Title

STRESS ANALYSIS OF THE SUPPORT STRUCTURE FOR THE CARRIAGE FRAME IN SPOOL #1 OF THE VACUUM TANK

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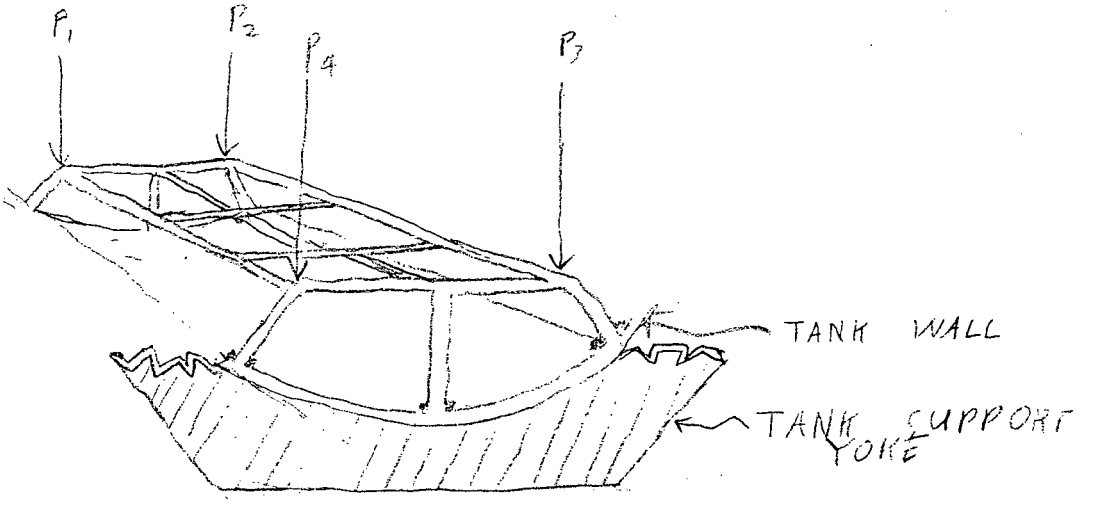
STRESS ANALYSIS OF THE SUPPORT STRUCTURE FOR THE CARRIAGE FRAME IN SPOOL #1 OF THE VACUUM TANK.

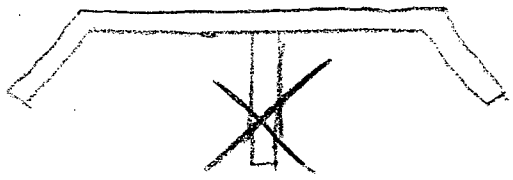
SPOOL #1 OF THE VACUUM TANK CONTAINS, AMONG OTHER THINGS, THE NEUTRALIZER TUBES, THE BEAM DUMPS AND THE FINGERS FOR THE MAGNETS. THE AFORE MENTIONED ITEMS ARE MOUNTED ON A FRAME CALLED THE CARRIAGE FRAME WHICH IS PLACED ON A SUPPORT STUCTURE INSIDE SPOOL #1 OF THE VACUUM TANK.

IT IS IMPORTANT THAT THE COMPONENTS OF THE BEAM LINE NOT BE ALLOWED TO VARY MORE THAN 1 MILIMETER IN THE VERTICAL DIRECTION. THIS ANALYSIS IS TO SHOW THAT THE SUPPORT STRUCTURE WILL MEET THIS REQUIREMENT WHEN LOADED.



