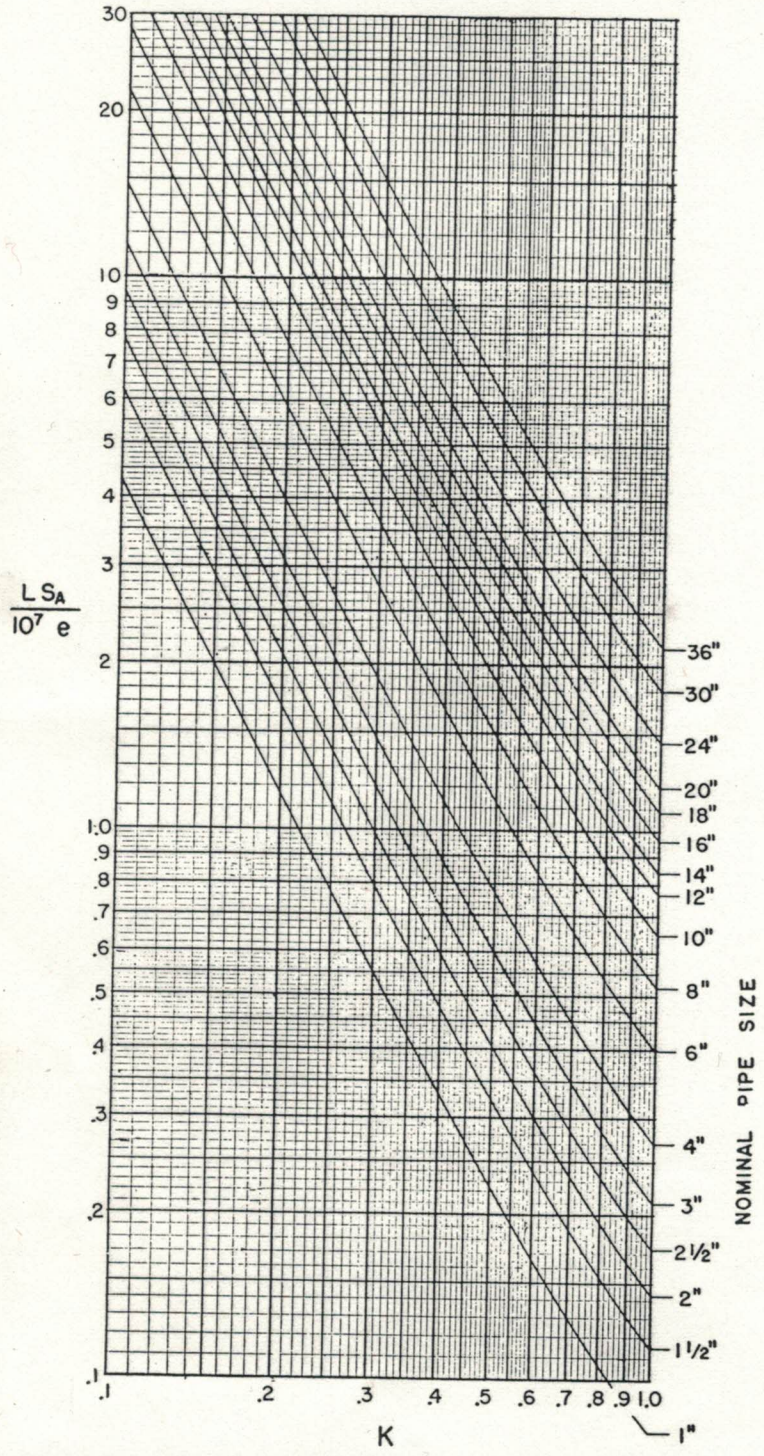
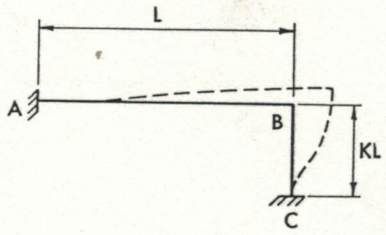
## C-5. LENGTH OF LEG REQUIRED

### Two-Member System, Both Ends Fixed, Thermal Expansion in Plane of Members




$L$ = Length of leg $AB$, ft.

$e$ = Unit linear thermal expansion, in./ft.

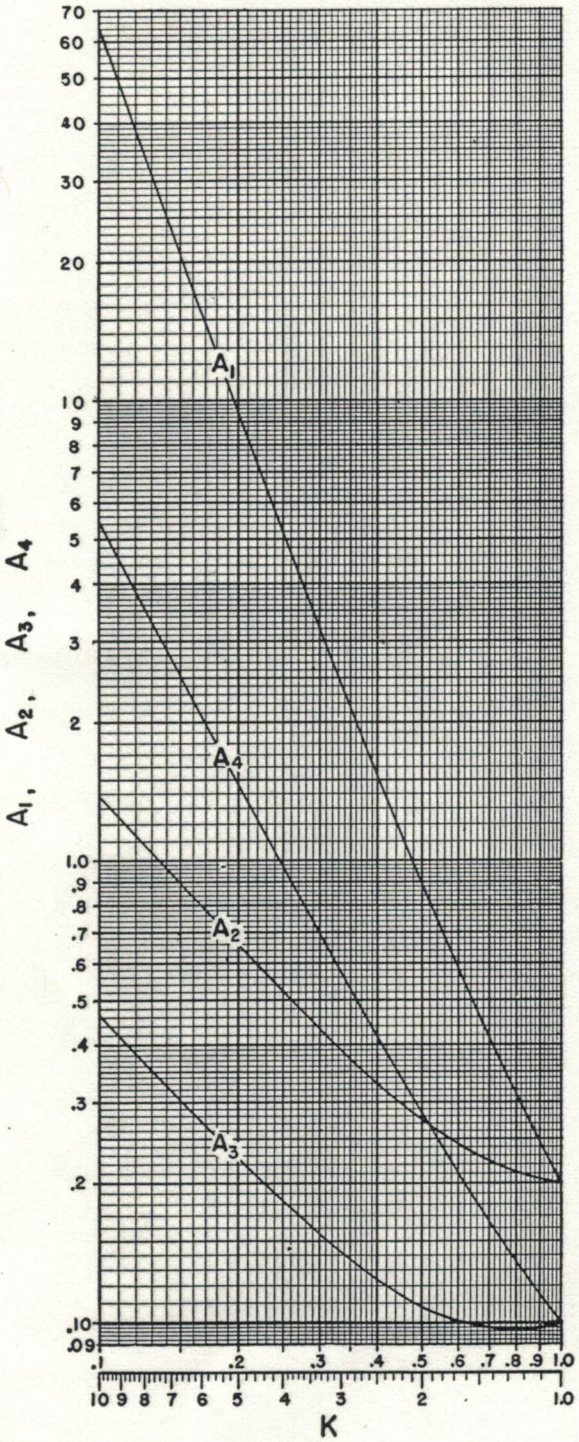
Value of $E$ used = $29 \times 10^6$ psi.

