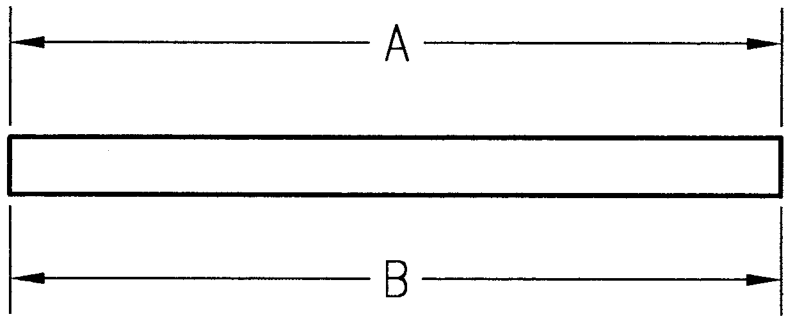
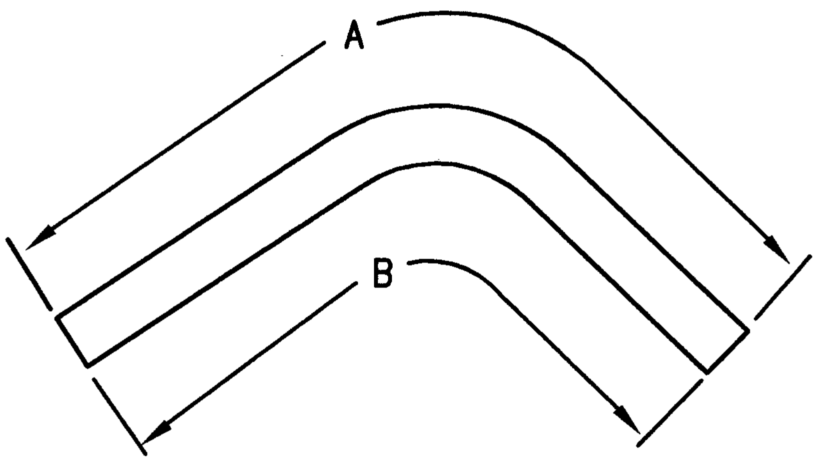
HOW METAL REACTS TO FORMING

Most of these diagrams show the edge view of the sheet metal.

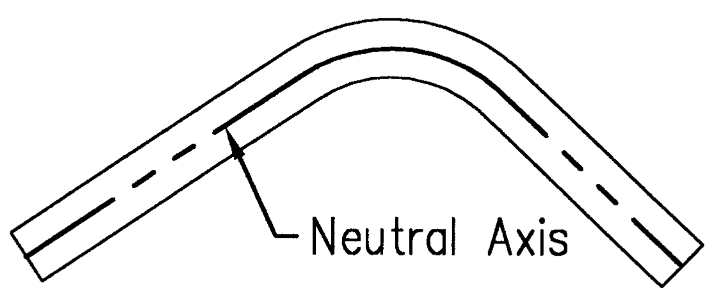
This is the edge condition of the part before bending. All of the metal fibers are locked into a position with one another. Length "A" equals length "B".



The same strip after bending. Length "A" has increased, length "B" has shortened.



An imaginary line exists between planes "A" and "B", that does not stretch or shrink due to the bending process. This line is called the "Neutral Axis" of the part. Since this line does not stretch or shrink, its length can be used to develop the flat pattern of the part.



DEFINING GEOMETRY OF THE FORMED PART

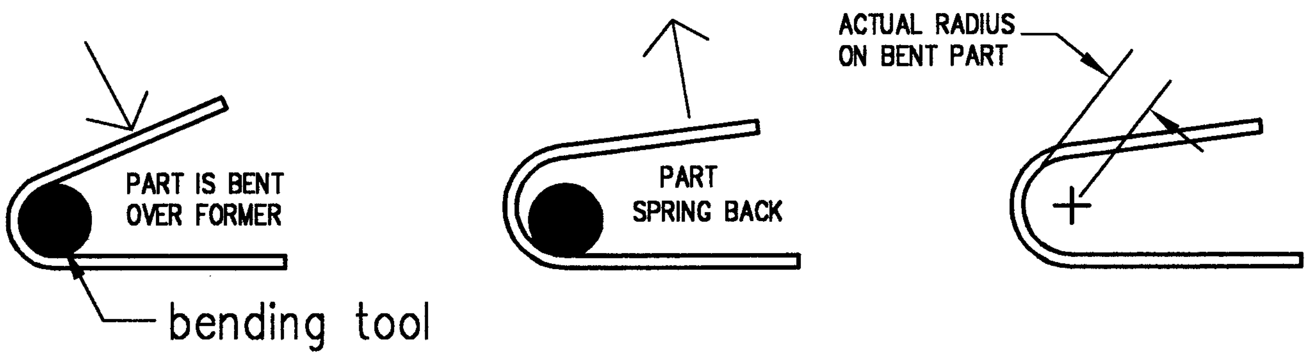
Sheet metal has a tendancy to resist bending. Corrections need to be made to find what the actual produced part geometry will be. Take these steps to find what your tools will produce.

