DESIGN OF A LIGHT-WEIGHT AUTOMOBILE CARRYING FREIGHT CAR

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Design of a Light-Weight Automobile Carrying Freight Car

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By

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Dedication

To people, like myself, who really get a thrill out of watching a train go by.

Probably the most neglected subject by student engineers, here at Michigan State College, is our greatest means of goods transportation, the Railroads.

In past years, railroading was what aviation is today; the top interest to most young men as far as a medium of travel.

Railroads made great strides in improvement until the first World War. Since that time, they have done little research or advancement until the end of the last war when most of their equipment had gone beyond the maintenance point and must be replaced.

In view of this fact, I have chosen this thesis title, "A Light Weight Automobile Carrying Freight Car." I chose to design this car due to the advantages this would have for the industry as a whole.

Railroads are in their infancy as far as their development. They are being forced to compete with various modes of transportation and shipping. When they drove the stagecoach from the road, they had a monopoly on land transportation until the automobile came into existence. During this period, they had no reason to purchase new equipment except to enlarge their business and profits. Then, in the twenties, trucking companies began to infringe on their traffic, and in the Depression of 1929 through 1934, many roads changed hands and failed.

Through the later thirties, up until the last war, the railroads were feeling the latest pinch of competition. This was the airplane, and it was, in most part, being used as a passenger carrier. Now, however, the airplane has also commenced to carry freight and their speed, which means time saving to the producer as well as the consumer, is only the beginning of infringement of air transportation on the revenue of the railroads.

Railroads can beat the competition if they are willing to give services to the traveller and the shipper that are equal or better than other methods of transportation. Many of the new passenger trains have improved their comfort and cleanliness and have instituted many new services to make travelling by train the most convenient. Movies, excellent diners, and playrooms for children are some of the inducements now available on a few of the new streamliners; yet, they have more things to do that will help put the railroads ahead.

The main thing to improve upon at present is speed. During the last twenty to thirty years, little advancement in speed has taken place. Trains in 1920 were travelling at approximately sixty miles an hour; today, the streamliners average about fifty-five to sixty-five miles an hour. Little or no change whatsoever has taken place.

To increase their speed, there is the need for rail improvement; the use of heavier rail, straighter and easier curves, and more gentle grades. All of these are slowly being done on the major roads. Before the war, I read an article stating that it would take one hundred thousand men, working five eight hour days for twenty years, to bring the standard of all railroads up to the present most advanced system. That was before the war when the trains were not being run around the clock seven days a week as they have been doing for the last eight years.

With the track and roadbed improvement designed for travel at one hundred and fifty miles an hour, the trains could actually compete with air travel and shipping, and outmode a great deal of the long distance trucking.

The biggest asset a railroad has is convenience. It has, with little exception, its stations in the heart of the cities because railroads have been the main means of transportation since our country began to enlarge. Airports are usually ten to twenty miles from the city and an hour is lost on both ends of a trip. Travelling by air is also more expensive. Short hops by air are not economical to operate, and the present day railroads can easily compete within a radius of three hundred miles.

If trains were travelling at 150 miles per hour, they could eliminate the airplane on short hauls because of the convenience, safety, and cost. Faster trains need lighter cars, and along this line of thought, the aluminum-fabricated cars have developed. Lightness means less dead load which is the main item that railroads are interested in at present. The lowering of the dead load would increase efficiency of the engine and would lower operation costs.

Railroad men are, generally, keenly aware of the fact that the average pay load in freight cars tends to decrease steadily. If the pay load, the amount of weight carried as paying freight is going to continue to decrease, the weight of the dead load will also have to decrease accordingly.

Car loads have decreased as follows:

29.3 tons per car in 1920

25.6 tons per car in 1933

27.1 tons per car in 1937

20.1 tons per car in 1946

This decrease can only mean that some radical design changes must be forthcoming and that they are coming soon.

In general, cars that are in service today are made of 16, 000 pound steel. This is low strength steel as compared with the steels of today. During the last war, the steel industry was called upon to develope steels that would withstand as much as 150,000 pounds per square inch; however, at this time, the cost of this chrome steel is mcuh too expensive to even consider for freight car construction.

The steel industry has developed a new high strength and corrosion resistant steel with many easy fabricating properties and low cost. This steel is called Mayari-R, and it has a minimum tensile strength of 70,000 pounds per square inch and a yield point of 50,000 pounds per square inch with an endurance limit equal to the yield point. This was developed by the Bethlehem Steel Company. In this design, it will be used for the main undercarriage construction.

Another weight saving device is to weld the members together thereby eliminating the flanges, laps, and the rivet heads. By using the Unionmelt continuous, an automatic process developed by OxWeld Railroad Service Company, you have numerous advantages. The joint is stronger than the parent plates which eliminates one of the detrimental reasons why welding has been frowned upon for so many years. For many years, welders who were not qualified to do uniform work have held back the use of welding in railroad construction. Now, with the development of machines to do the same work, it is accepted practice.