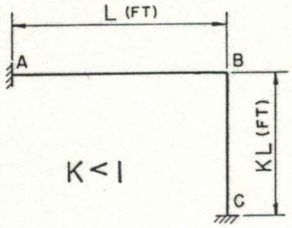
$S_A$ = Code allowable stress range $(1.25S_c + 0.25S_h)$, psi.

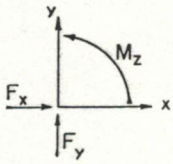
Multiply $L$ by $K$ to obtain length of leg $BC$ required.

## C-6. MOMENTS AND FORCES

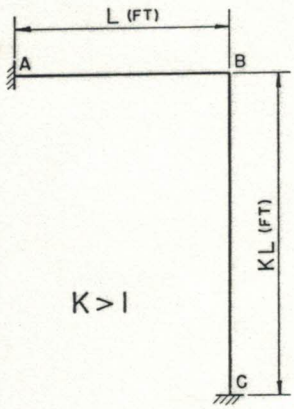
### Two-Member System, Both Ends Fixed
### Thermal Expansion in Plane of Members




$$F_{xA} = -F_{xC} = -10^6 A_1 Ie/L^2$$
$$F_{yA} = -F_{yC} = +10^6 A_2 Ie/L^2$$
$$M_{zA} = +10^6 A_3 Ie/L$$
$$M_{zC} = -10^6 A_4 Ie/L$$




$$F_{xA} = -F_{xC} = -10^6 A_2 Ie/(KL)^2$$
$$F_{yA} = -F_{yC} = +10^6 A_1 Ie/(KL)^2$$
$$M_{zA} = 10^6 A_4 Ie/KL$$
$$M_{zC} = -10^6 A_3 Ie/KL$$

$F$ = Force, lb.

$M$ = Moment, ft-lb.

First subscript denotes *direction*.

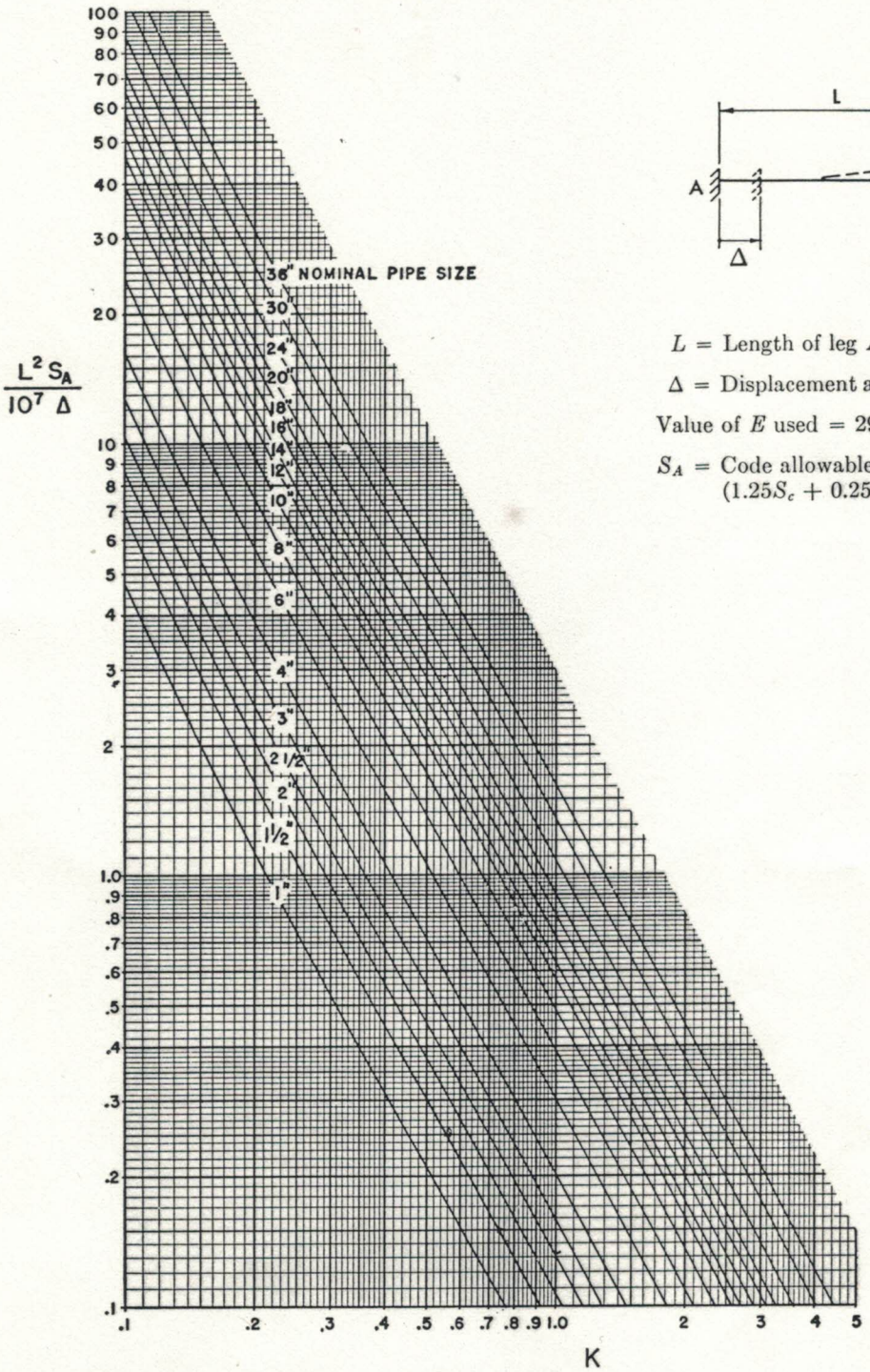
Second subscript denotes *location*.