Step one: define all inside bend radii of the drawn part

When sheet metal is bent, a radius is formed on the inside contour of the metal at the bend point. This radius is imparted by bending the metal over a forming tool of some kind: even one as simple as a metal rod.
Typically, the bend radius is defined on the part drawing in order to satisfy functional or appearance requirements. Good drafting practice dictates that the inside radius is specified. If only the outside radius is given, simply subtract the material thickness from it to find the inside radius.

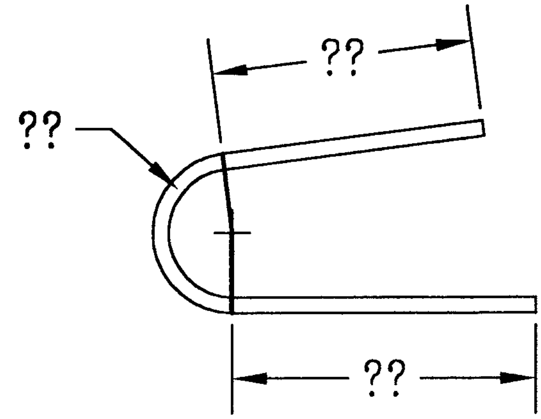
Step two: what will your forming tool produce

Select a rod or load your bender with a mandrel that has a radius equal to the bend radius. Cut a test strip of the same metal that you will be using for the finished part, long enough to to be bent into a half circle of the desired radius. If the finished part is to be annealed, anneal the sample before bending. Bend the sample part, and allow it to spring back as much as it wants to.
Lay the test piece on paper or a scrap of metal coated with layout fluid. Scribe an arc inside of the bent test piece. measure the radius of the scribe line as accurately as you can. Use a divider, or lay a drafting circle template over the scribe to determine the actual inside radius that your tooling will produce. This is the radius that you will later use to calculate the developed length of your parts.



Step three: draw the part profile

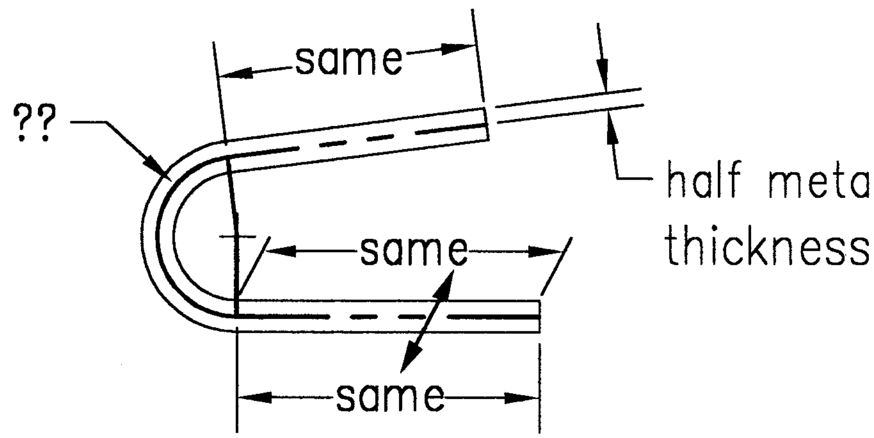
Profiles of the bent part are a combination of arcs and straight lines only. It is the sum of the lengths of the arcs and lines that gives you the flat length of the part.
Use the actual developed radii to draw the profile of the formed part. Draw lines from the centers of each bend radius to the tangency points of the profile.