Another advantage of welding is the water tightness feature. This not only eliminates a lot of corrosion, but it tends to lessen the chances of damage due to to moisture getting to the merchandise inside the car. Railroads loose a great deal of money due to water damage caused by loose joints.

Still another is the advantage of stresses being distributed over a greater area eliminating the concentration due to riveting.

Welding can be used on most any thickness and sections of the panels can easily be removed and hand-welded new ones put in their place.

One thing must be remembered in car construction, as in any other work where repair and replacement is necessary, and that is the ability to remove parts and replace or repair with the minimum cost. Frequently this is impossible and makes the whole unit of no value or the cost of replacement so expensive that it would have been cheaper to buy a new unit.

The first all aluminum freight cars were built in 1931, by the Canton Car Company and were placed in service in the aluminum industry in the middle west. These cars are now sixteen years old and have shown no evidence of wear or tear from service. However, there was some evidence of electrolytic corrosion between dissimilar aluminum alloys which was principally due to the use of steel rivets. A great deal of research has been done on aluminum freight cars by the Reynolds Car Manufacturing

Company.

For the design of freight cars, the engineer has a number of alloys to choose from, but he is usually in doubt which alloy will be best suited for a particular part of the car.

The alloys recommended for load carrying framing are, in the order of preference; 17 S-T, R 361-T, and R 361-W. Alloys 17 S-T and R 361-T have strength equal to that of Open Hearth Steel, and should be used wherever no severe offsetting or forming is required.

R 361-W is recommended for parts requiring severe offsetting or forming. The strength of R 361-W is about one half of the strength of R 361-T or 17 S-T, and if aluminum parts are designed to equal deflection of similar steel parts, usually, the stresses will be low enough to use R 361-W. When the maximum strength is required, then the formed shapes can be age hardened to R 361-T.

For outside sheathing of cars, aluminum alloys that are recommended are, in the order of preference: R 301-T, R 301-W, R 301-O, R 361-T, and R 361-O. Alloys in "T" temper should not be sed for parts without severe bends or flanges, and then only used when proper bend radii can be used. For parts requiring flanging and some forming, "W" temper alloys should be used. For parts requiring severe forming combined with draw, "O" temper, which is in the annealed state, should be used. In all cases, an aluminum service engineer should be consulted for information as to the exact types of metal to use.

All this reduction of dead load leads to the main purpose of this thesis. That is that one of the services that is being completley neglected by the railroads today is the problem of passenger transportation after the train destination has been reached. In this complex life of ours, it is necessary that a traveller, upon reaching the station nearest his destination to use public transportation to continue on his way. Frequently upon reaching said station, it is necessary to go many additional miles by bus or taxi. This inconvenience and expense could be easily eliminated by transporting the automobile on the same train with the passenger. It is from this idea, that this thesis has grown.

Not altogether a new idea to the world, I thought I had hit upon an untried thing, but the Hungarian National Railway had a few cars converted to carry a car in the baggage car for the same purpose; however, my idea deals with the carrying of four automobiles in one freight car.

This car is designed to be simply loaded eliminating layover time which tends to raise the cost of shipping. It is designed to be placed at the head end of passenger trains, directly behind the engine, so that ease in unloading can be utilized. On this idea, the end loading system has come. Instead of the conventional type of side loading, the ends of the box car can be two doors that swing to each side which eliminates the need of turning dollys.

During the war, the army used to transport all of their larger equipment on flat cars. This was done by running them from one flat car to the next merely by placing planks between the decks of each successive one. This idea is incorporated in my car with the addition of a regular top and sides to conform to the standard passenger designs.

Side loading, or standard methods, are at this time the only accepted method in general use; however, the end loading method has the advantage of driving right up a ramp to the deck of the car and right on without the chance of damage through attempting a treacherous turn.

Also along this line, the railroad would need attendents for end-loading to do the driving of the cars on and off the train. With sideloading also, it is nearly impossible to use more than the floor, but with the end loading, two decks are easily accessible because of the ease of entry.

Similar to the autohauler trailer, this car can carry two cars on each deck, allowing ample room for each automobile. Simple channels are used as ramps and are easily carried with the freight car. All of this leads to savings for the railroad that can be passed on to the traveller.

The cost of present freight car service, over a period of a year, is from one to five mils per ton per mile. From this rate, we can see that our car will be about half as heavy as standard cars. For convenience, we use one mil per ton per mile. This would mean that the railroads are doing the service for cost, which is impractical, but we can use this as an illustration.

A trip from Detroit, Michigan, to Buffalo, New York, a distance of 250 miles will be used as a comparison to show the difference between driving and the use of this freight car.