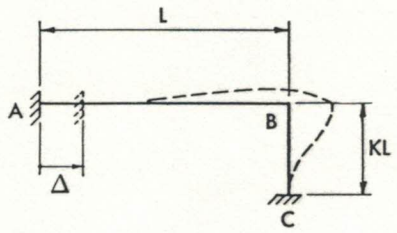
Signs are those of forces or moments *acting* on anchors.

$I$ = Moment of inertia of pipe, in.$^4$.
$e$ = Unit linear thermal expansion, in./ft.
Value of $E$ used = $29 \times 10^6$ psi.

## C-7. LENGTH OF LEG REQUIRED

### Two-Member System, Both Ends Fixed
### One Support Displaced in the Direction of the Adjoining Member




$L$ = Length of leg $AB$, ft.

$\Delta$ = Displacement as shown of end $A$, in.

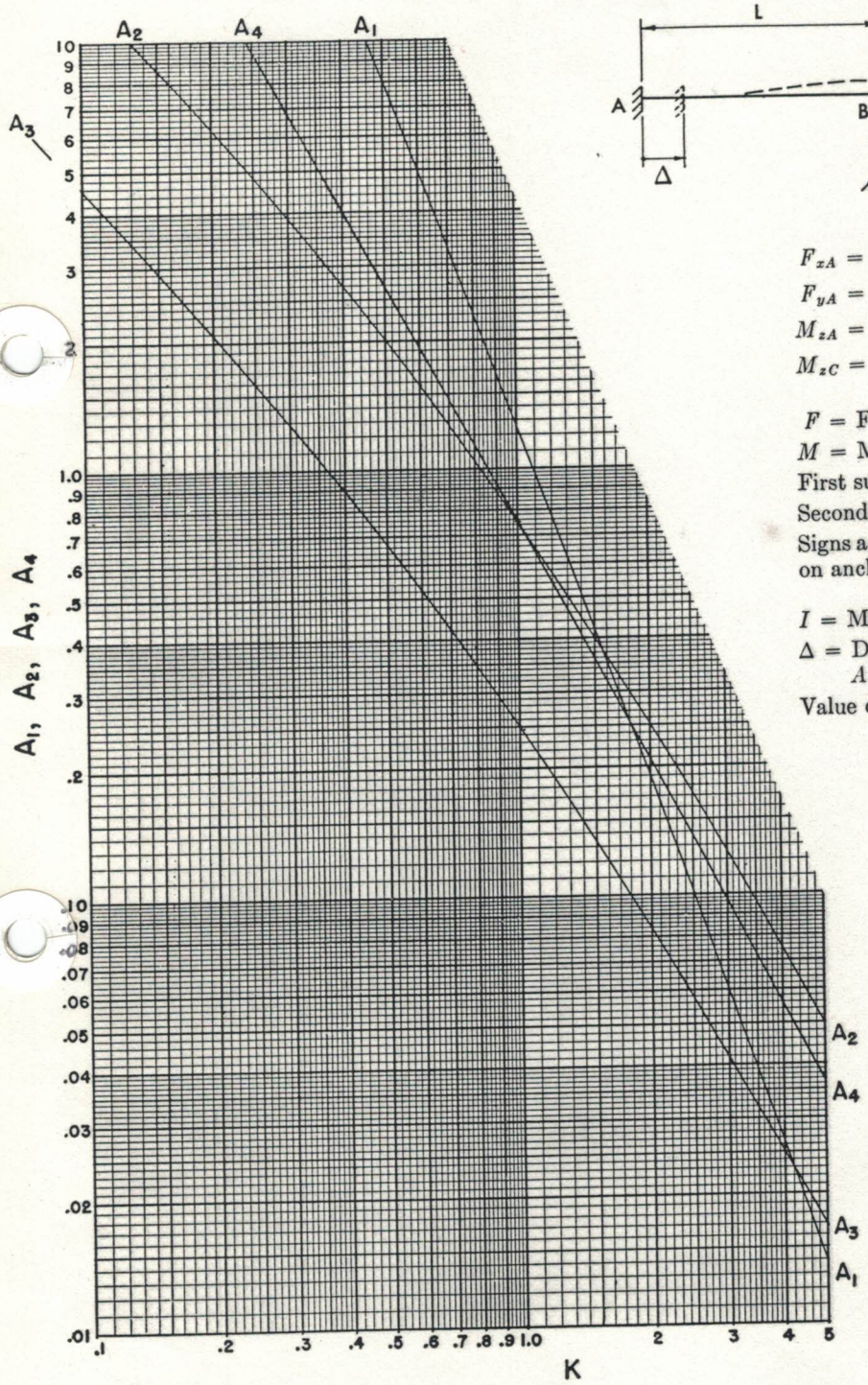
Value of $E$ used = $29 \times 10^6$ psi.

$S_A$ = Code allowable stress range $(1.25S_c + 0.25S_h)$, psi.

Multiply $L$ by $K$ to obtain length of $BC$ required.