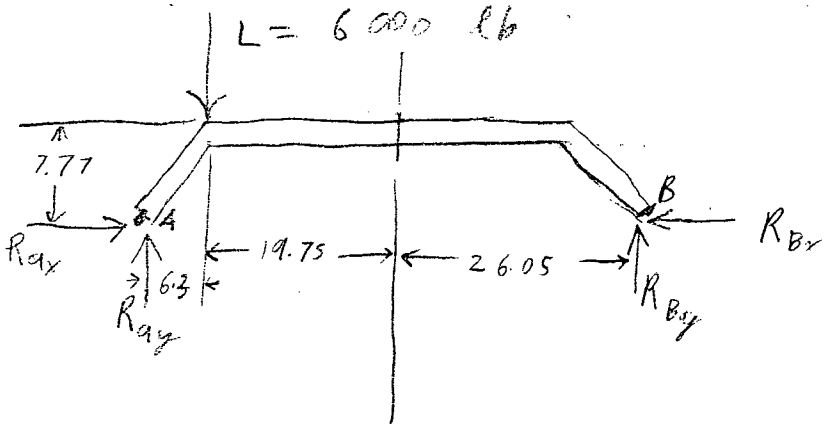
THE STRUCTURE SUPPORTS A TOTAL LOAD OF LESS THAN 6000 lb AT THE FOUR POINTS LABELED P_1, P_2, P_3, P_4.

DEFLECTION IN THE SUPPORTS



FOR THE SAKE OF SIMPLIFYING THE CALCULATIONS, THE REDUNDANT CENTER LEG IS NEGLECTED IN THIS ANALYSIS. THE REAL STRUCTURE WILL THEREFORE BE STIFFER THAN WHAT THESE CALCULATIONS SHOW.

WORST CASE: THE LOAD IS ALL AT ONE POINT.