DEFINE THE NEUTRAL AXIS OF THE PART

Step four: draw the neutral axis, define all straights and arcs

We will assume the position for the neutral axis to fall at the middle of the thickness of the sheet metal. Split the thickness of the profile into two equal parts: the boundary between them being the neutral axis. The straight line segments of the neutral axis remain the same length as they originally were. The new radii at the neutral axis are larger than at the inside bends. Larger radii, when flattened, will be longer in length than smaller. The next task will be to determine these arc lengths.



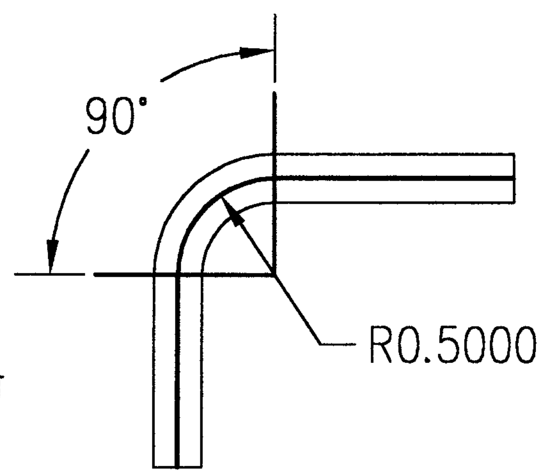
Step five: calculate arc lengths

Arc lengths are found by using simple math. First, you will calculate the number of inches length for each degree of arc bend. Then, multiply that constant by the number of degrees of arc included in the bend.

step 1) find circumference of a circle where R=radius at neutral axis:

(2) x (R) x pi = circumference

(2) x (.500) x 3.1415 = 3.1415 inches



step 2) find length of arc for each degree of bend:

there are 360 degrees in one revolution of arc

$$\frac{\text{circumference of neutral axis circle}}{360} = \frac{\text{flat length of arc}}{\text{per degree included in bend}}$$

$$\frac{3.1415}{360} = .0087 \text{ inches / degree}$$

step 3) find the length of arc included in the bend:

for this example, there are 90 degrees included in the bend

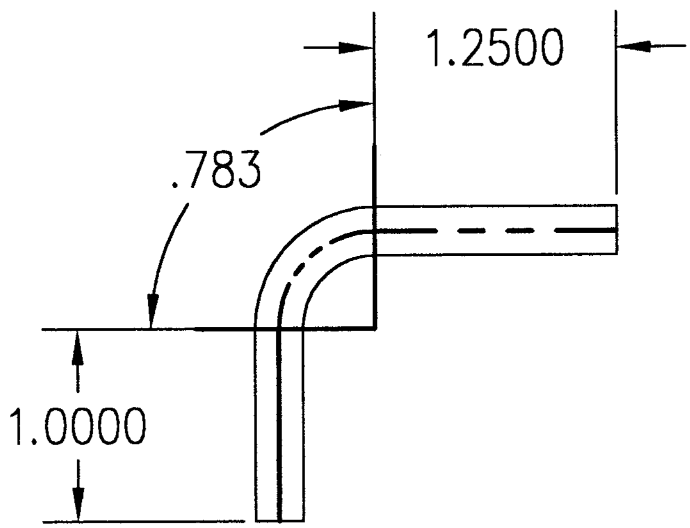
(.0087) x 90 = .783 inches of arc length

DEVELOPMENT OF THE PART PATTERN

Step six: Determine "flat length"

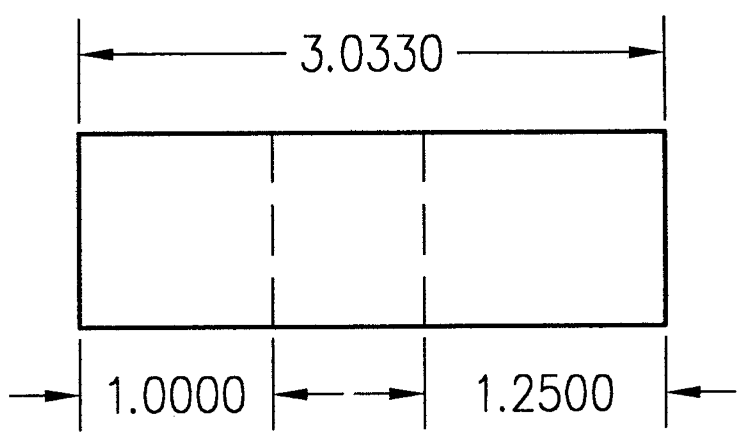
Add all of the straight lengths and arc lengths together in order to find the developed length of the part profile.

