

SECTION 2, CHAPTER 6

SHEET METAL BENDING

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Introduction

1. When making a fitting in sheet metal it is necessary to calculate the length of the curved parts of the fitting. This is essential because the length of the metal required for a radiused bend is less than that needed when the metal is bent round a square edge. For example (Fig. 1), the length of metal required for the radiused bend "X" is much less than the distance of 2 in. round the square edge.

Note.—In practice, owing to the formation of cracks in the bend, the bending of sheet metal round a square edge is prohibited, and it is only mentioned in this paragraph to indicate the reason for obtaining the true length of a bend.

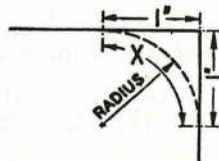


Fig. 1. RADIUSSED BEND

Calculating Length

2. To calculate the length of a bend (i.e., the length of the arc of the circle which forms the bend), the formula for obtaining the circumference of a circle is applied; circumference = πd ($\pi = 3.142$, d = twice the radius of the circle). For a part of a circle, the length of the bend is in proportion to the angle of bend (the angle of bend for a complete circle is 360°), therefore,

$$\text{For a } 90^\circ \text{ bend, length of bend} = \frac{90 \times \pi d}{360}$$

$$\text{For a } 45^\circ \text{ bend, length of bend} = \frac{45 \times \pi d}{360}$$

$$\text{For a } 30^\circ \text{ bend, length of bend} = \frac{30 \times \pi d}{360}$$

For example (Fig. 2), if the angle of bend is 90° , and the radius is $\frac{7}{8}$ in. ($.875$ in.), the length from A to B = $\frac{90}{360} \times 3.142 \times 1.75 = 1.375$ in. ($1\frac{3}{8}$ in.).

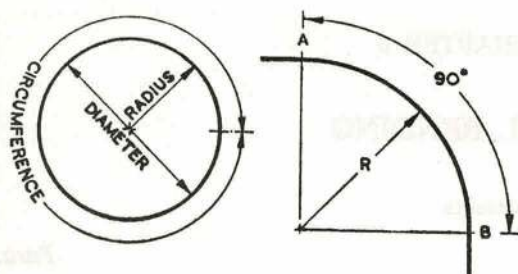


Fig. 2. PARTS OF A CIRCLE

3. The foregoing is true for very thin material, but, because sheet metal has thickness, certain factors must be taken into consideration when marking out. The distance round the inside of the bend is clearly less than the distance round the outside (Fig. 3), but on the original unbent metal both distances were the same; therefore, the surface of the metal on the outside has been stretched and the surface of the metal on the inside has been compressed. The amount of strain varies with different metals, and, in theory, at a point midway between the inner and outer surfaces the metal is neither stretched nor compressed. To obtain the true length of the metal required for the bend, half the thickness or gauge of the metal is usually taken as the position of the mean line and, therefore, the formula is amended as follows:

$$\frac{\text{Number of degrees bend}}{360} \times d$$

$$D = 2R + \text{gauge of metal}$$

$$\pi = 3.142$$

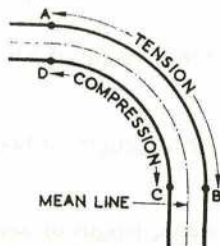


Fig. 3. STRAINS AT THE BEND

Single Bend

4. If it is required to shape a piece of metal of 16 S.W.G. (.064 in.) to the form shown in Fig. 4, i.e., angle of bend 90° , radius $1\frac{1}{2}$ in., $3 \text{ in.} \times 3 \text{ in.}$, the length needed is obtained as follows:—

$$A \text{ to } B \text{ (straight)} = 1\frac{1}{2} \text{ in.}$$

$$B \text{ to } C \text{ (bend)} = 2\frac{13}{32} \text{ in. } (.25 \times 3.142 \times 3.064 = 2.408 \text{ in.})$$

