given in Table 1 show that in the band between 1000 and 1500 CPS the loss of H-44 limiting loaded loops is generally about one db greater than H-88 loops. The Loop Checker is designed for use on H-88 loaded loops when the length dial is set to "OVER 18." To use the Loop Checker on H-44 loaded loops, the sensitivity must be increased by one db because of the one db added loss referred to above. Table 1 attached to Section AB22.090.1 shows that the "OVER 18" length-dial position provides the same sensitivity as the 6 KFT position and that the 10 KFT position provides an added one db sensitivity. Therefore, when testing H-44 loaded loops, the length dial should be set to 10 KFT rather than to "OVER 18."

* Tables of the Incomplete Beta Function, Edited by K. Pearson, Issued by the Biometrika Office, 1932.

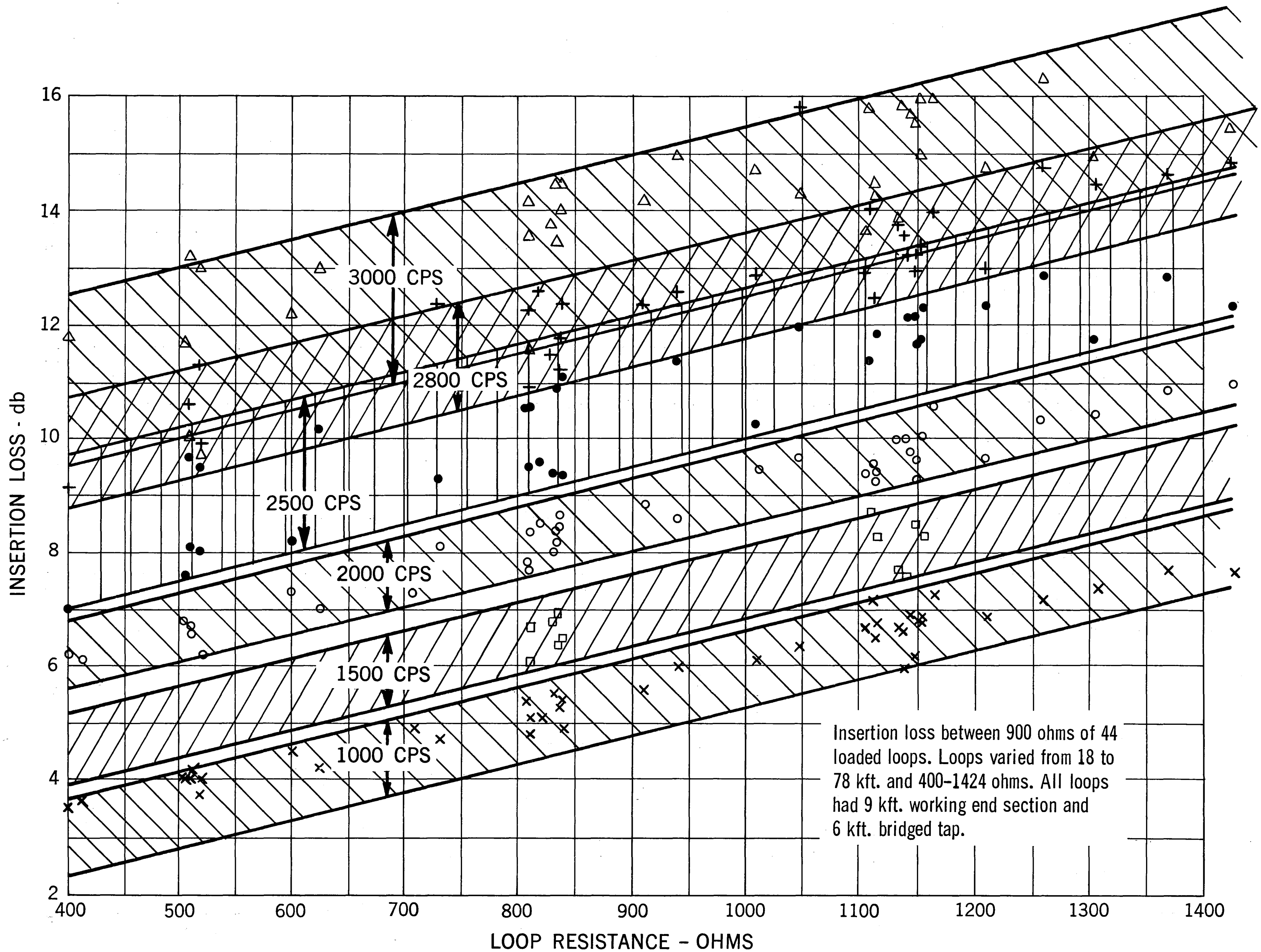
INSERTION LOSS - db
16
14
12
10
8
6
4
2
400
500
600
700
800
900
1000
1100
1200
1300
1400
LOOP RESISTANCE - OHMS
3000 CPS
2800 CPS
2500 CPS
2000 CPS
1500 CPS
1000 CPS
Insertion loss between 900 ohms of 44 loaded loops. Loops varied from 18 to 78 kft. and 400–1424 ohms. All loops had 9 kft. working end section and 6 kft. bridged tap.

