EXAMPLE 4-7—Cont.

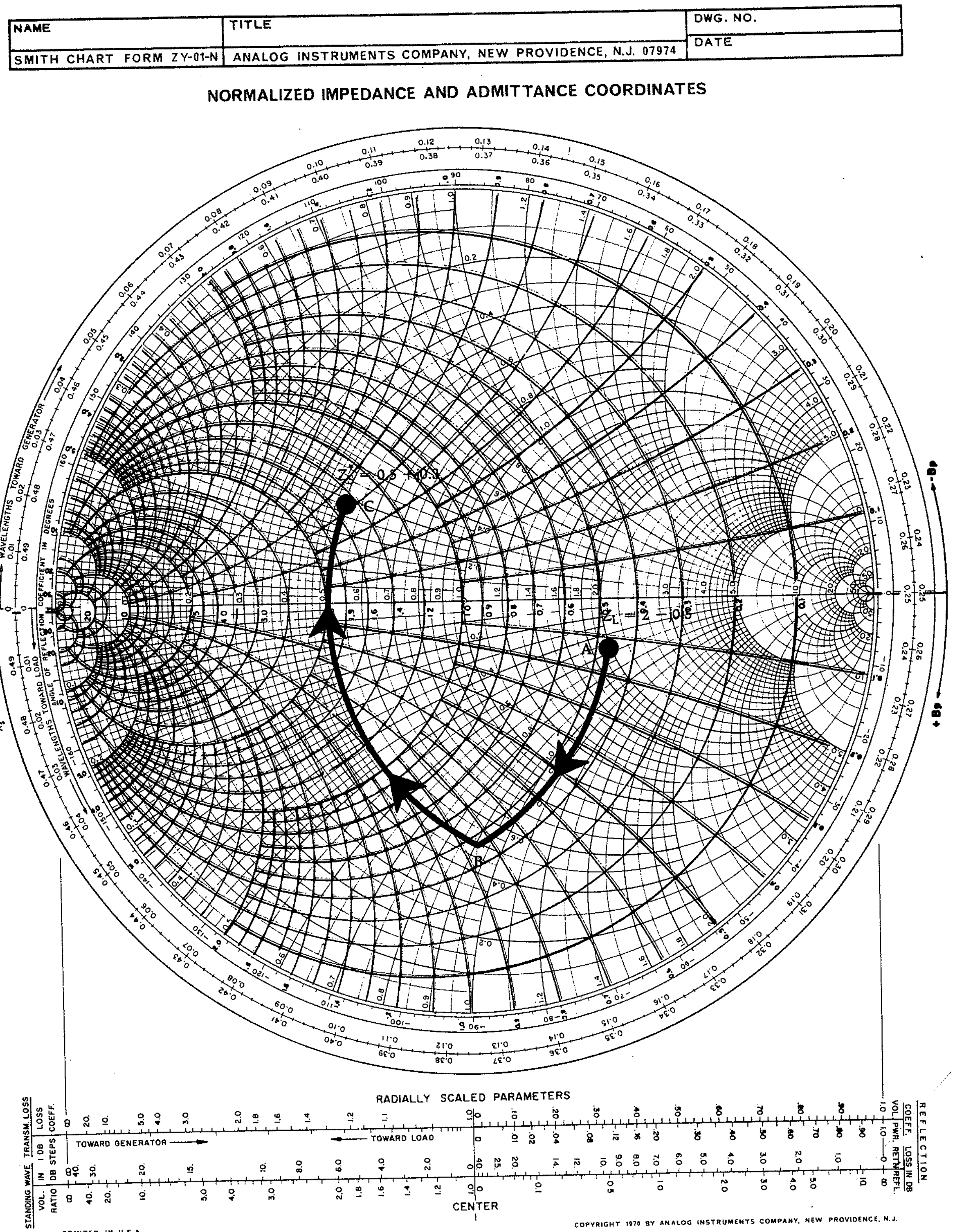


Fig. 4-44. Solution to Example 4-7.