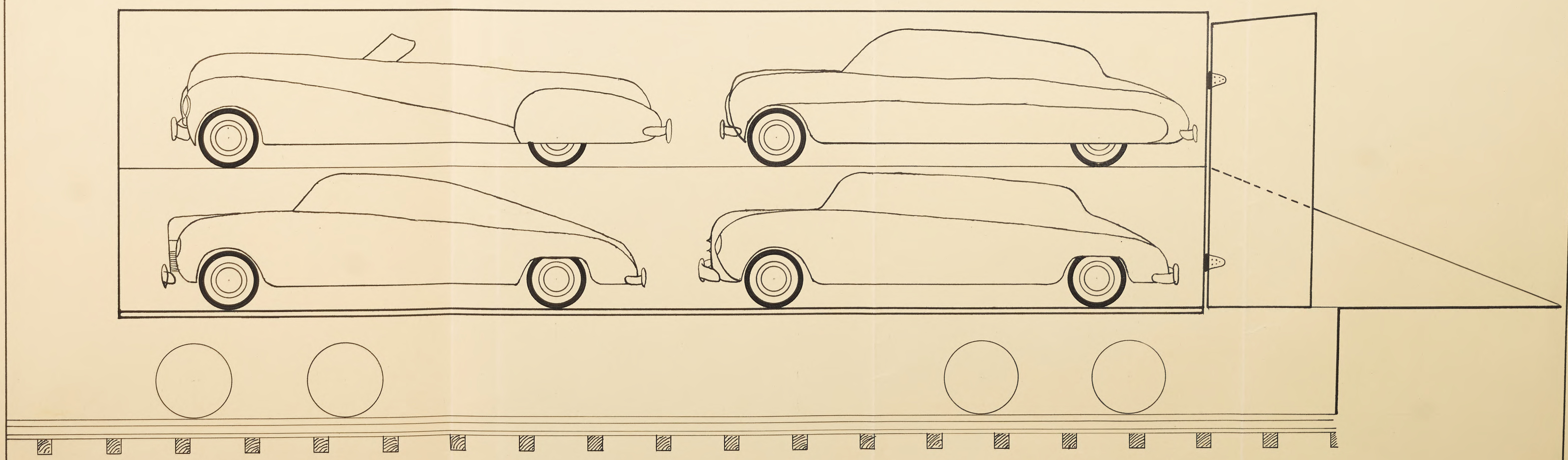
We are allowing two tons for the standard automobile. The weight of the freight car is 30,000# and 16,000# or twenty-three tons total; therefore, the cost to the railroad, to include the auto-carrier car in the train, would be five dollars and seventy-five cents($5.75). If this were put in as a service to the passengers, it would be about one dollar and twenty cents($1.20).

From Highway Economics, it is learned that you can not operate an automobile for less than seven cents a mile. This includes all depreciation, cost of operation, taxes, and insurance. This would mean a cost of seventeen dollars and fifty cents($17.50). In comparison to the cost of the carrier car, there would be a saving of sixteen dollars and thirty cents($16.30) which would be a great encouragement to drivers to use the service offered by the trains.

Besides a saving in monetary values, there is the safety value a person gets by using rail transportation. Railroads have been sited for their record of safety for years.

All the facts presented are the reasons why this idea helped to convince me that there is not only a need for this car, but this service would help increase passenger traffic and lessen traffic accidents by lessing traffic on the highways. Everyone would be more relaxed upon arriving at their destination because of the lack of driving fatigue. Besides these reasons, the financial savings and time savings would more than make their project worth trying.

40'-6" AUTO-CARRYING FREIGHT CAR



METHOD OF PLACEMENT OF CARS

SPECIFICATIONS

General Dimensions:

Distance c/c of Body Bolsters	30'-10"
Height inside	11'-0"
Height of Door Opening	11'-0"
Height of Top of Rail to Center of Couplers	2'-10½"
Total Height, top of Rail to Roof	15'-00"
Height, top of Rail to Floor	3'-7 3/4"
Length inside	40'-6"
Length inside to inside Coupler Knuckles	44' -4"
Length over end sills	40'-10"
Truck wheelbase	5'-6"
Width over side plates	9'-10"
Width inside	9'-2"
Width over roof eaves	9'-4 3/8"

Material:

All materials covered by A.A.R. specifications shall conform thereto.

The following aluminum alloys shall be used:

Outside sheathing	R-301-W
Shapes	17 S-T
Follower Blocks	R -303-T
Rivets	A-17 S-T
Plates	R-301-c & R-301-W

Safety Appliances:

The number, dimensions, locations, and manner of application to be in accordance with the Interstate Commerce Commission orders and A.A.R. requirements.

Welding:

All welding to be automatic by the OxWeld Railroad Service Company process.

Center Sills:

Two 12 7/8" - 31.3# 36,000 psi Steel Standard center sill sections, spaced 12 7/8" apart, extending full length of the car from striker to striker, welded.

Side Sills:

Aluminum angles 6" x3½" x 5/16" - 3.49# alloy 17 S-T, extending full length of the car and reinforced at bolster with ¼" channel shaped bent steel plate.

End Sills:

6" x3½"x 5/16" - 3.49# alloy 17 S-T aluminum angles extending full width of the car and welded to center sill.