$$\Sigma M_A$$

$$52.1\ R_{By} - 6.30\ L = 0$$

$$R_{By} = .121\ L$$

$$\Sigma F_y = 0$$

$$R_{Ay} + R_{By} - L = 0$$

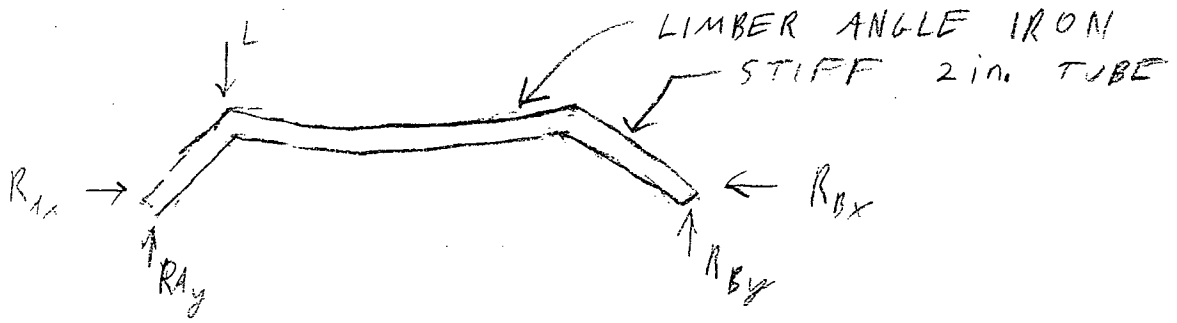
$$R_{Ay} + .121L - L = 0$$

$$R_{Ay} = .879\ L$$

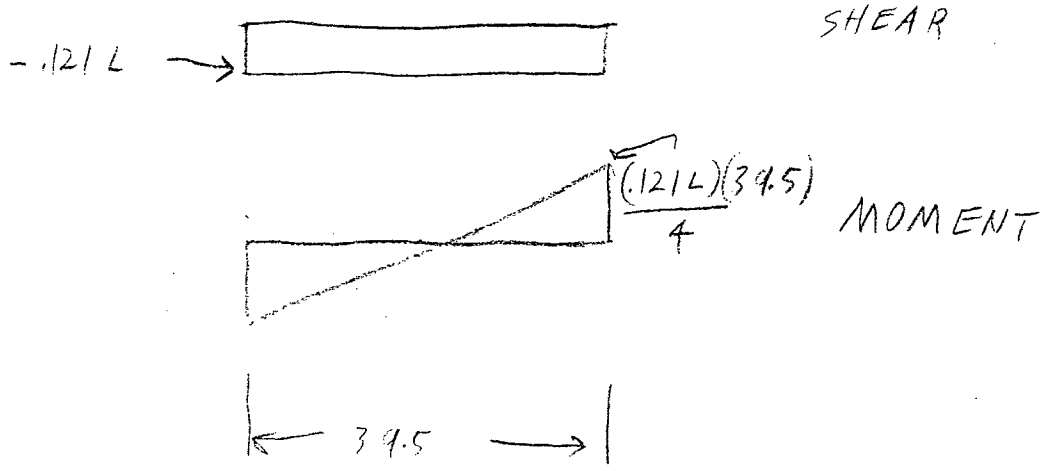
$\Sigma F_x = 0$

$R_{Ax} - R_{Bx} = 0$

$R_{Ax} = R_{Bx}$ INDETERMINATE



THE HORIZONTAL FORCES SERVE TO CREAT MOMENTS AT THE JOINTS OF THE FRAME, THAT COUNTERACT THE BENDING MOMENTS OCCURING AT THE ENDS OF THE HORIZONTAL BEAM DUE TO THE SHEAR IN THE HORIZONTAL BEAM. [THIS IS AN APROXIMATION)



THE COUNTERACTING MOMENT DUE TO THE HORIZONTAL

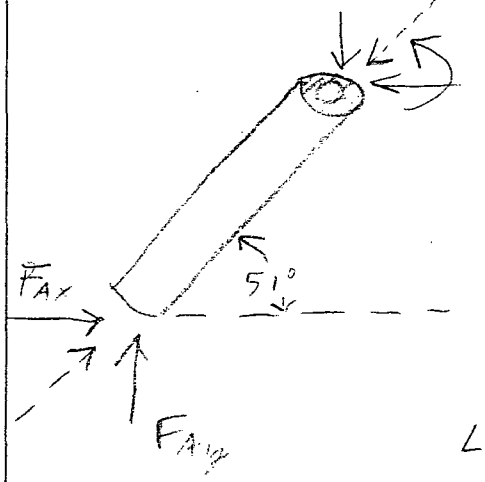
$$M = F_x (7.77)$$

$$\frac{(.121L)\,39.5}{4} = F_x\ 7.77$$

$$F_x = \frac{(.121L)\,39.5}{4\,(7.77)}$$

$$F_x = .154L$$

COMPRESSIVE LOAD ON SUPPORT TUBE

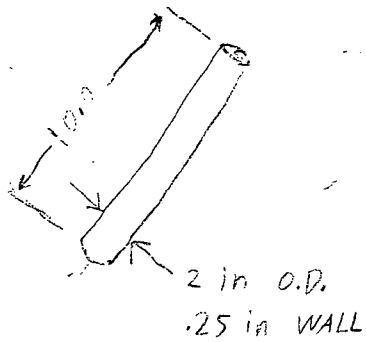


$$LOAD = F_{Ay} \sin 51 + F_{Ax} \cos 51$$

$$= .879L \sin 51 + .154L \cos 51$$

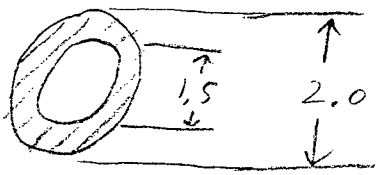
$$LOAD = .780L = .780\,(6000)$$

$$= 4680$$



THE SUPPORT TUBE

COMPRESSIVE STRESS ON THE TUBE



$$A = \pi\left(\frac{2.0}{2}\right)^2 - \pi\left(\frac{1.5}{2}\right)^2$$

$$A = 1.37 \text{ in}^2$$

$$\sigma = \frac{\text{LOAD}}{\text{AREA}} = \frac{4860}{1.37} = 3416 \text{ psi}$$

DEFLECTION OF THE SUPPORT TUBE.

δ = AXIAL DEFLECTION
ε = AXIAL STRAIN
ℓ = LENGTH OF SUPPORT

$\delta = \varepsilon \ell$ REF. ①

$\varepsilon = \frac{\sigma}{E}$ REF. ②

$E = 2.8 \times 10^7$

$$\delta = \frac{2822}{2.8 \times 10^7}(10) = .0012 \text{ in.}$$

THIS DEFLECTION IS LESS THAN $\frac{1}{10}$ mm.