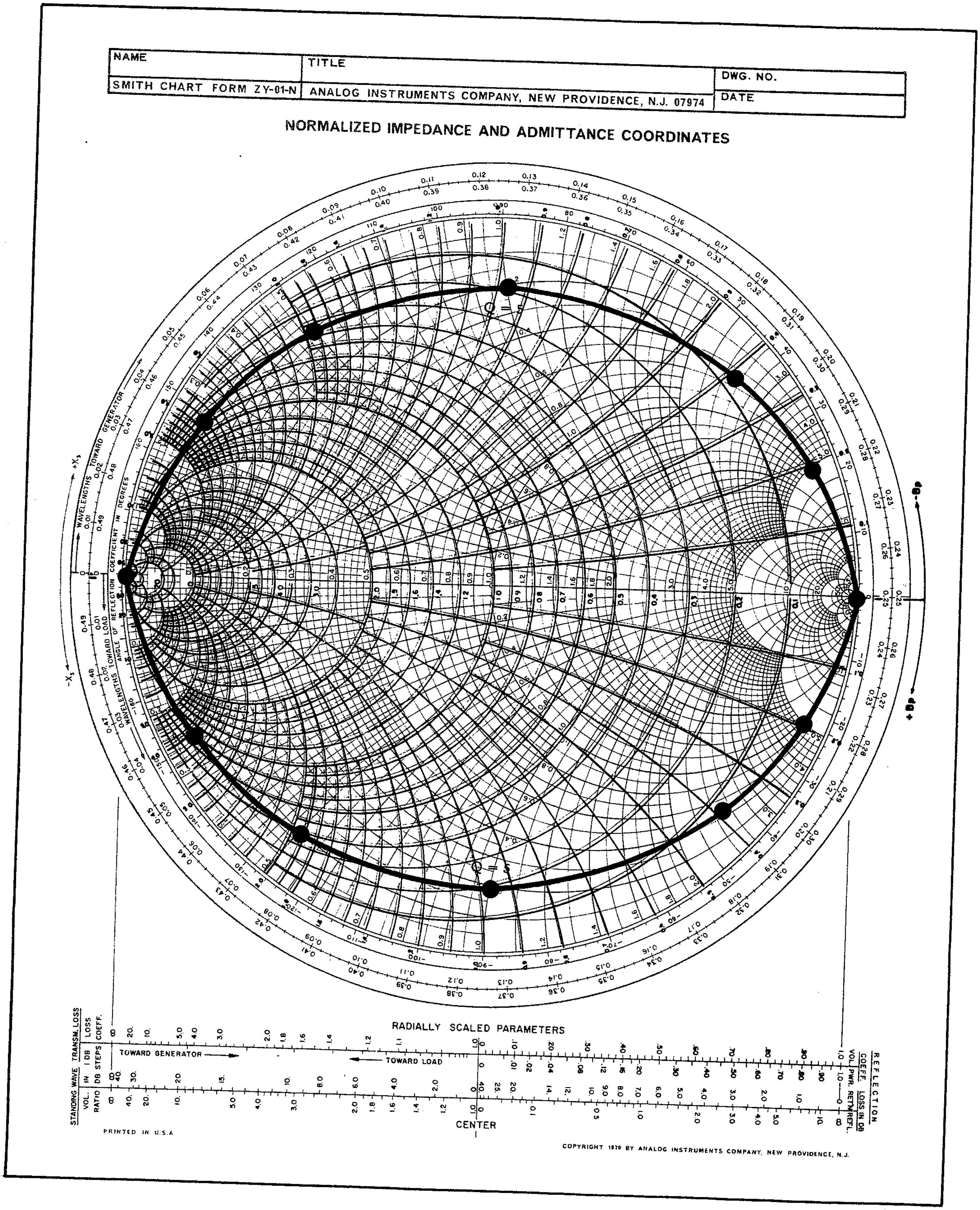


Fig. 4-45. Lines of constant Q.