$$\begin{array}{r} 1.250 \\ .783 \\ +\,1.000 \\ \hline 3.033 \end{array}$$



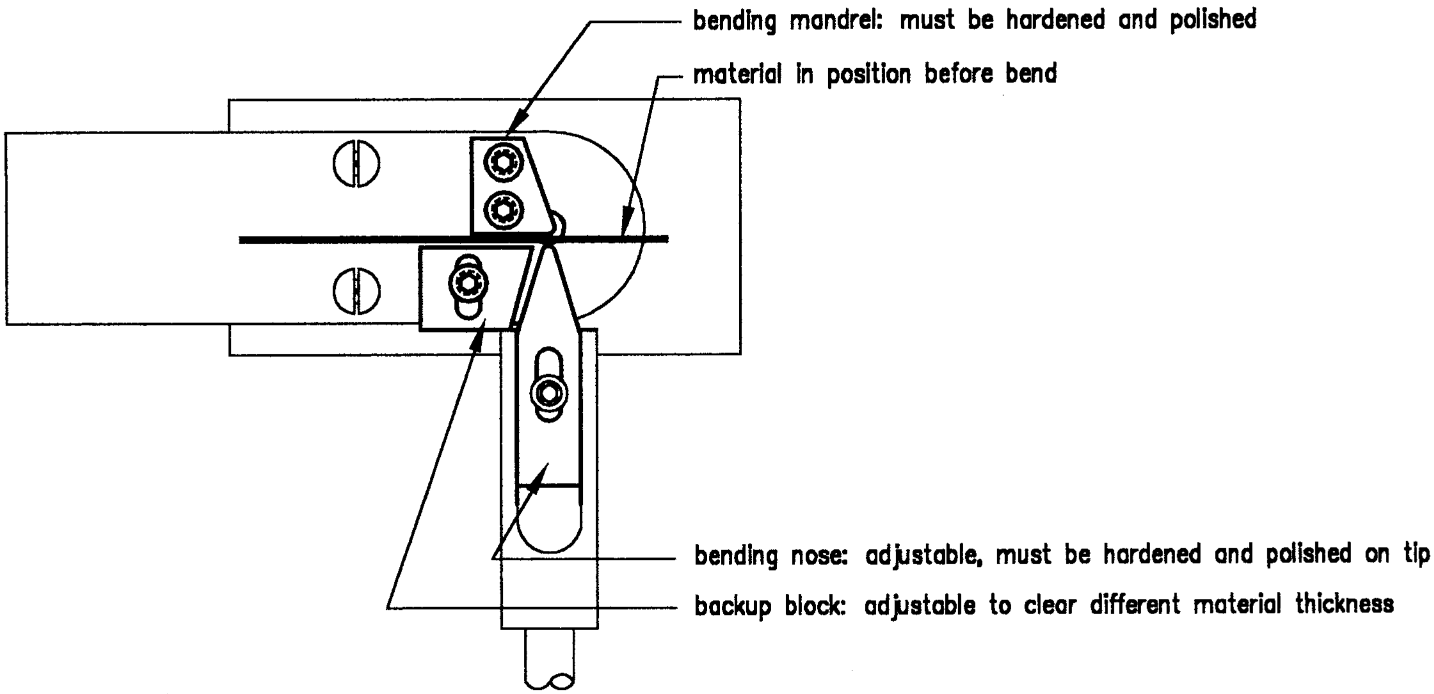
Step seven: draw the flat pattern of the part