$$C \text{ to } D \text{ (Straight)} = 1\frac{1}{2} \text{ in.}$$

$$\text{Total} = 5\frac{13}{32} \text{ in.}$$

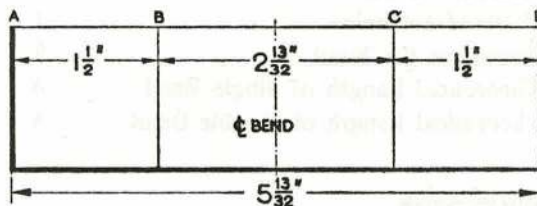
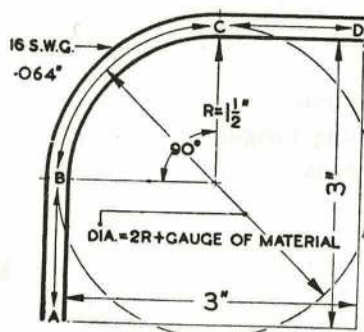


Fig. 4. THEORETICAL LENGTH OF SINGLE BEND

Double Bend

5. The development of a double bend is similar to that of a single bend. For example (Fig. 5), from the dimensions given the metal is marked out after first calculating the length of the bends.

$$\begin{aligned} \text{Length of bends} &= .25 \times \pi D \\ &= .25 \times 3.142 \times 1.75 \\ &= 1.375 \text{ in. } (1\frac{3}{8} \text{ in.}) \end{aligned}$$

$$\text{Length A (straight)} = 2 \text{ in.} - R = 1\frac{3}{8} \text{ in.}$$

$$\text{Length B (bend)} = 1\frac{3}{8} \text{ in.}$$

$$\text{Length C (straight)} = 4 \text{ in.} - (2 \times R) = 2\frac{3}{8} \text{ in.}$$

$$\text{Length D (bend)} = 1\frac{3}{8} \text{ in.}$$

$$\text{Length E (straight)} = 2 \text{ in.} - R = 1\frac{3}{8} \text{ in.}$$

$$\text{Total length} = (A) 1\frac{3}{8} + (B) 1\frac{3}{8} + (C) 2\frac{3}{8} + (D) 1\frac{3}{8} + (E) 1\frac{3}{8} = 7\frac{1}{2} \text{ in.}$$

Note.—In practice, the internal development lines of the simple fittings illustrated are marked on the edge of the

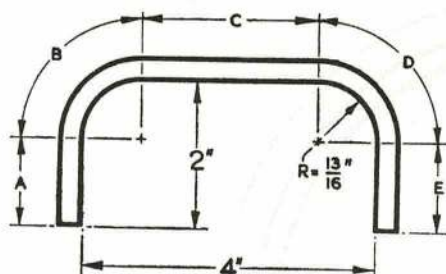
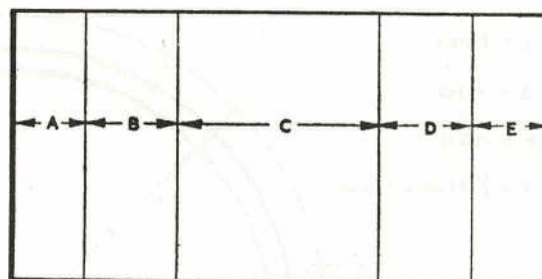


Fig. 5. THEORETICAL LENGTH OF DOUBLE BEND



10 S.W.G. = .128"

material only, so as to prevent confusion when the full length sighting line(s) are added.

Practical Bending and Bend Allowance

6. Practical Bending. Bend bars (Fig. 6), shaped to the correct radius, are used to clamp sheet metal which is to be bent, the bars being held securely in a bench vice. A hide faced hammer is used to bend the metal over the radius, care being taken not to hammer excessively, otherwise the metal may be thinned and stretched. To ensure that the centre of the bend occurs in the correct position, the metal is marked with a sighting line, which must be set level with the top of the bend bars when the metal is clamped. If the metal to be bent is light alloy, a pencil should be used to mark the sighting line as the use of a scribe may cause the metal to crack when it is bent.