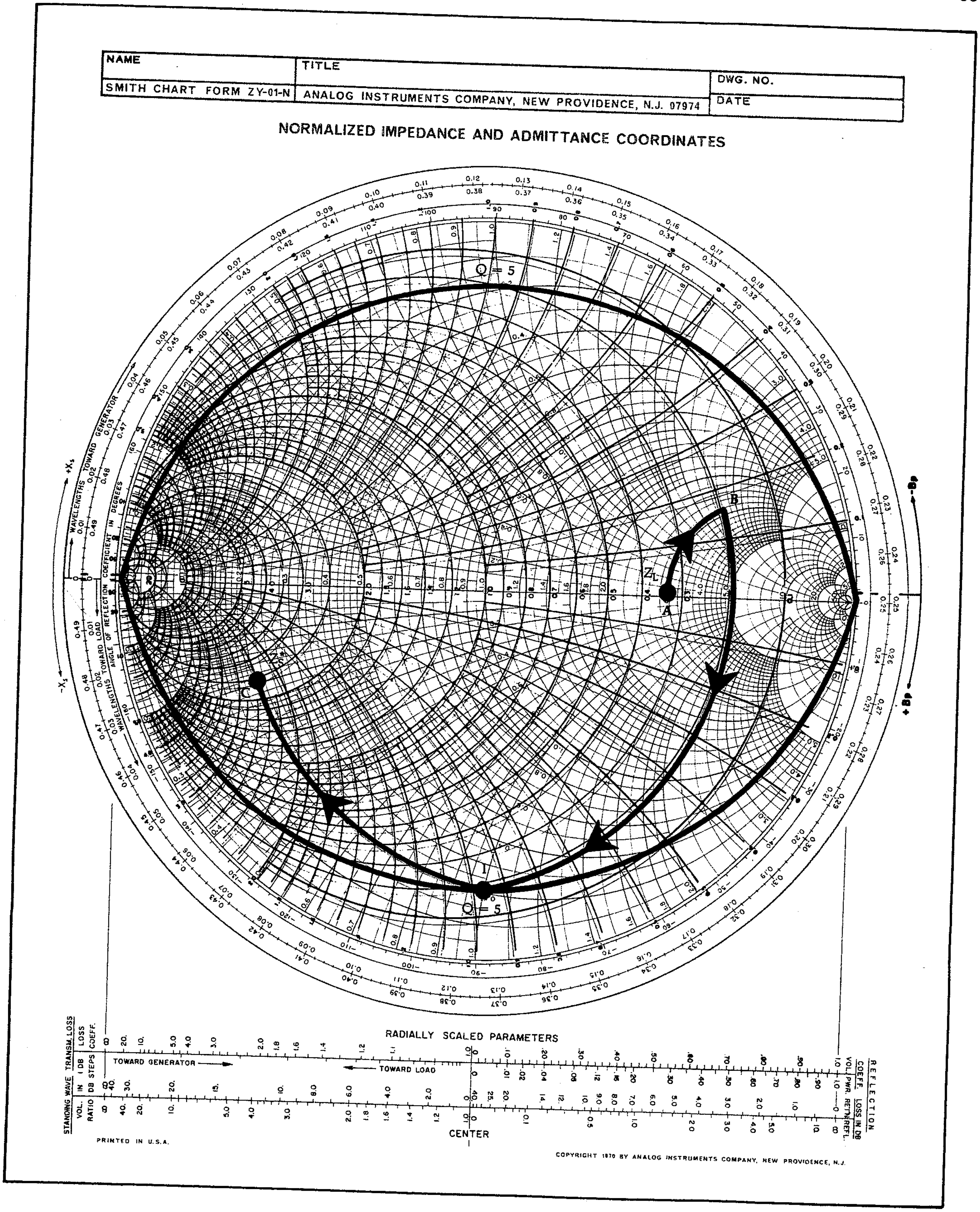