Bolsters:

Built up type of alloy steel plates. Top and Bottom pans 5/16" alloy steel with edges joined by continious weld and secured to center sill by welding. 5/16" alloy steel tpp cover plate extends over center sills and is welded to the bolster pans. Bottom bolster pan reinforced over side bearing with 4 3/4" x 5/16" pressed alloy steel channel welded in place as specified by A.A.R. Standard requirements.

Crossties:

3/16" pressed alloy steel diaphram flanged 2 3/4" all around and securely fasted to center sill and side sill.

Diagonal Braces:

¼" pressed aluminum plate, alloy R-301-W welded to side and end sill at one end and to 5/16" pressed steel gusset welded to center sill.

Coupling Device:

Standard A.A.R. coupling.

Braking:

Standard Westinghouse Air Brakes with braking power

to be 75% of light weight of car based on fifty pounds per square inch cylinder pressure.

Side Plates:

3/16" thick aluminum plate weighing 2.69# per foot, alloy 17 S -T.

Side Posts:

Thirty per car special aluminum, 17 S-T, 3" 4.05# per foot "Z" section 5/16" web with flanges 7/16" and 9/16" thick.

Corner Posts:

Special aluminum, 17 S-T, "W" sections with ½" web and 9/16" flanges, weighing 4.06# per foot.

Track Channels:

Four standard channels, 12" x 4" weighing 35.5# per foot, 40' long.

Deck beams:

Nine standard 4" x 2 5/8" "I" section weighing 7.7# per foot.

End Doors:

Four hinged doors made of ½" thick aluminum plate

alloy 17 S-T weighing 3.59# per foot.

Roof:

Murphy aluminum (.072) welded roof as manufactured by the Standard Railway Manufacturing Company.

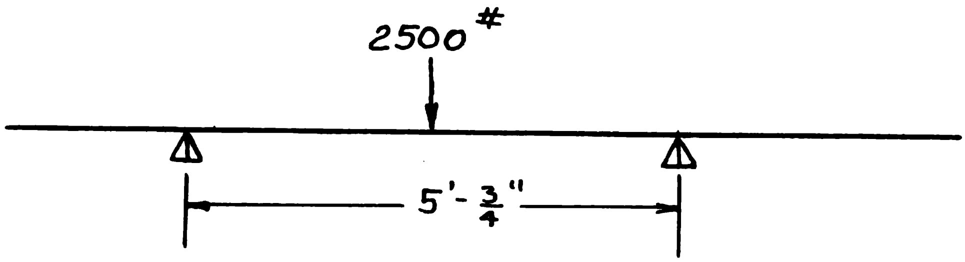
Flooring:

Tongue and groove 1 3/4" x 5 1/16" face yellow pine fastened to underframe with clips as manufactured by the MacLean-Fogg Company.

Spark Shields:

Black Iron #18 gauge to be nailed to the bottom of the floor over wheels to meet Interstate Commerce Commission safety appliance rules that requires car operating in passanger service to have.

TRACK CHANNEL



P = 2500# per wheel

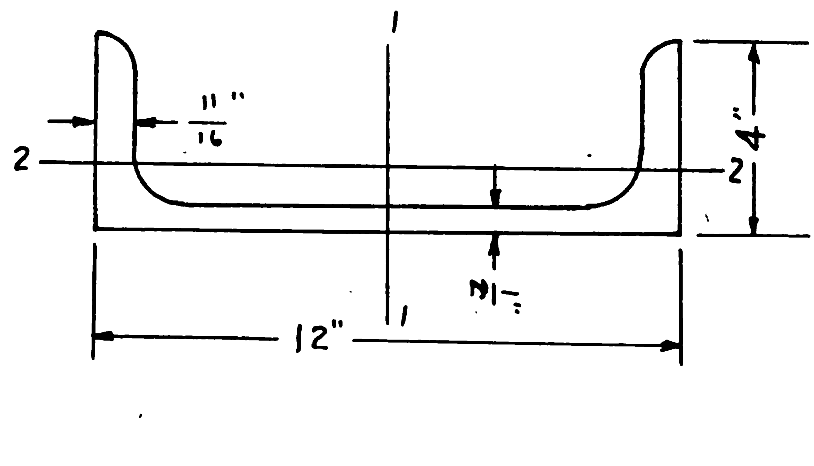
Max. Moment = $\frac{Pl}{4} = \frac{2500\,(60.75)}{4}$ = 38000 in. lb.