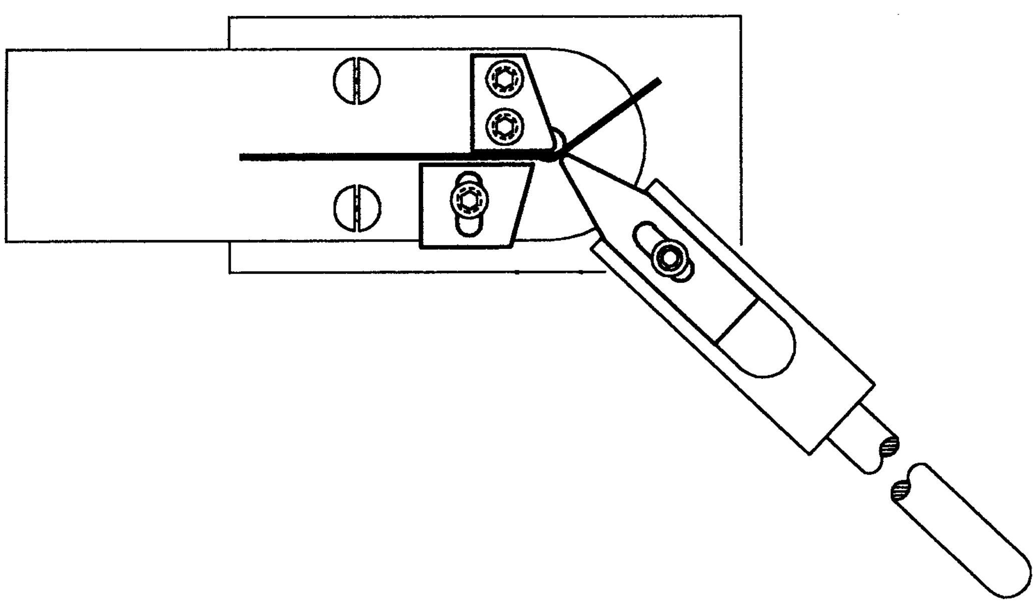
Draw the part outline. Add lines at the tangency points: the place where straight lengths and arc lengths meet. Add any holes or other features to the part.

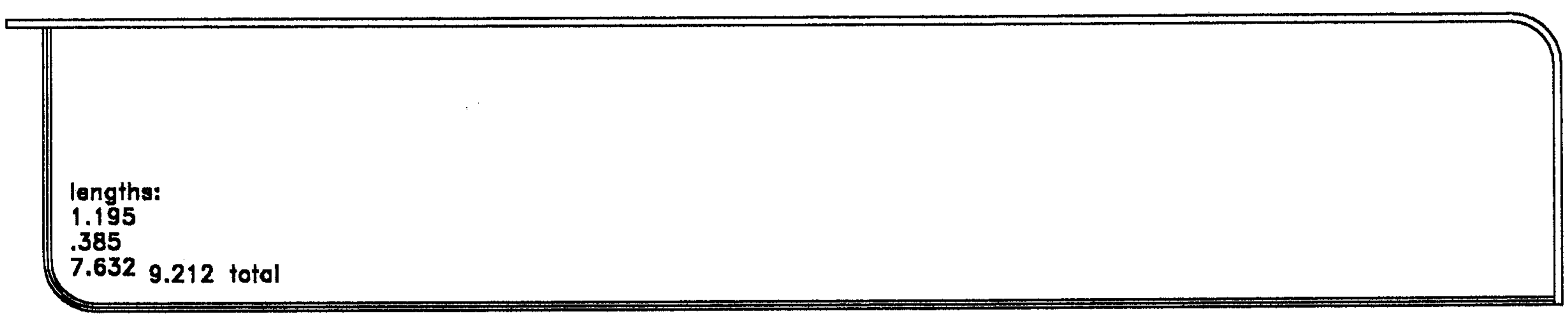


When bending the part, line up the tangency points to a mark on your bender, so that bends begin and end at the correct places.