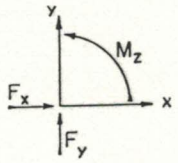
## C-8. MOMENTS AND FORCES

### Two-Member System, Both Ends Fixed
### One Support Displaced in the Direction of the Adjoining Member










$$F_{xA} = -F_{xC} = -10^5\, I\Delta A_1/L^3$$
$$F_{yA} = -F_{yC} = +10^5\, I\Delta A_2/L^3$$
$$M_{zA} = +10^5\, I\Delta A_3/L^2$$
$$M_{zC} = -10^5\, I\Delta A_4/L^2$$

$F$ = Force, lb.

$M$ = Moment, ft-lb.

First subscript denotes *direction*.

Second subscript denotes *location*.

Signs are those of forces or moments *acting* on anchors.

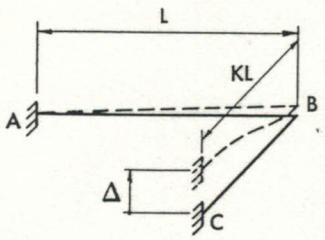
$I$ = Moment of inertia of pipe, in.$^4$.

$\Delta$ = Displacement in $x$-direction of end $A$, in.

Value of $E$ used = $29 \times 10^6$ psi.

## C-9. LENGTH OF LEG REQUIRED

### Two-Member System, Both Ends Fixed
### One Support Displaced Normal to Plane of Members

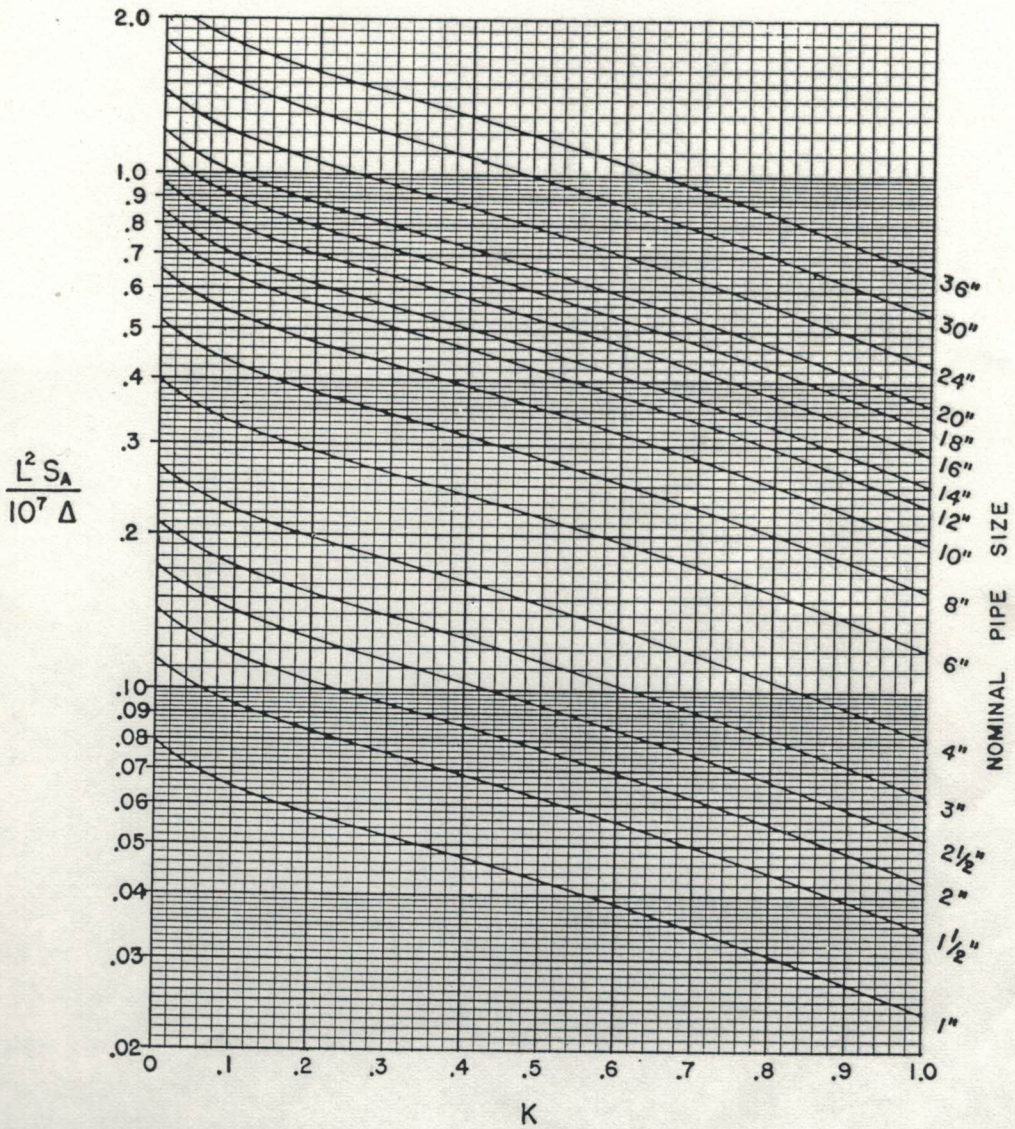



$L$ = Length of leg $AB$, ft.

$\Delta$ = Displacement normal to plane, in.

Value of $E$ used = $29 \times 10^6$ psi.

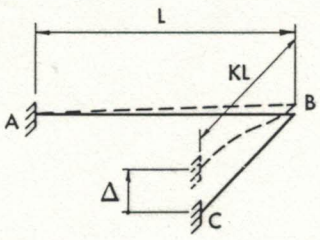
$S_A$ = Code allowable stress range $(1.25S_c + 0.25S_h)$, psi.