THE VERTICAL COMPONENT OF THIS DEFLECTION WILL BE EVEN SMALLER.

BUCKLING OF THE SUPPORT TUBE

FIRST, THE SUPPORT TUBE MUST BE DETERMINED TO BE A "SLENDER" OR A "SHORT" COLUMN. *

IF

$$\frac{l}{r_n} < \sqrt{\frac{2\pi^2 E}{\sigma_y}}$$

THEN THE SUPPORT TUBE IS A "SHORT" COLUMN

l = SUPPORT TUBE LENGTH

$r_n = \sqrt{\frac{I}{A}}$

I = MOMENT OF INERTIA

A = CROSS SECTIONAL AREA

σ_y = YEILD STRESS

E = MODULUS OF ELASTICITY

$l = 10$ in

$I = .537\ in^4$

$A = 1.37\ in^2$

$E = 2.8 \times 10^7$ psi

$\sigma_y = 35000$ psi

$$\frac{10}{\left[\frac{.537}{1.37}\right]^{\frac{1}{2}}} \quad ? \quad \sqrt{\frac{2\pi^2 (2.8\times10^7)}{35000}}$$

$$16.0 < 125.7$$

THE SUPPORT IS A "SHORT" COLUMN

*= REF. (3)

FOR A "SHORT" COLUMN, THE CRITICAL LOAD IS GIVEN TO BE

$$\frac{P_{cr}}{A} = 6_y - \frac{1}{E}\left[\frac{6_y l}{2\pi r_n}\right]^2 \qquad \text{REF. } ④$$

P_{cr} = CRITICAL LOAD

ALL OTHER VARIABLES ARE DEFINED ON THE PREVIOUS PAGE.

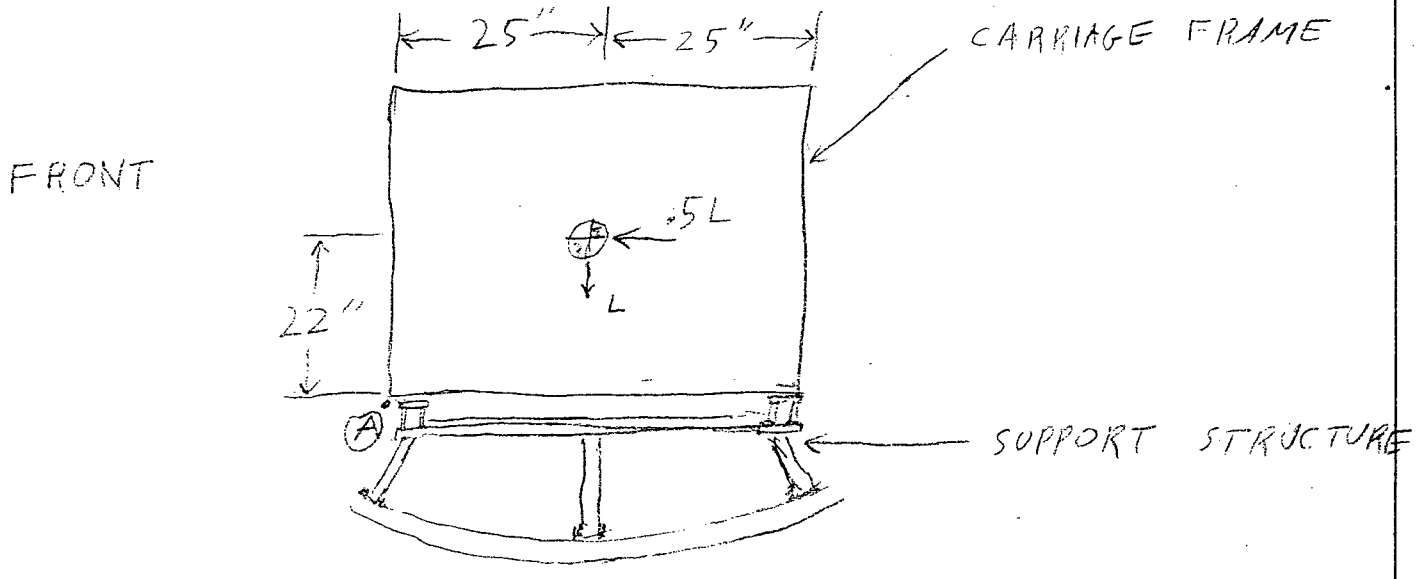
$$\frac{P_{cr}}{1.37} = 35000 - \frac{1}{2.8\times10^7}\left[\frac{35000\,(10)}{2\pi\sqrt{\frac{.537}{1.37}}}\right]^2$$