DEVELOPING THE BENDING TOOL



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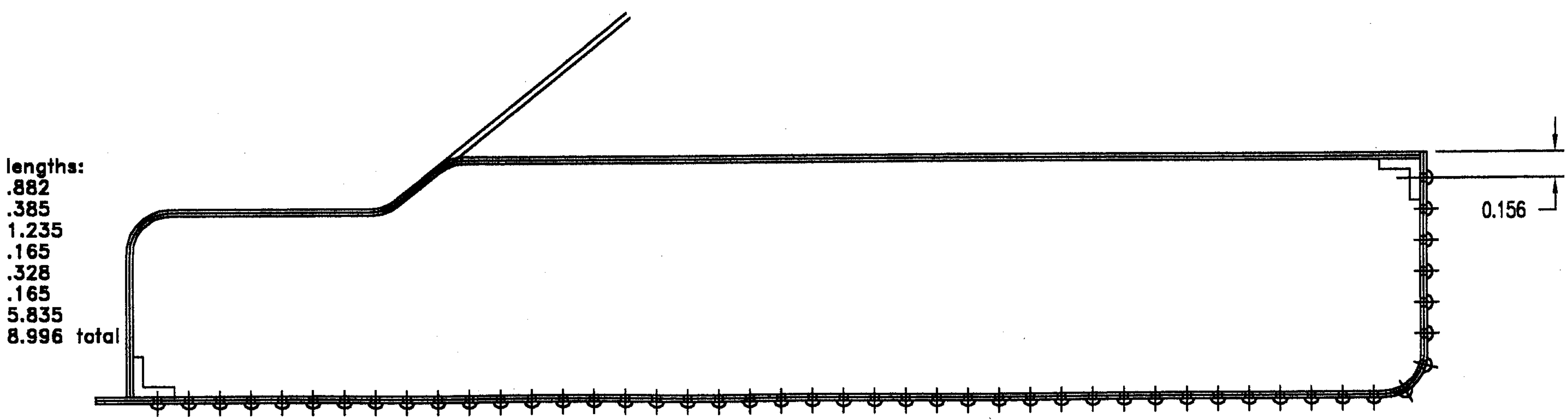
1.195
.385
7.632 9.212 total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.328