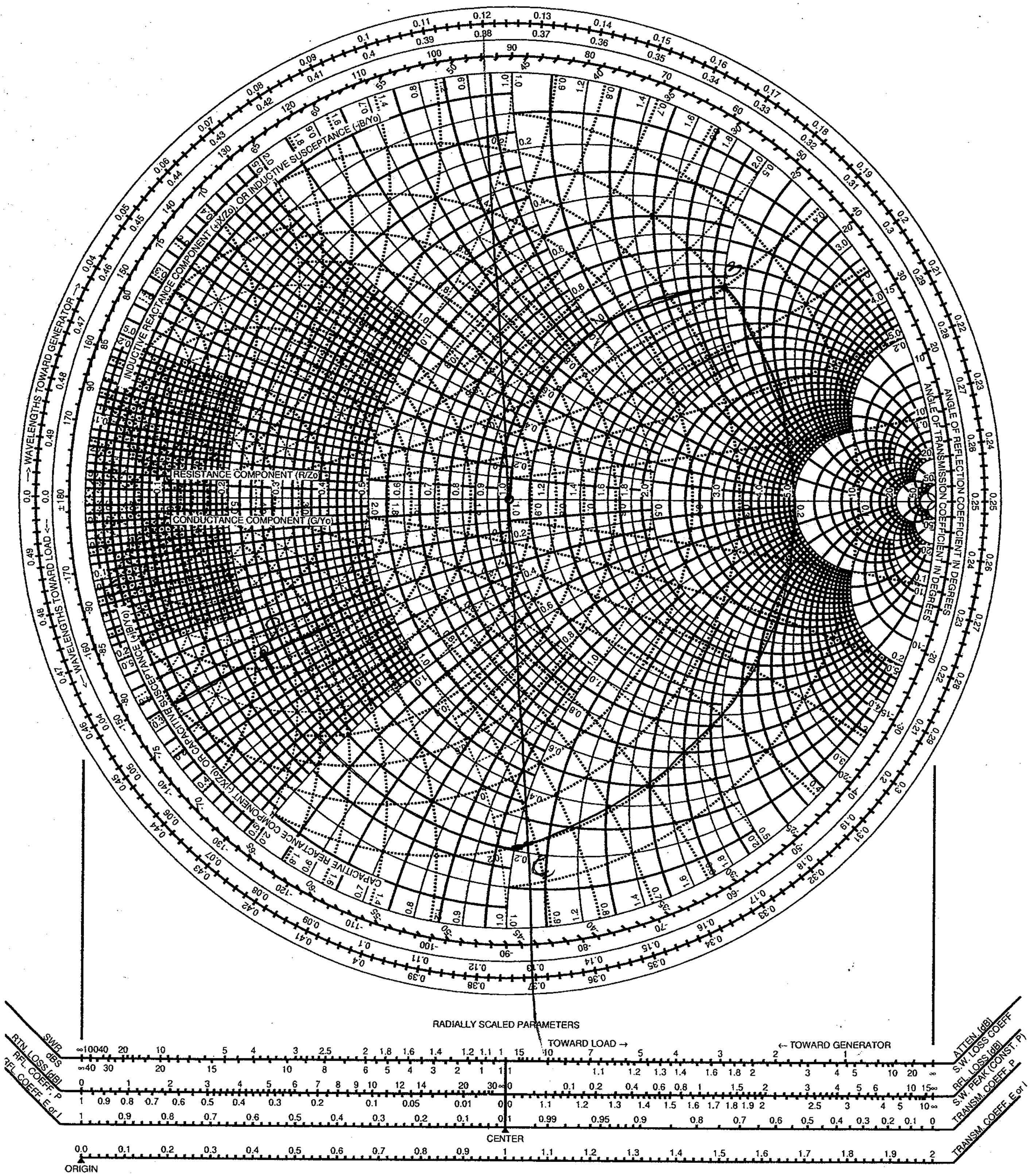