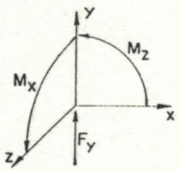


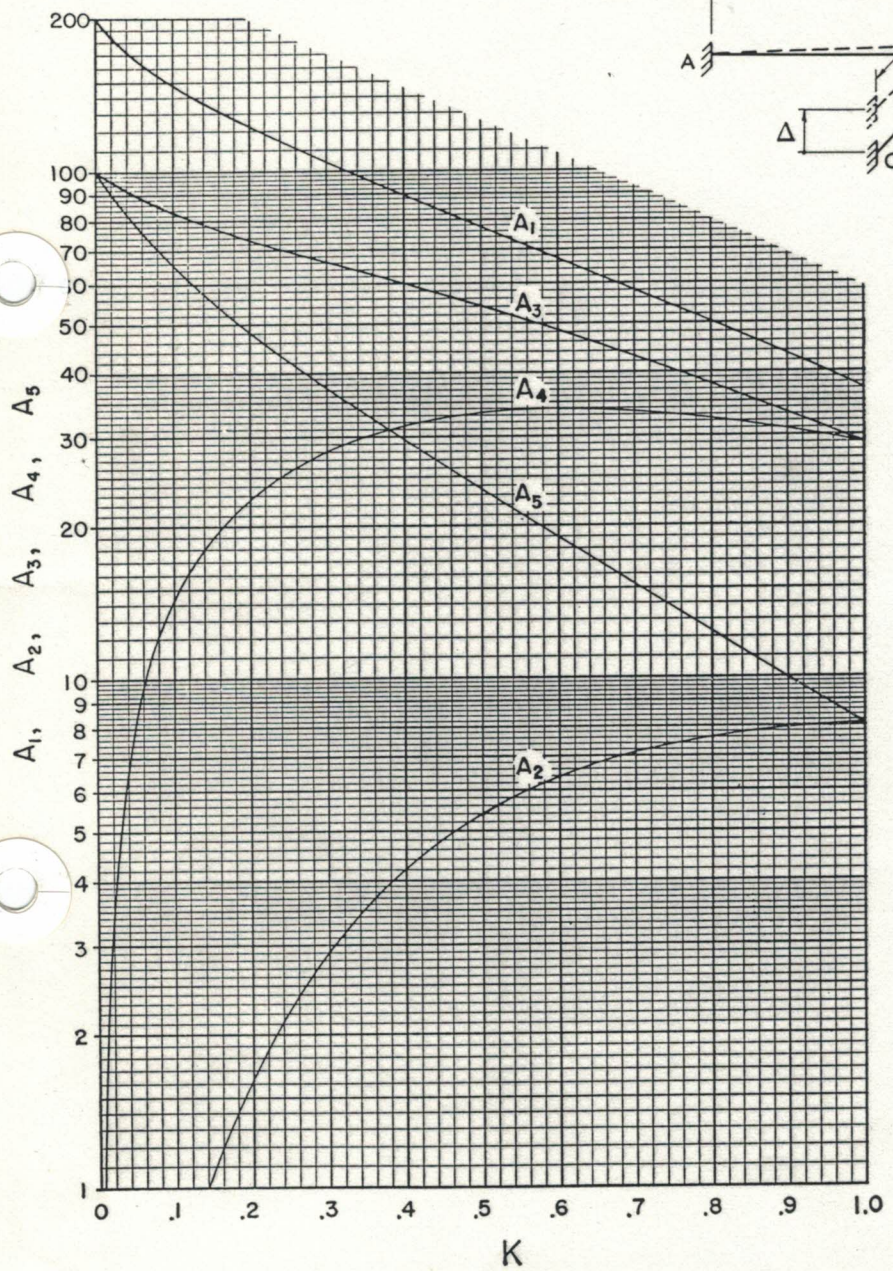

Multiply $L$ by $K$ to obtain length of leg $BC$ required.

## C-10. MOMENTS AND FORCES

### Two-Member System, Both Ends Fixed
### One Support Displaced Normal to Plane of Members




$$F_{yA} = -F_{yC} = 10^3 \frac{I\Delta}{L^3} A_1$$

$$M_{xA} = -10^3 \frac{I\Delta}{L^2} A_2$$

$$M_{zA} = +10^3 \frac{I\Delta}{L^2} A_3$$

$$M_{xC} = -10^3 \frac{I\Delta}{L^2} A_4$$

$$M_{zC} = 10^3 \frac{I\Delta}{L^2} A_5$$

$F$ = Force, lb.

$M$ = Moment, ft-lb.

First subscript denotes *direction.*

Second subscript denotes *location.*

Signs are those of forces or moments *acting* on anchors.