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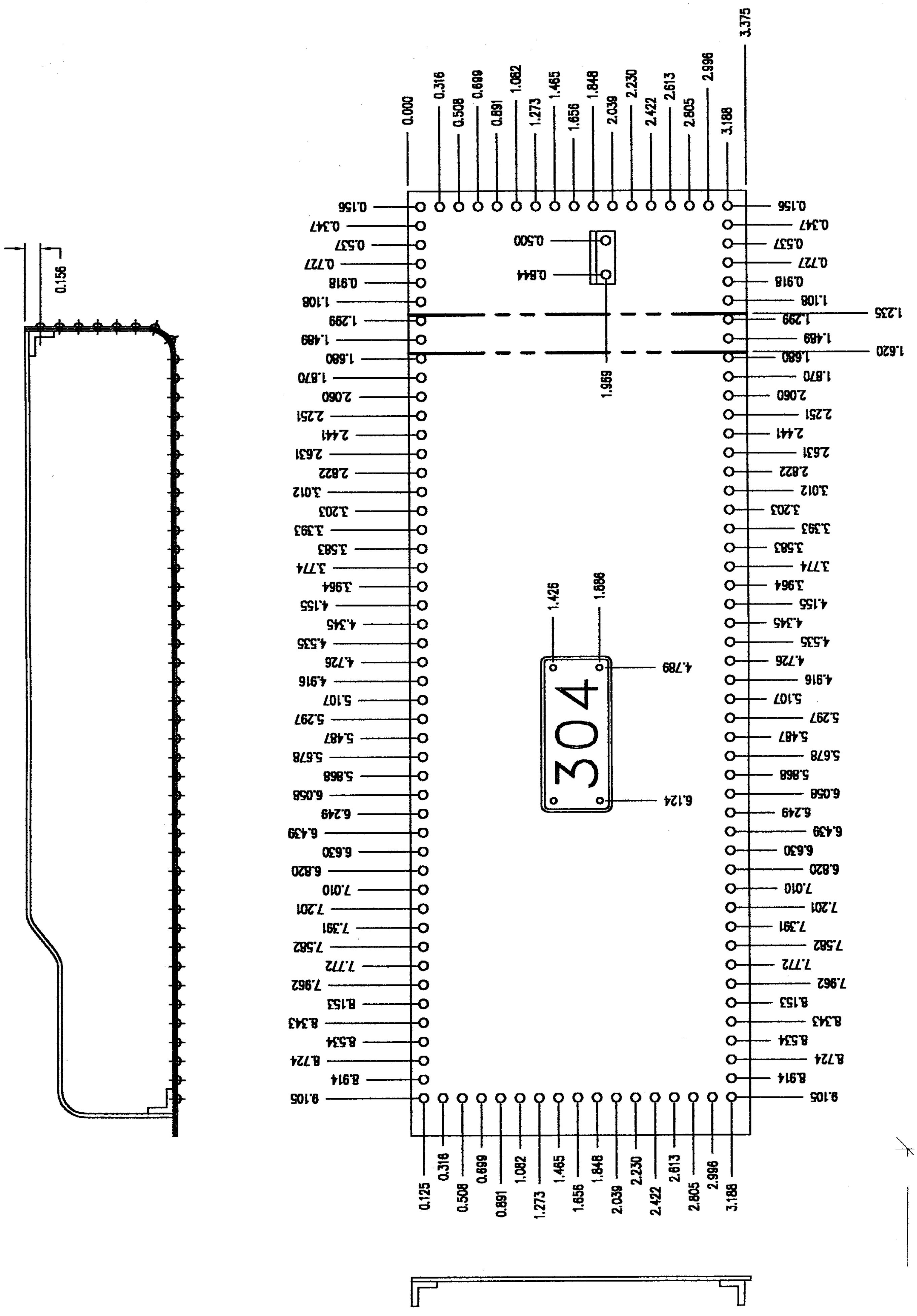
8.996 total
0.156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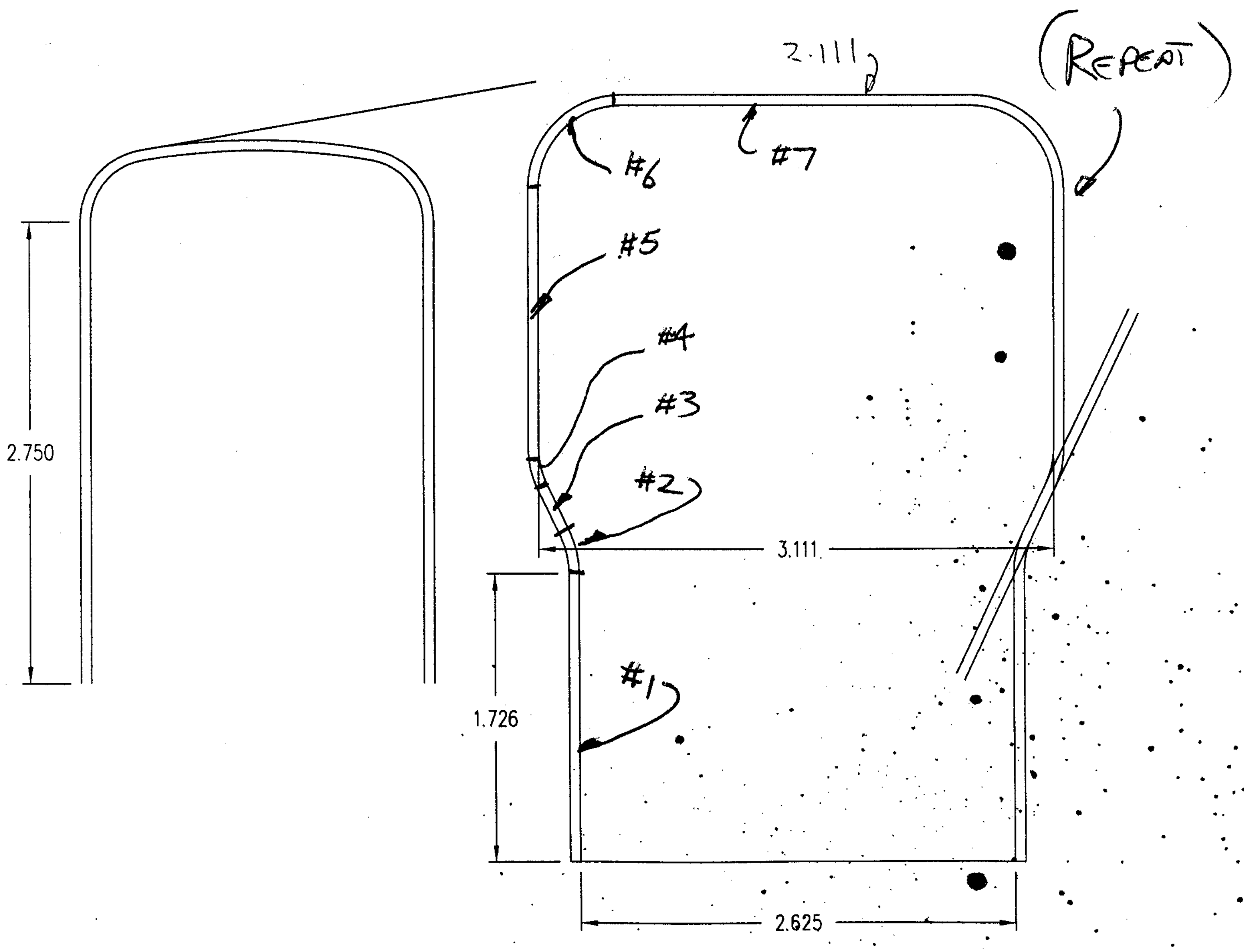