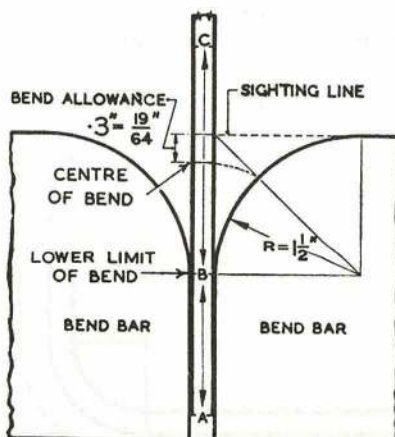


Fig. 6. USING THE BEND BARS

7. Bend Allowance. Bend allowance is the difference between the length of metal required for half the bend and the radius of one of the bend bars being used, and, theoretically, the marking of the sighting line is governed by the bend allowance. In practice, the sighting line is marked at the stated radius from the line marking the start of the bend, and in the single bend shown (Fig. 4), this will be 1.5 in. from the line B which marks the start of the bend. The distance (.3 in. Fig. 6) between the sighting line and the centre of the bend is the bend allowance, i.e., $R - (B \div 2) = 1.5 \text{ in.} - 1.2 \text{ in.} = .3 \text{ in.}$

8. The sighting line may occur on, below or above the centre of the bend, depending on the gauge of the metal and the radius round which the metal is to be bent. When the sighting line occurs above the centre of the bend, the bend is termed a "minus bend," (less metal in half the bend than one radius). When the sighting line occurs below the centre of the bend, the bend is termed a "plus bend" (more metal in half the bend than one radius). After marking out, it is essential to clamp the metal the right way up, so that the sighting line is above the end of the bend from which calculation was made.

Reverse Bends

9. Fittings with reverse bends are rather more difficult to calculate, and require different bending methods. In the part illustrated (Fig. 7), it is assumed that the small bends B and D are 90° bends; although this is incorrect by a very small amount, the development of the shape is satisfactory in

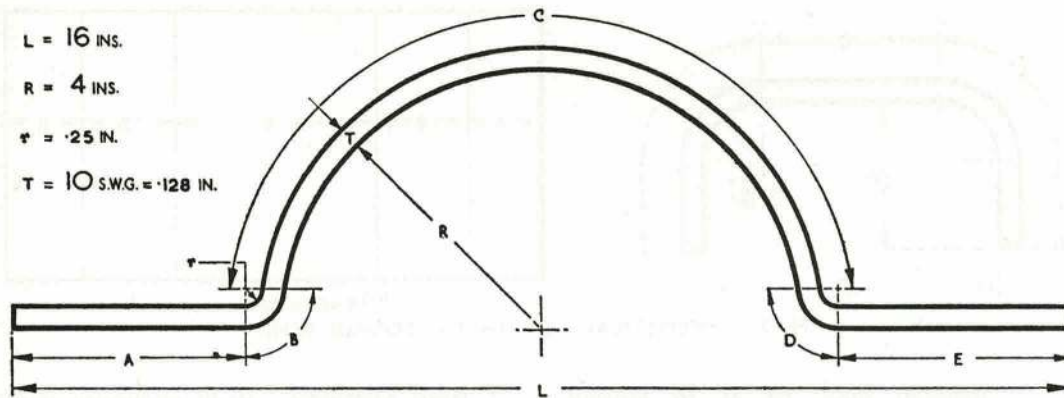


Fig. 7. REVERSE BEND FITTING

practice. Bend C is semi-circular, less $(r + T)$ at each end. Therefore:—

$$\begin{aligned}
 \text{Length of C} &= \pi D \times .5 - 2(r + T) \\
 &= 3.142 \times 8.128 \times .5 - 2 \times .378 \\
 &= 12.769 - .756 \\
 &= 12.013 \text{ in. (12 in. approx.)}
 \end{aligned}$$