Fig. 4-46. Smith Chart solution for Example 4-8.

The Complete Smith Chart (ZY)



EXAMPLE 4-8

Design a T network to match a $Z = 15 + j15$-ohm source to a 225-ohm load at 30 MHz with a loaded Q of 5.

Solution

Following the procedures previously outlined, draw the arcs for $Q = 5$ first and, then, plot the load impedance and the complex conjugate of the source impedance. Obviously, normalization is necessary as the impedances are too large to be located on the chart. Divide by a convenient value (choose $N = 75$) for normalization. Therefore:

$$Z_s^* = 0.2 - j0.2 \text{ ohm}$$

$$Z_L = 3 \text{ ohms}$$

The construction details for the design are shown in Fig. 4-46.

The design statement specifies a T network. Thus, the source termination will determine the network Q because $R_S < R_L$.

Following the procedure for $R_S < R_L$ (Step 4, above), first plot point I, which is the intersection of the $Q = 5$ curve and the R = constant circuit that passes through Z_s^*. Then, move from the load impedance to point I with two elements.

Element 1 = arc AB = series L = j2.5 ohms
Element 2 = arc BI = shunt C = j1.15 mhos

Then, move from point I to Z_s^* along the R = constant circle.

Element 3 = arc IC = series L = j0.8 ohm

Use Equations 4-11 through 4-14 to find the actual element values.

Element 1 = series L:

$$L = \frac{(2.5)75}{2\pi(30 \times 10^6)} = 995 \text{ nH}$$

Element 2 = shunt C:

$$C = \frac{1.15}{2\pi(30 \times 10^6)75} = 81 \text{ pF}$$

Element 3 = series L:

$$L = \frac{(0.8)75}{2\pi(30 \times 10^6)} = 318 \text{ nH}$$

The final network is shown in Fig. 4-47.

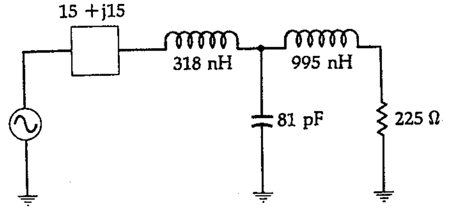


Fig. 4-47. Final circuit for Example 4-8.

treasure trove containing an infinite number of possible solutions. To get from point A to point B on a Smith Chart, there is, of course, an optimum solution. However, the optimum solution is not the only solution. The two-element network gets you from point A to point B with the least number of components and the three-element network can provide a specified Q by following a different route. If you do not care about Q, however, there are 3-, 4-, 5-, 10-, and 20-element (and more) impedance-matching networks that are easily designed on a Smith Chart by simply following the constant-conductance and constant-resistance circles until you eventually arrive at point B, which, in our case, is usually the complex conjugate of the source impedance. Fig. 4-48 illustrates this point. In the lower right-hand corner of the chart is point A. In the upper left-hand corner is point B. Three of the infinite number of possible solutions that can be used to get from point A to point B, by adding series and shunt inductances and capacitances, are shown. Solution 1 starts with a series-L configuration and takes 9 elements to get to point B. Solution 2 starts with a shunt-L procedure and takes 8 elements, while Solution 3 starts with a shunt-C arrangement and takes 5 elements. The element reactances and susceptances can be read directly from the chart, and Equations 4-11 through 4-14 can be used to calculate the actual component values within minutes.

SUMMARY

Impedance matching is not a form of "black magic" but is a step-by-step well-understood process that is used to help transfer maximum power from a source to its load. The impedance-matching networks can be designed either mathematically or graphically with the aid of a Smith Chart. Simpler networks of two and three elements are usually handled best mathematically, while networks of four or more elements are very easily handled using the Smith Chart.