Z needed = 1.9

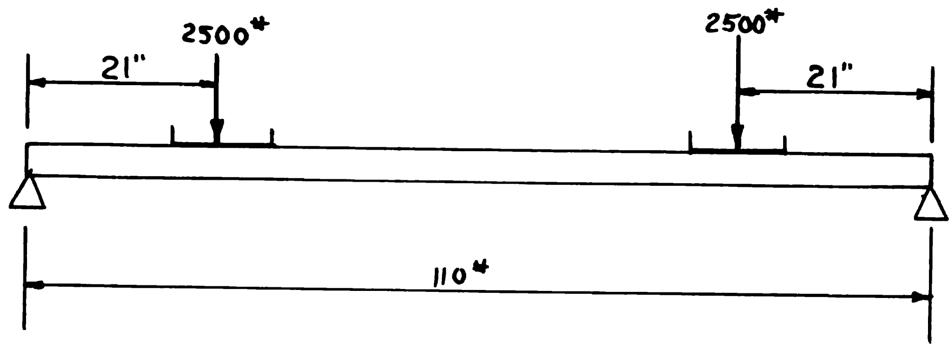
12" x 4" Channel

WEIGHT - 35.5 lbs/ft.

	Axis 1-1	Axis 2-2
I =	214.9	12.9
Z =	35.8	4.8



DECK BEAM



Allow 2500# per wheel, a Factor of Safety to give $2\frac{1}{2}$ times the actual load to take into consideration the vibration and inertia effect for the rounding curves.

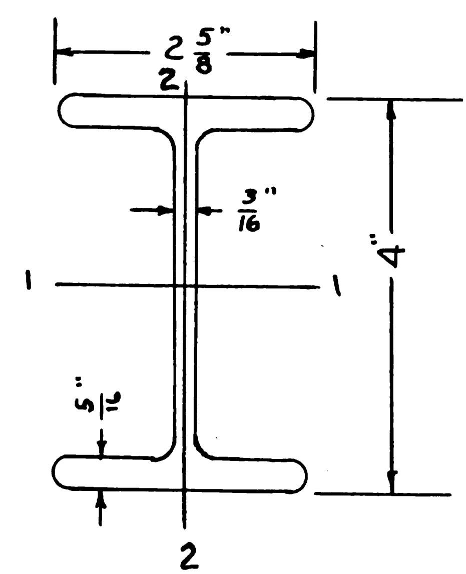
CRITICAL SECTION

$$Z = \frac{Pa}{f_s} = \frac{2500\,(21)}{20{,}000} = 2.6$$

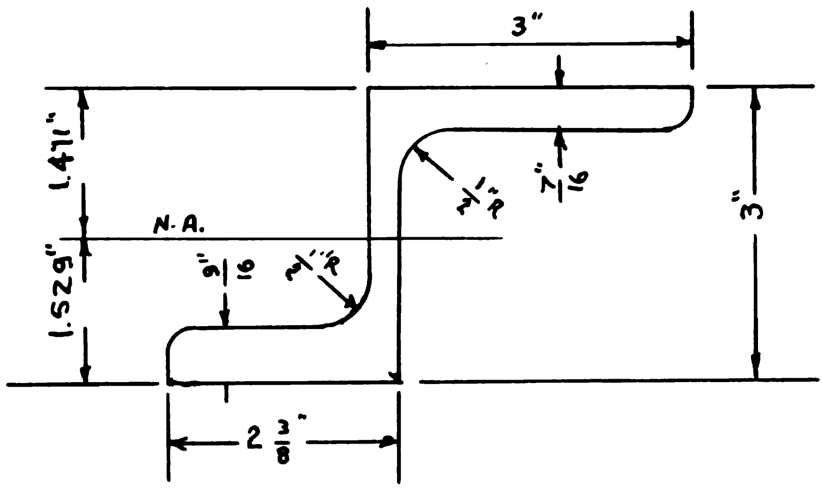
AREA = 2.21 sq in

WEIGHT = 7.7 #/ft.

	Axis 1-1	Axis 2-2
I =	6.0	0.77
Z =	3.0	0.58



SIDE POST



ALUMINUM 17S-T

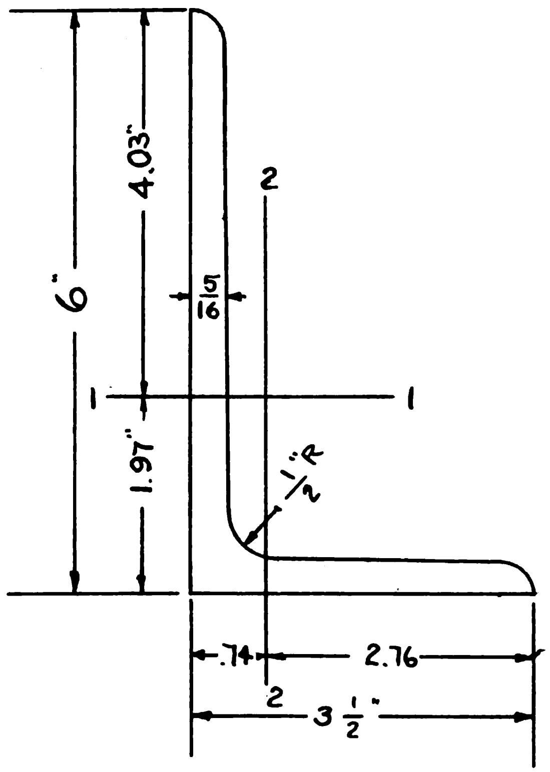
AREA = 3.35 sq in.