$$\begin{aligned}
 \text{Bends B and D} &= \pi D \times .25 \\
 &= 3.142 \times .628 \times .25 \\
 &= .494 \text{ in. } (\frac{1}{2} \text{ in. approx.}) \text{ each.}
 \end{aligned}$$

$$\begin{aligned}
 \text{A and E} &= \frac{1}{8} - R - T - r \\
 &= 8 - 4 - .128 - .25 \\
 &= 3.622 \text{ in. } (3\frac{5}{8} \text{ in. approx.}) \text{ each.}
 \end{aligned}$$

$$\begin{aligned}
 \text{Total length} &= (\text{A}) 3\frac{5}{8} + (\text{B}) \frac{1}{2} + (\text{C}) 12 + \\
 &\quad (\text{D}) \frac{1}{2} + (\text{E}) 3\frac{5}{8} \\
 &= 20\frac{1}{4} \text{ in.}
 \end{aligned}$$

10. Bending. Having prepared the piece of sheet metal to the correct width and length ($20\frac{1}{4}$ in.), mark it out. The bends B and D are then formed with the aid of the bend bars in the normal manner (Fig. 8). In this instance, the centre of the bends are set in line with the top of the bend bars; as the length of half of each bend is approximately equal to the radius of the bend, bend allowance is not necessary. Bend C is then formed by using a mandrel and a pair of bend bars (Fig. 9) in a mandrel press or vice. Before bending the metal, ensure that the mandrel is central and square to the edge of the metal. Allowance must be made for the spring of the metal; to allow for this the mandrel used should be slightly smaller than the required diameter of the bend. As the springiness of metals varies, the exact size of mandrel to use will be found by experience.