Fig. 1

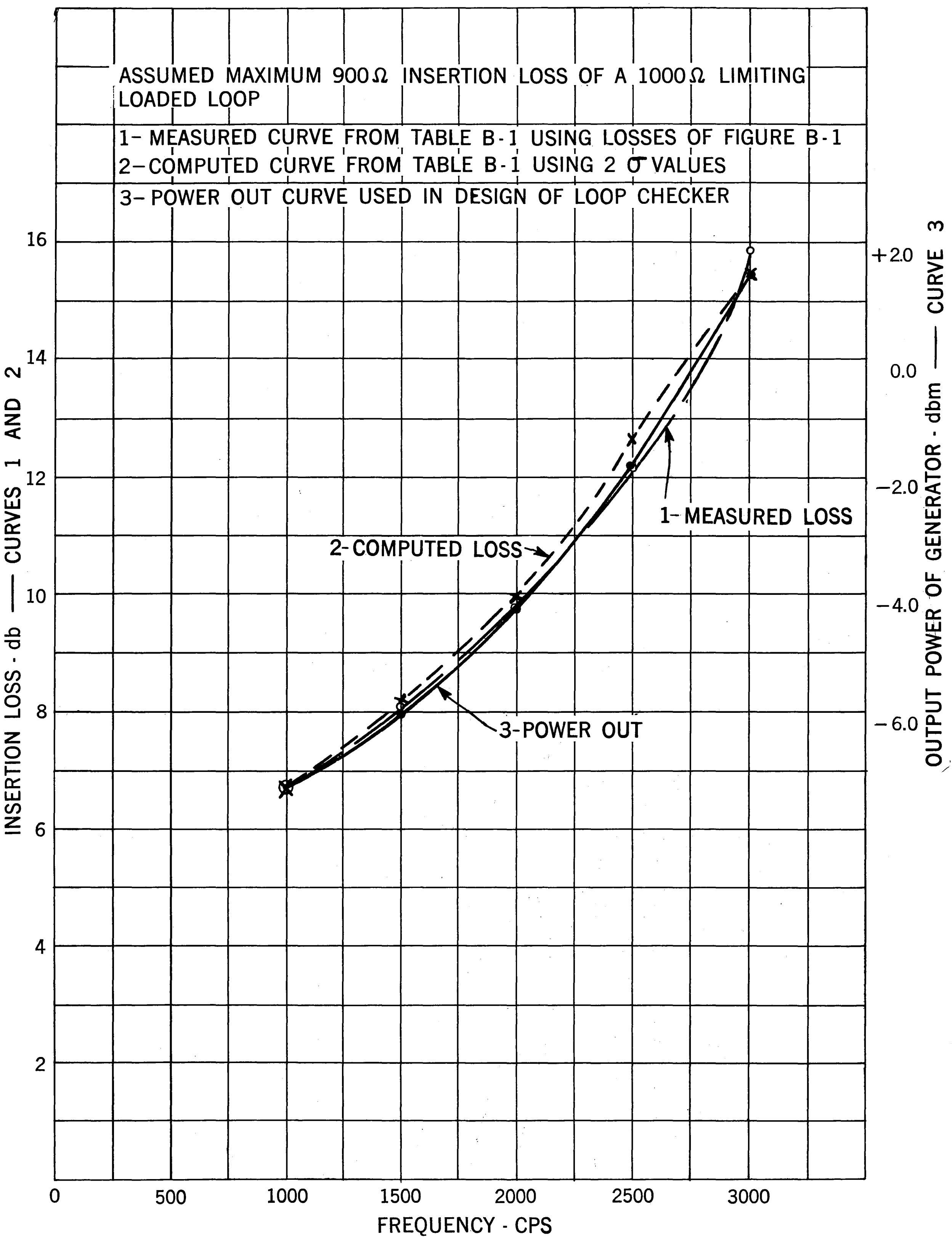
ASSUMED MAXIMUM 900Ω INSERTION LOSS OF A 1000Ω LIMITING LOADED LOOP
1- MEASURED CURVE FROM TABLE B-1 USING LOSSES OF FIGURE B-1
2- COMPUTED CURVE FROM TABLE B-1 USING 2 σ VALUES
3- POWER OUT CURVE USED IN DESIGN OF LOOP CHECKER
1- MEASURED LOSS
2- COMPUTED LOSS
3-POWER OUT
INSERTION LOSS - db —— CURVES 1 AND 2
OUTPUT POWER OF GENERATOR - dbm —— CURVE 3
FREQUENCY - CPS
16
14
12
10
8
6
4
2
+2.0
0.0
−2.0
−4.0
−6.0
0
500
1000
1500
2000
2500
3000

Fig. 2