$$P_{cr} = 4.76\times10^4 \text{ lb}$$

THE GREATEST LOAD THE SUPPORT TUBE COULD SEE IS 4.68×10^3 lb. THEREFORE THE SUPPORT TUBE IS SAFE FROM BUCKLING

EARTHQUAKE LOADING

THE EARTHQUAKE LOAD IS BASED ON A .5g HORIZONTAL ACCELERATIVE FORCE ACTING AT THE CENTER OF GRAVITY AS SPECIFIED FOR L.B.L.

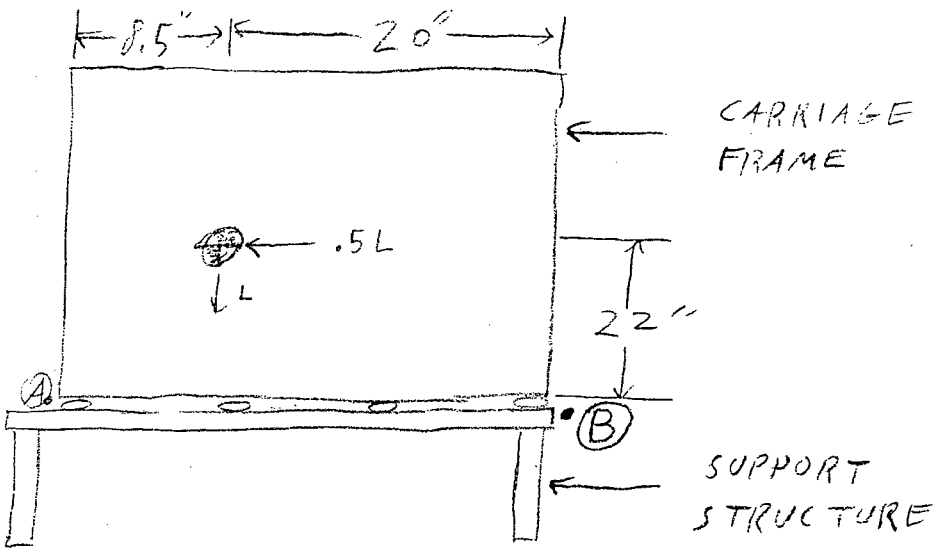


$M_A = 22(.5)L - 25L$

$M_A = -14L$

THE CARRIGE FRAME IS STABLE

SIDE



$$M_A = 22(.5)L - 8.5\,L$$

$$M_A = 2.5L$$

THE CARRIGE FRAME IS NOT STABLE IN THIS DIRECTION. IN THE EVENT OF A .5g HORIZONTAL ACCELERATION DUE TO AN EARTH QUAKE, THE CARRIGE FRAME COULD TIP FORWARD ABOUT POINT (A).

TO PREVENT THE CARRIAGE FRAME FROM OVER TURNING IN THE EVENT OF AN EARTHQUAKE, THE CARRIAGE FRAME WILL BE CLAMPED TO THE SUPPORT STRUCTURE AT POINT (B).

REFERENCES

(1) VAN VLACK, L "ELEMENTS OF MATERIAL SCIENCE", ADDISON-WESLEY PUBLISHING CO. 1964 p. 2

(2) IBID p. 3

(3) DEUTSCHMAN, A "MACHINE DESIGN" MACMILLIAN PUBLISHING Co. 1975 p. 284

(4) IBID p. 285

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