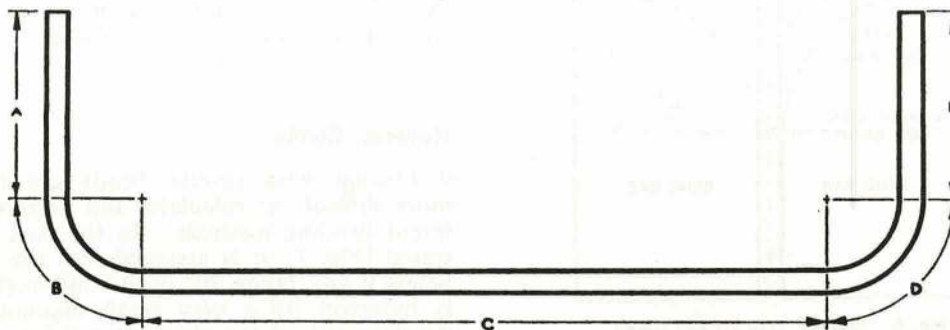


Fig. 8. DEVELOPMENT OF REVERSE BEND

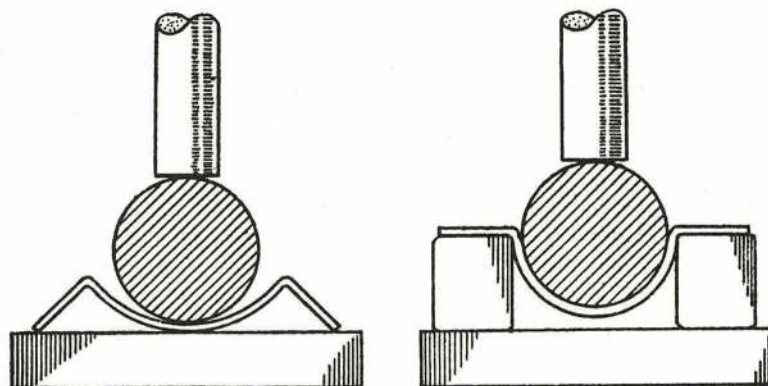
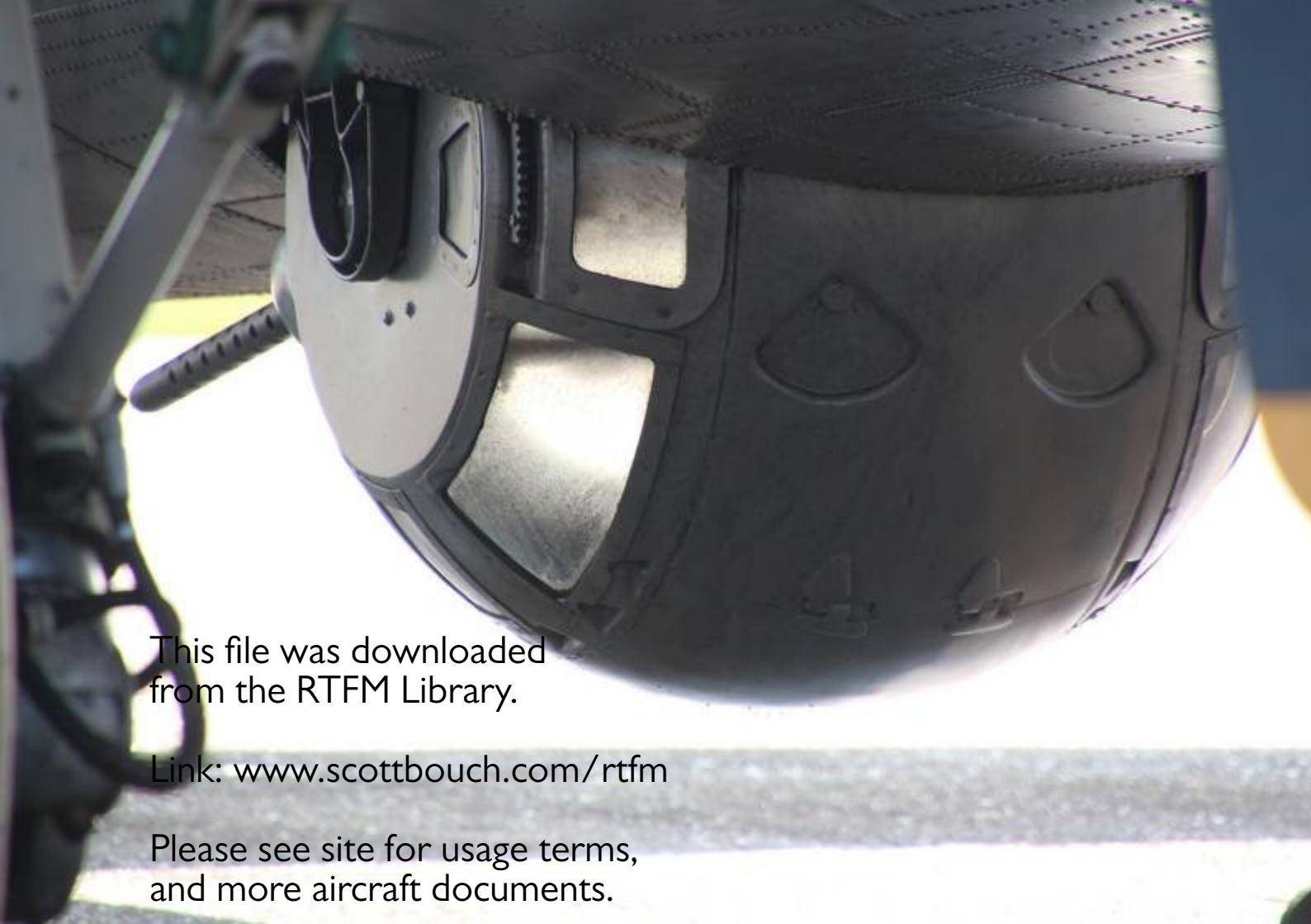


Fig. 9. USE OF MANDREL



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