HMS

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SESSION WORKSHOP PRESENTATIONS

"APPLICATION OF THE DRAGNET VEHICLE ARRESTING BARRIER TO MOVABLE BRIDGES"

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Application of the Dragnet Vehicle Arresting Barrier to Movable Bridges

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INTRODUCTION

All movable bridges use some sort of barrier or gate to warn motorists that the bridge is open and unsafe to cross. Despite this practice, there are still fatalities and serious injuries which result from motorists who ignore or circumvent these barriers. Other impenetrable barriers, which cannot be circumvented, have been employed, but this type brings the errant vehicle to an abrupt and sudden stop with great potential for serious injury to the motorists.

With the objective of combining an impenetrable barrier which is forgiving and offers little or no risk of injury or serious damage to the errant vehicle, the Florida Department of Transportation has contracted with Roadway Safety Service, Inc. to provide a Dragnet Vehicle Arresting Barrier at both ends of the Main Street Bridge in Jacksonville, Florida.

This paper will describe the device and document its installation on the bridge during a recent overhaul of the structure.

THE DRAGNET SYSTEM

The Dragnet Vehicle Arresting Barrier System is patented and manufactured by the Entwistle Company of Hudson, Massachusetts, a major supplier of products and technology for the various branches of the US. Armed Forces. The system is an outgrowth of the crash nets formerly used on aircraft carriers.

It has seen widespread use in the United States to safely stop passenger vehicles from intruding into perilous areas such as construction zones, open drawbridges, reversible traffic lanes, railroad crossings, emergency road closures, etc. It is designed to stop errant vehicles with very low accelerations and minimal damage. A typical system, shown in Figure 1, consists of a net made of a continuous steel cable and chain link fence attached at each end to energy absorbers. The energy absorbers are supported by anchor posts that are embedded into the pavement or the road shoulder or attached to longitudinal barriers. These energy absorbers, which are the heart of the Dragnet System, are steel chambers containing a series of staggered rollers around which a long length of metal tape or strap is bent back and forth as it is pulled through this deformation chamber. Each end of the net is attached to one end of these metal tapes protruding from the energy absorber case. A cut-a-way view of the device is shown in Figure 2. A photograph is included as Figure 3. These energy absorbers are designed so that a specific force is required to pull the tape through the chamber. This force is constant and not dependent on the impact velocity or environmental conditions. It is rather a function of the geometry and the material properties of the tape material. Basically, the capability of the system to absorb kinetic energy is the product of the restraining force of both energy absorbers and the runout distance of the metal tapes.

Equation 1 $C = T(R_1 + R_2)$

where
C = capacity of Dragnet
T = pullout force of one energy absorber
R_1 = runout distance of left side absorber
R_2 = runout distance of right side absorber

Dragnet System absorber units are rated first by the amount of force needed to initiate pull of the tape. The absorber units are provided in differing lengths as follows:

RATED PULL OUT FORCE	TAPE LENGTH
4,500 pounds (20.016 kilonewtons)	75 feet (22.86 meters)
4,500 pounds (20.016 kilonewtons)	200 feet (60.96 meters)
18,000 pounds (80.064 kilonewtons)	40 feet (12.19 meters)
25,000 pounds (111.20 kilonewtons)	100 feet (30.44 meters)

As there is one absorber at each end of the fence or net assembly, a hit automatically activates both absorbers. Therefore, to calculate total capacity, the combined energy force of two absorbers must be used. By reference to Equation 1, we can then determine the attenuating capacities for these standard units as follows:

2 Units of 4500 lbs with 75 foot tapes.............675,000 ft lbs (915.132 kn m)
2 Units of 4500 lbs with 200 foot tapes.......1,800,000 ft lbs (2440.351 kn m)
2 Units of 18,000 lbs with 40 foot tapes.......1,440,000 ft lbs (1951.960 kn m)
2 Units of 25,000 lbs with 100 foot tapes.. .5,000,000 ft lbs (6778.753 kn.m)

By equating these capacities to the kinetic energy of an impacting vehicle we can calculate the maximum permissible impact velocity of a given weight car. This has been done for a range of vehicles in Table 1 for the 4500 lb Energy Absorber with 75 foot tapes and in Table 2 for the 4500 lb Energy Absorber with 200 foot tapes. Tables 1A and 2A report the same data in the metric system. It should be noted that these values are somewhat conservative since only the restraining for of the tapes has been considered effective in stopping the vehicle. Other factors such as tire friction, braking, and aerodynamic drag have been ignored.

The maximum theoretical acceleration is simply the restraining force in the tapes divided by the weight of the vehicle and can only be approached when the tapes are parallel to the velocity vector of the impacting vehicle. Initial accelerations are much lower as indicated in the schematic of Figure 4.

The Dragnet System has been extensively tested for a wide variety of vehicle weights up to speeds of 70 mph (112.7 km/hr) and it impact angles up to 30°. Many in-service reports have substantiated the excellent performance of the Dragnet system in the field.

THE MAIN STREET BRIDGE

Since this was FDOT's first experience with the use of the Dragnet on a drawbridge, the specifications were very general in nature. They specified the location where the barrier was to be erected and the vertical clearance desired. The performance requirements were that the Dragnet be capable of bringing passenger vehicles ranging from 2250 lbs to 4500 lbs to a safe stop in 75 feet or less. It was also required that the barrier could be raised or lowered in ten seconds.

The design of the Main Street Bridge (see Figure 5), made the Dragnet installation a fairly simple matter. There was more than enough room to affix the net within the bridge superstructure and still provide more than 75 feet of runout before coming to the movable section. Figure 6 is a schematic which shows the connection of the mechanism to the bridge.