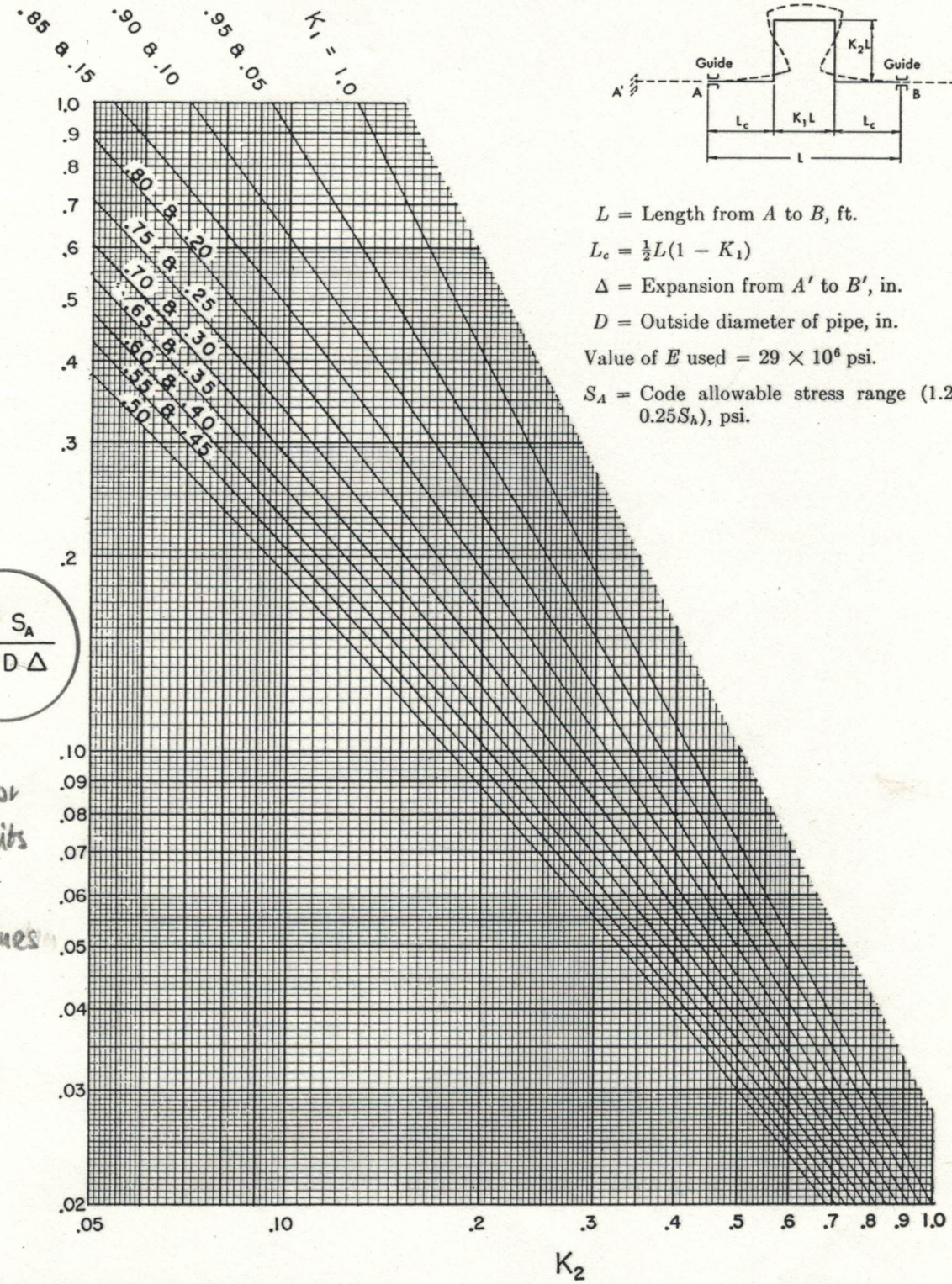
$I$ = Moment of inertia of pipe, in.$^4$.

$\Delta$ = Displacement normal to plane, in.

Value of $E$ used = $29 \times 10^6$ psi.

## C-11. REQUIRED HEIGHT

### Symmetrical Expansion Loop




$L$ = Length from $A$ to $B$, ft.

$L_c = \frac{1}{2}L(1 - K_1)$

$\Delta$ = Expansion from $A'$ to $B'$, in.

$D$ = Outside diameter of pipe, in.

Value of $E$ used = $29 \times 10^6$ psi.

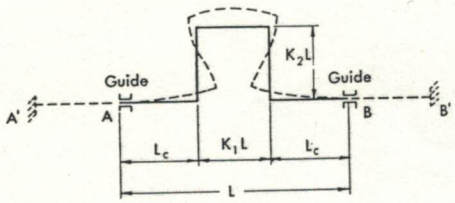
$S_A$ = Code allowable stress range ($1.25S_c + 0.25S_h$), psi.

Imperial or Metric Units both give identical values for $K_2$

Multiply $L$ by $K_1$ and $K_2$ to obtain dimensions of loop.