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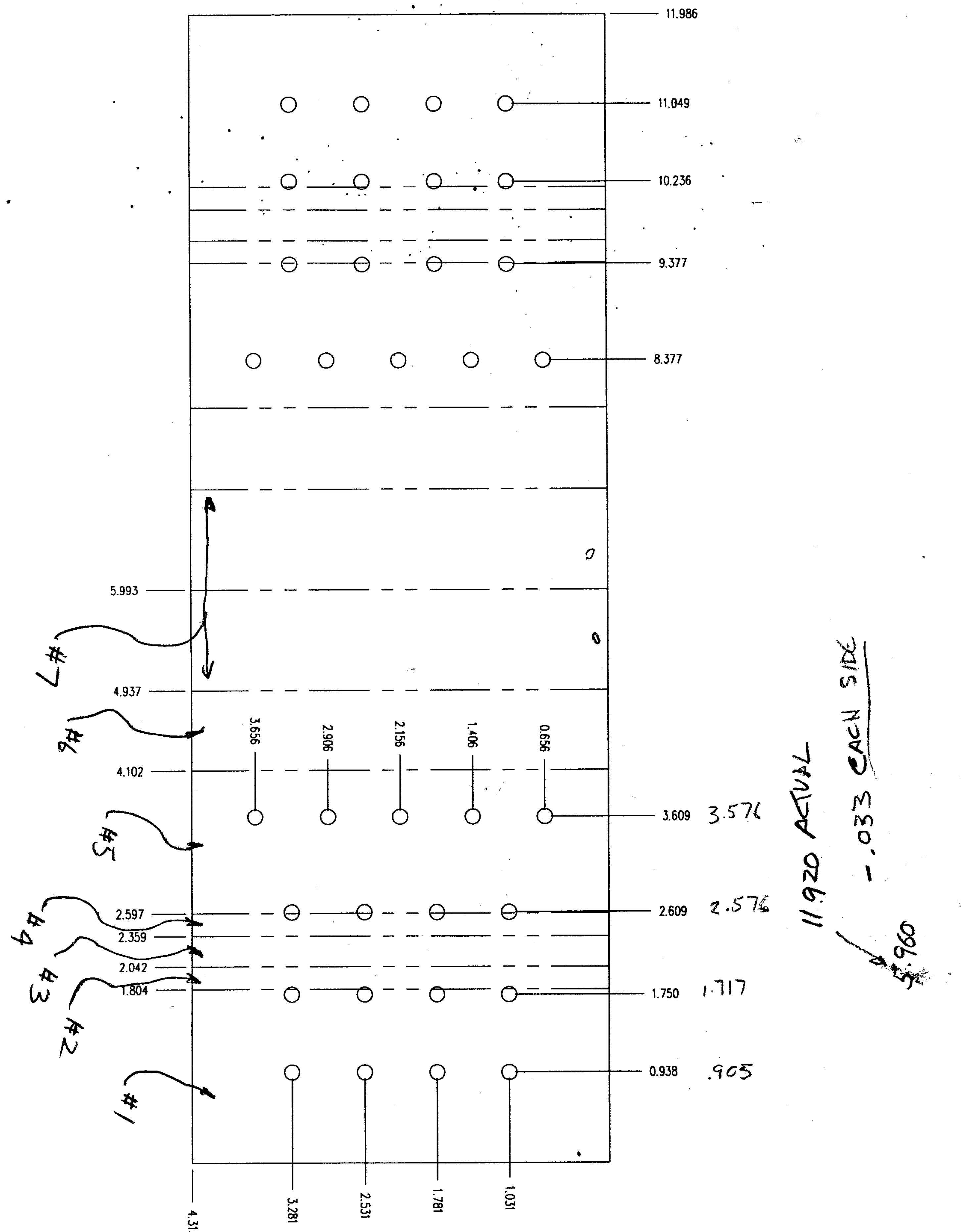

11.986
11.049
10.236
9.377
8.377
5.993
#7
4.937
#6
3.656
2.906
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0.656
4.102
3.609
3.576
#5
2.597
#4
2.359
#3
2.042
1.804
#2
2.609
2.576
1.750
1.717
0.938
.905
#1
4.313
3.281
2.531
1.781
1.031
11.920 ACTUAL
-.033 EACH SIDE
5.960