WEIGHT = 4.05#/ft.

I = 4.45

Z = 3.02

SIDE SILL

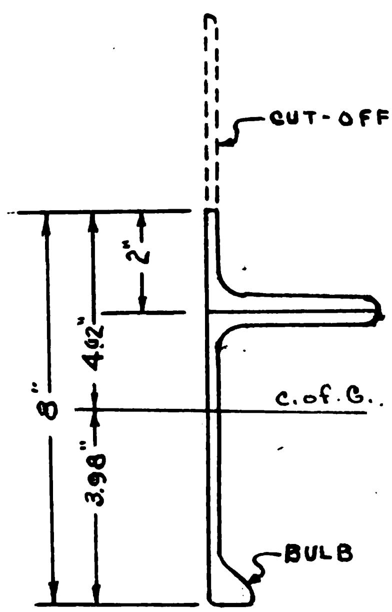


ALUMINUM 17S-T

AREA = 2.88 sq. in.

WEIGHT = 3.49#/ft.

	Axis 1-1	Axis 2-2
I	10.64	2.70
Z	2.64	0.98

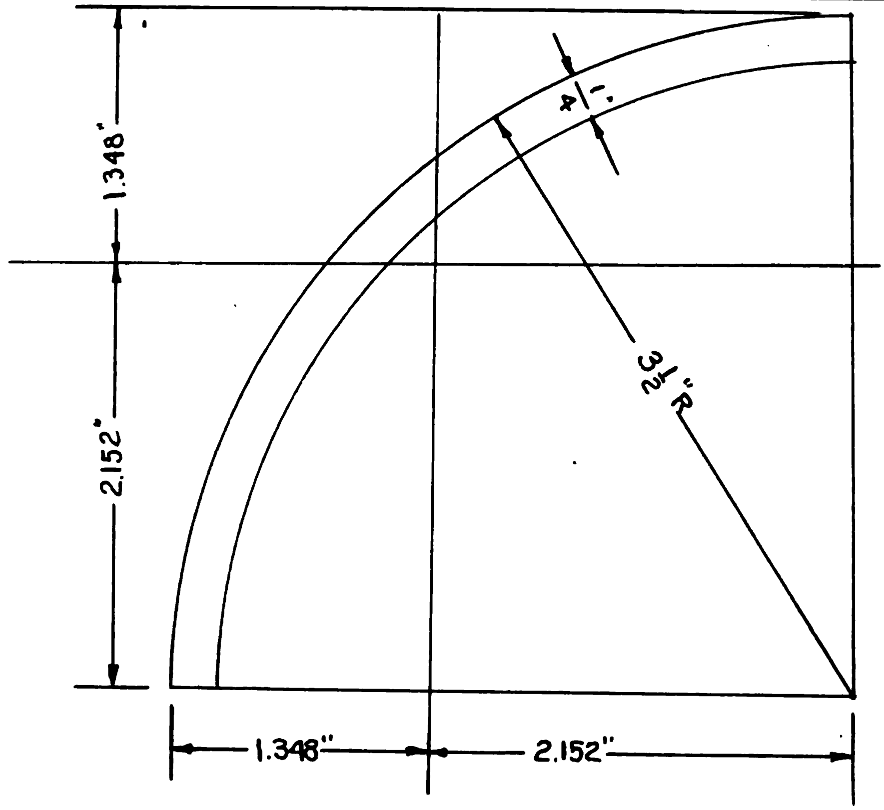


AREA = 10.76 sq in.