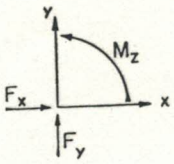
## C-12. MOMENTS AND FORCES

### Symmetrical Expansion Loop



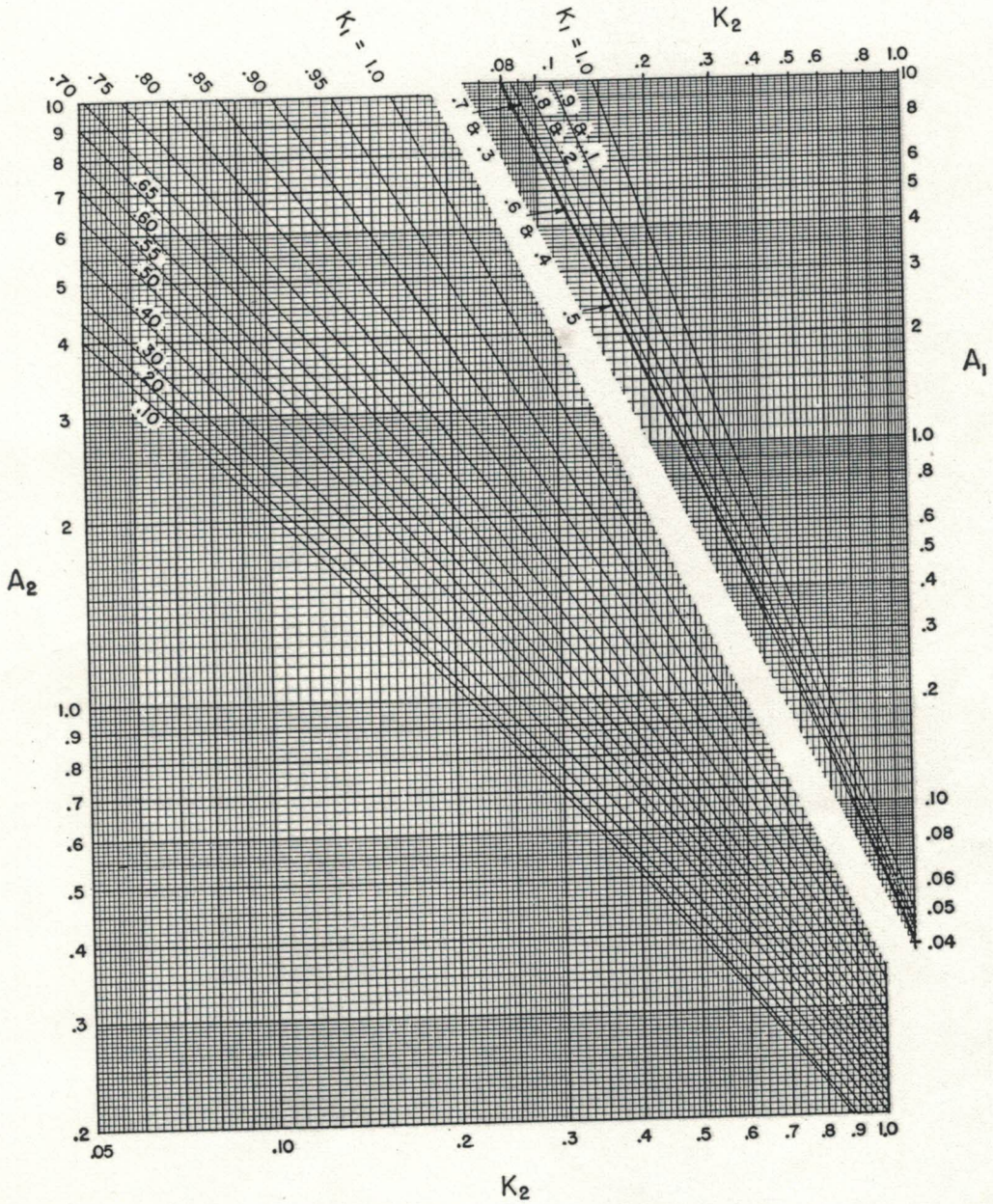

$$F_{zA'} = -F_{zB'} = -10^6 A_1 I\Delta/L^3$$

$$M_{zA} = -M_{zB} = 10^5 A_2 I\Delta/L^2$$

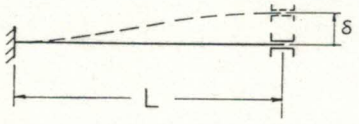



$I$ = Moment of inertia of pipe, in.$^4$.
$\Delta$ = Expansion from $A'$ to $B'$, in.
Value of $E$ used = $29 \times 10^6$ psi.

$F$ = Force, lb.
$M$ = Moment, ft-lb.
First subscript denotes *direction*.
Second subscript denotes *location*.
Signs are those of forces or moments *acting* on anchors.



## C-13. Guided Cantilever Chart



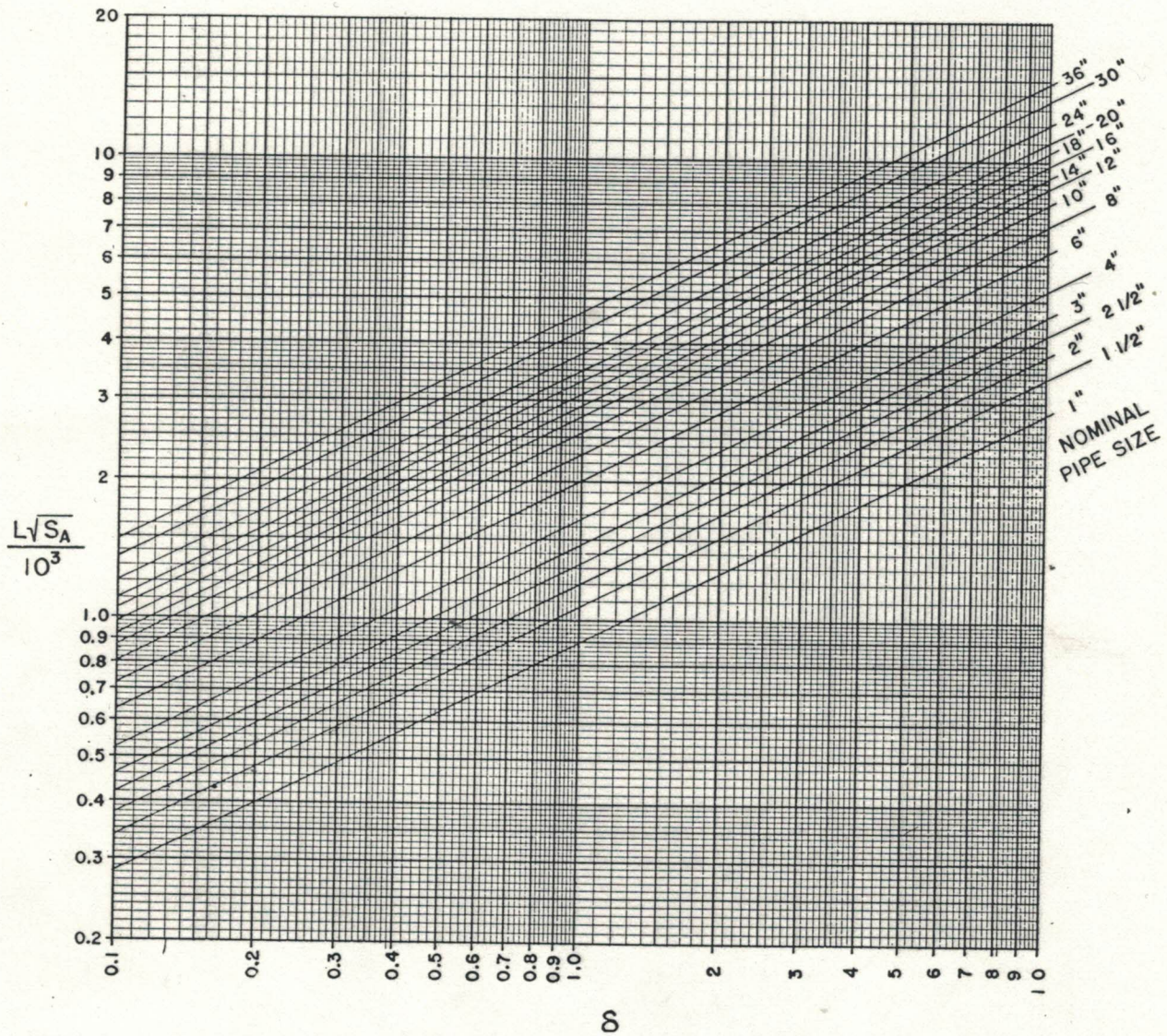

Assumed mode of deflection of guided cantilever.