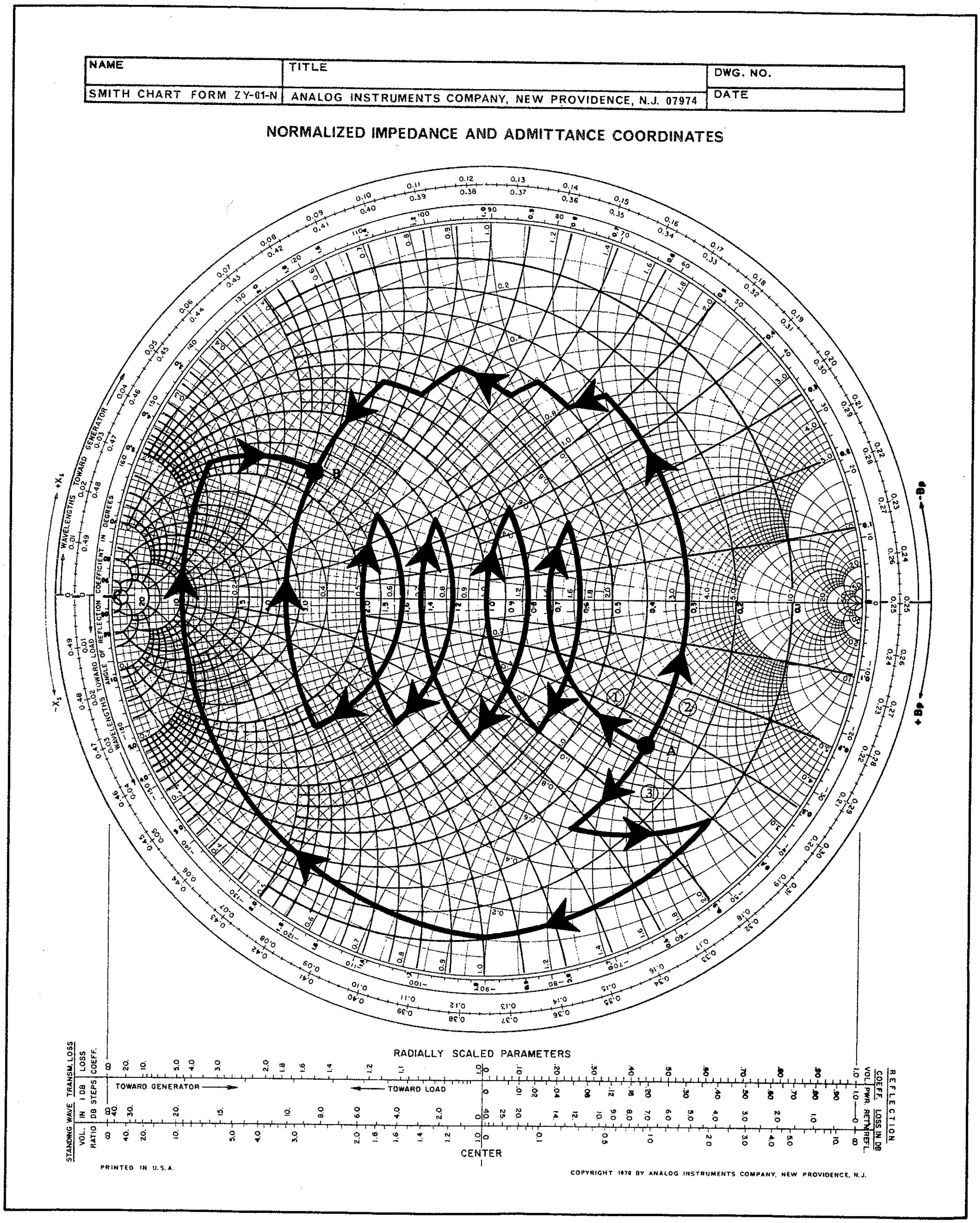


Fig. 4-48. Multielement matching.