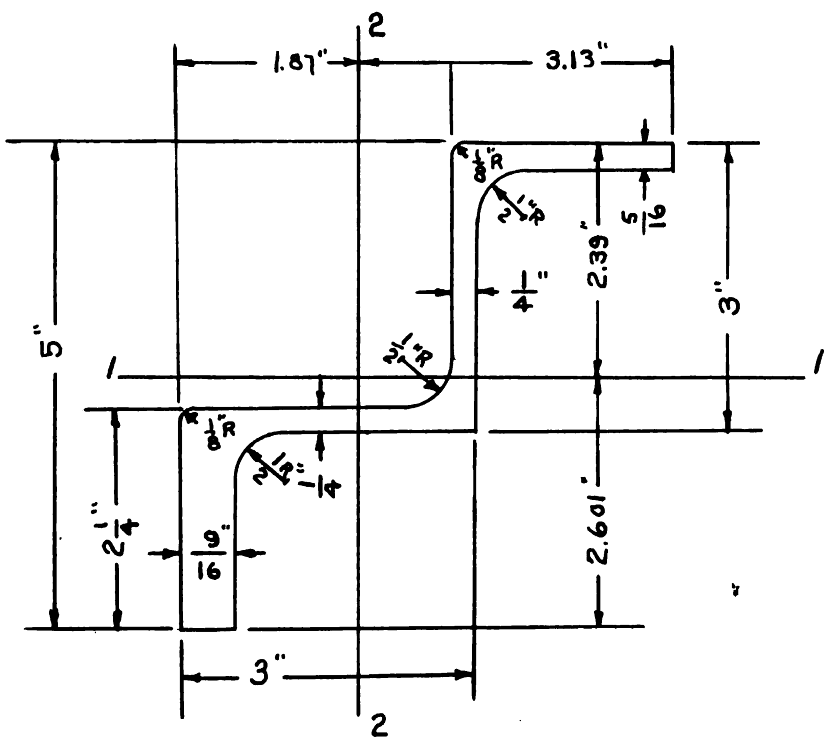
I = 55.40

NOTE:- AREA OF STEEL TO AREA OF ALUMINUM BY RATIO - $\frac{300}{103}$

CORNER POST SECT.



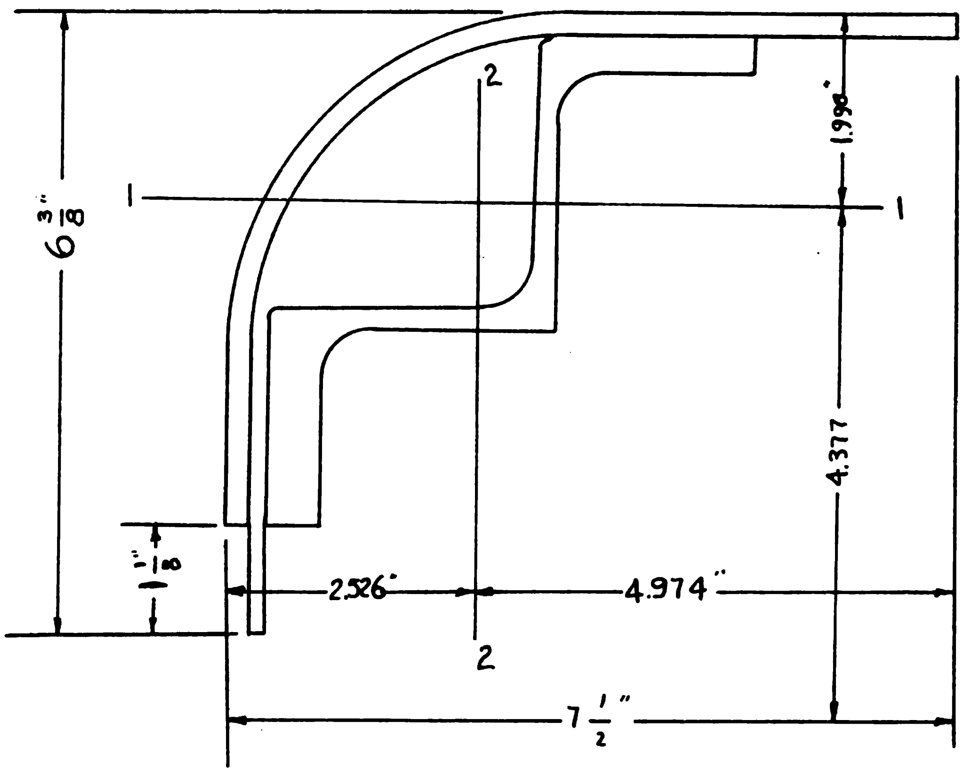
AREA = 1.325 sq in.
I = 1.414



ALUMINUM 17S-T
AREA = 3.35 sq.in.
WEIGHT = 4.06#/ft

	Axis 1-1	Axis 2-2
I =	7.98	7.45
Z =	3.07	2.39
Z =	3.33	3.99

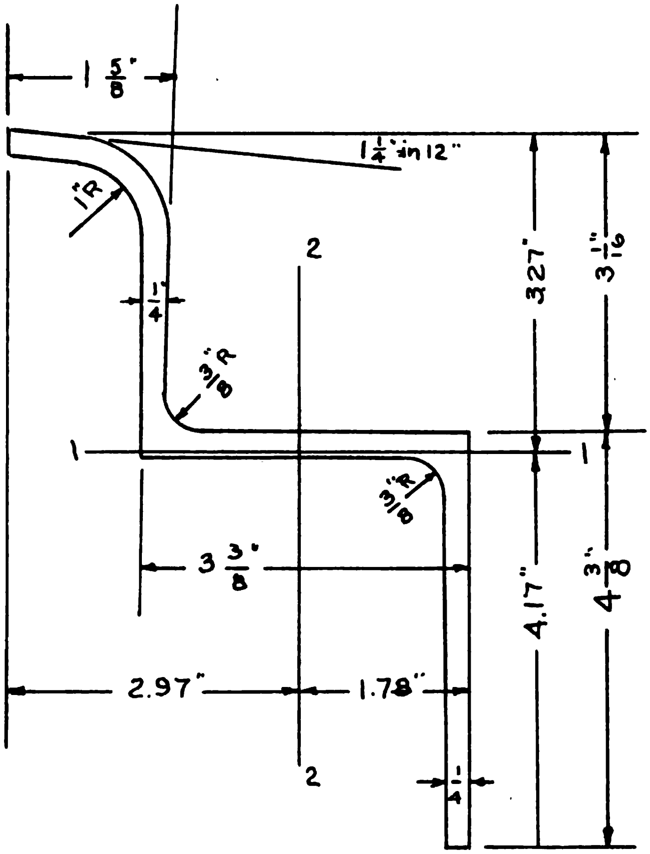
CORNER POST



AREA = 5.27 sq in.