$L$ = Length of leg, ft.

$\delta$ = Lateral deflection, in.

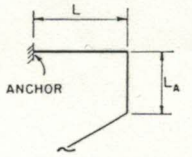
Value of $E$ used = $29 \times 10^6$ psi.

$S_A$ = Code allowable stress range $(1.25S_c + 0.25S_h)$, psi.

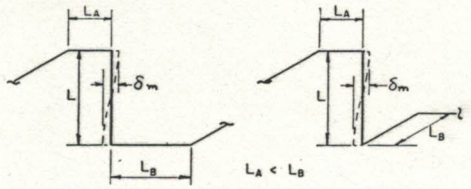



*Instructions:* Determine value of $L\sqrt{S_A}/10^3$. Enter with this value of ordinate scale and read over to line for proper nominal pipe size. Read down to abscissa scale. The value obtained will be the permissible lateral deflection for leg.

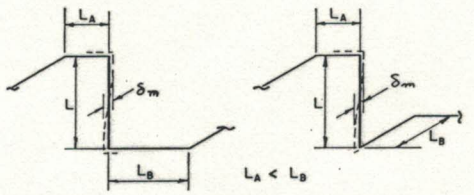
## C-14. Correction Factor $f$, Guided Cantilever Method




*Case I.* For any exterior leg $L$.

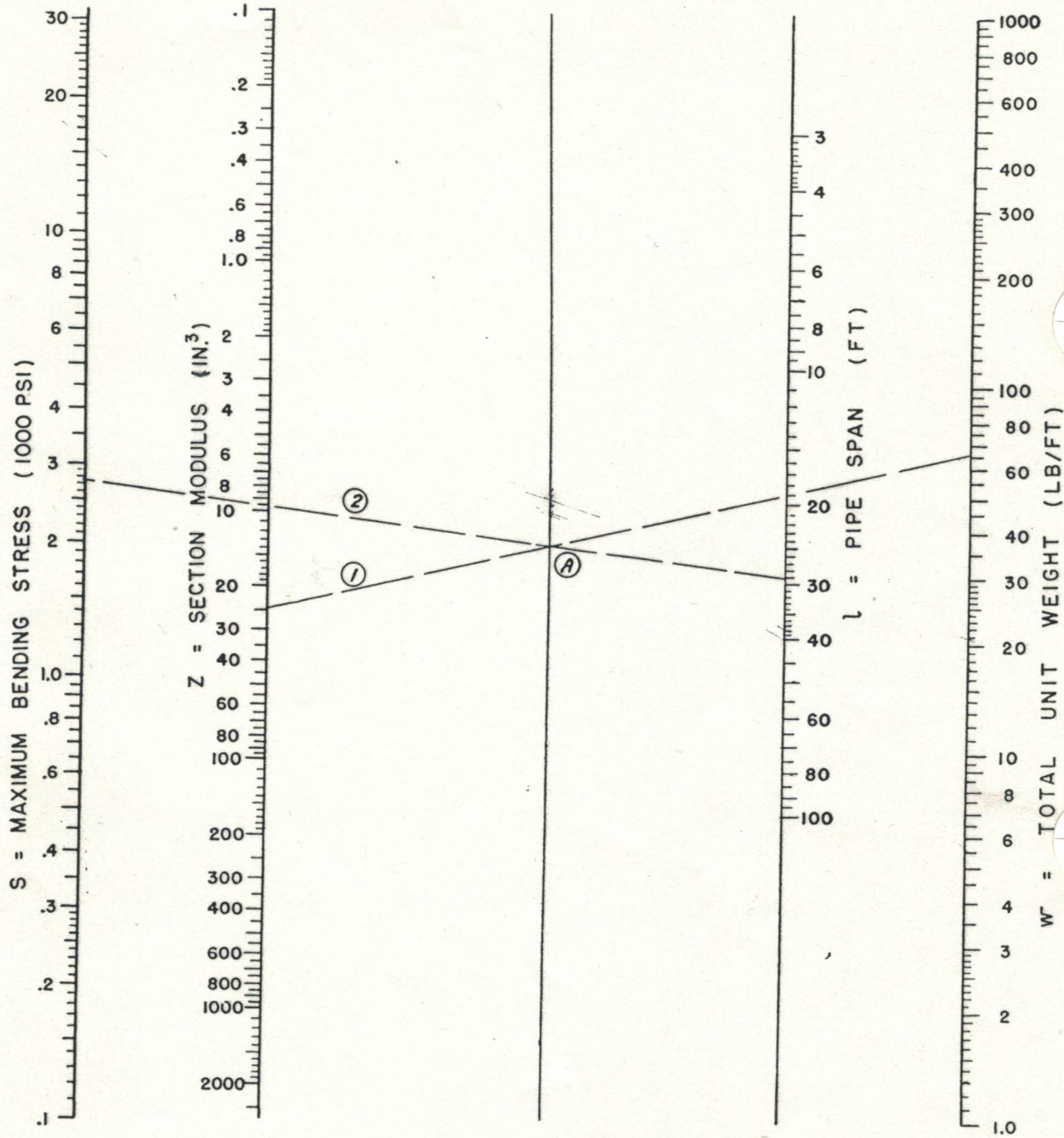



*Case II.* For any interior leg $L$ whose maximum deflection is in the plane of $L$ and $L_A$ where $L_A$ is the shorter of the connecting legs.




*Case III.* For any interior leg $L$ whose maximum deflection is perpendicular to the plane of $L$ and $L_A$ where $L_A$ is the shorter of the connecting legs.

## C-16. Span vs. Stress, Horizontal Pipe Lines, Uniform Load




Formula: $S = 1.2wl^2/Z$

Key: (1) Connect $Z$ with $w$ locating turning point ($A$).
(2) Connect ($A$) with $s$ locating $l$.
Connect ($A$) with $l$ locating $s$.

Example: Given: $Z = 24.5$ in.$^3$, $w = 66$ lb/ft, $S = 2750$ psi.
Result: $l = 29$ ft.