	Axis 1-1	Axis 2-2
I =	15.52	20.64
Z =	3.54	4.15
Z =	7.76	8.17

SIDE PLATE



ALUMINUM 17S-T

AREA 2.96 sq in.

WEIGHT 3.59 #/ft.

	Axis 1-1	Axis 2-2
I =	11.26	6.94
Z =	2.70	2.34

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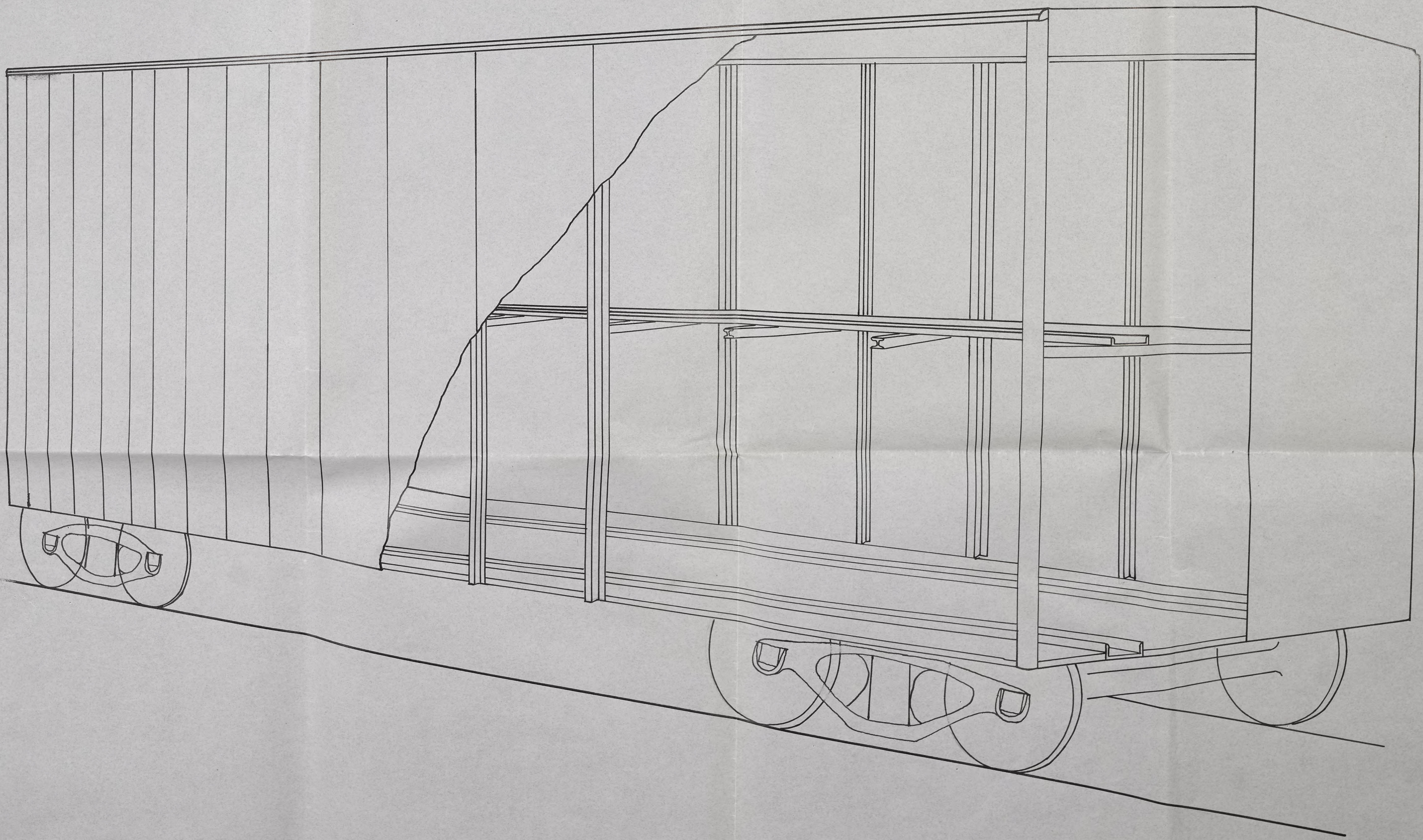

A SECTION OF AUTO-CARRYING FREIGHT CAR

J.B. STEVENS

Pocket has: 1 Drawing

126
868
THS
Draw

:5
:4