The Dragnet restraint forces when the system is impacted is only 4500 pounds. When the net is down, the load is taken by an 1.75 inch diameter steel pin integral with the hoistable carriage which contains the energy absorber. This pin is inserted into the high-strength steel base which houses the drive mechanism.

Photographs of the net, the uprights, and carriage assemblies are shown in Figures 7 and 8. The protective covering on the lower portion of the uprights is not installed in these photos. In Figures 9 and 10 the carriage is shown in the lowered position with some of the protective structure in place. The net is counterbalanced by weights which are contained in the upright posts. Each carriage is driven by its own fractional horsepower electric motor and drive assembly. Figures 10 and 11 show the interior of the base boxes which contain these mechanisms. Limit switches provide proper positioning of the net in the raised or lowered position.

The Dragnet electrical system is tied to the bridge raising-lowering electrical system so that the operation is completely automatic. In the event of a power failure, the Dragnet is easily raised or lowered by a manual crank.

CONCLUSION

The Dragnet was fabricated, assembled, and tested off-site and shipped to Jacksonville where it was installed on the bridge with no glitches. This particular design is easily adapted to any bridge where the superstructure permits locating the net at least seventy-five to one hundred feet from the movable section. With the addition of a horizontal bridge between the two vertical uprights, the design can be adapted to any bridge.

While there have not yet been any impacts on the Main Street Bridge, we believe we have achieved FDOT's objectives of providing an impenetrable barrier which is completely safe for passenger car impacts.

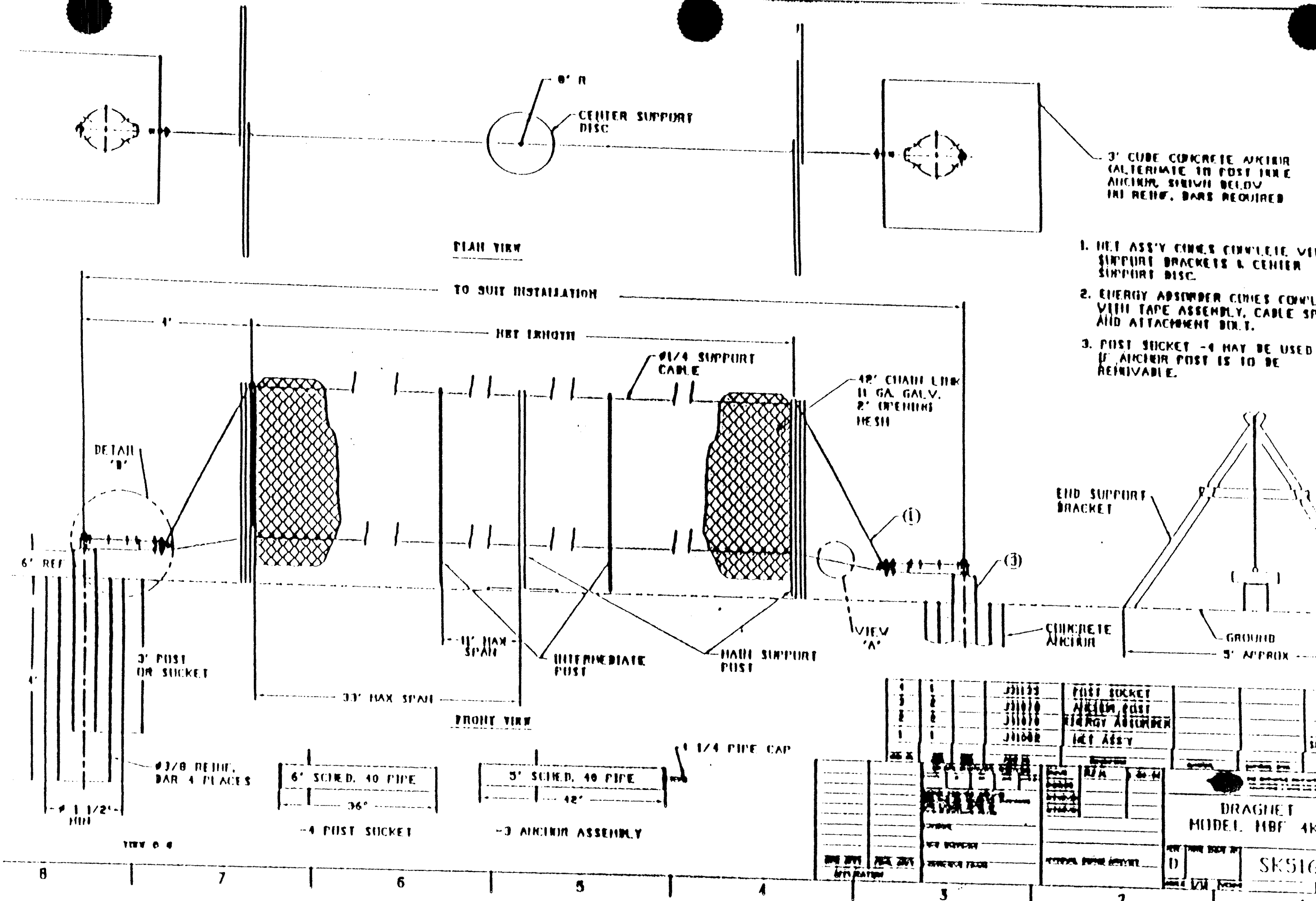

Figure 1 – Typical Dragnet System

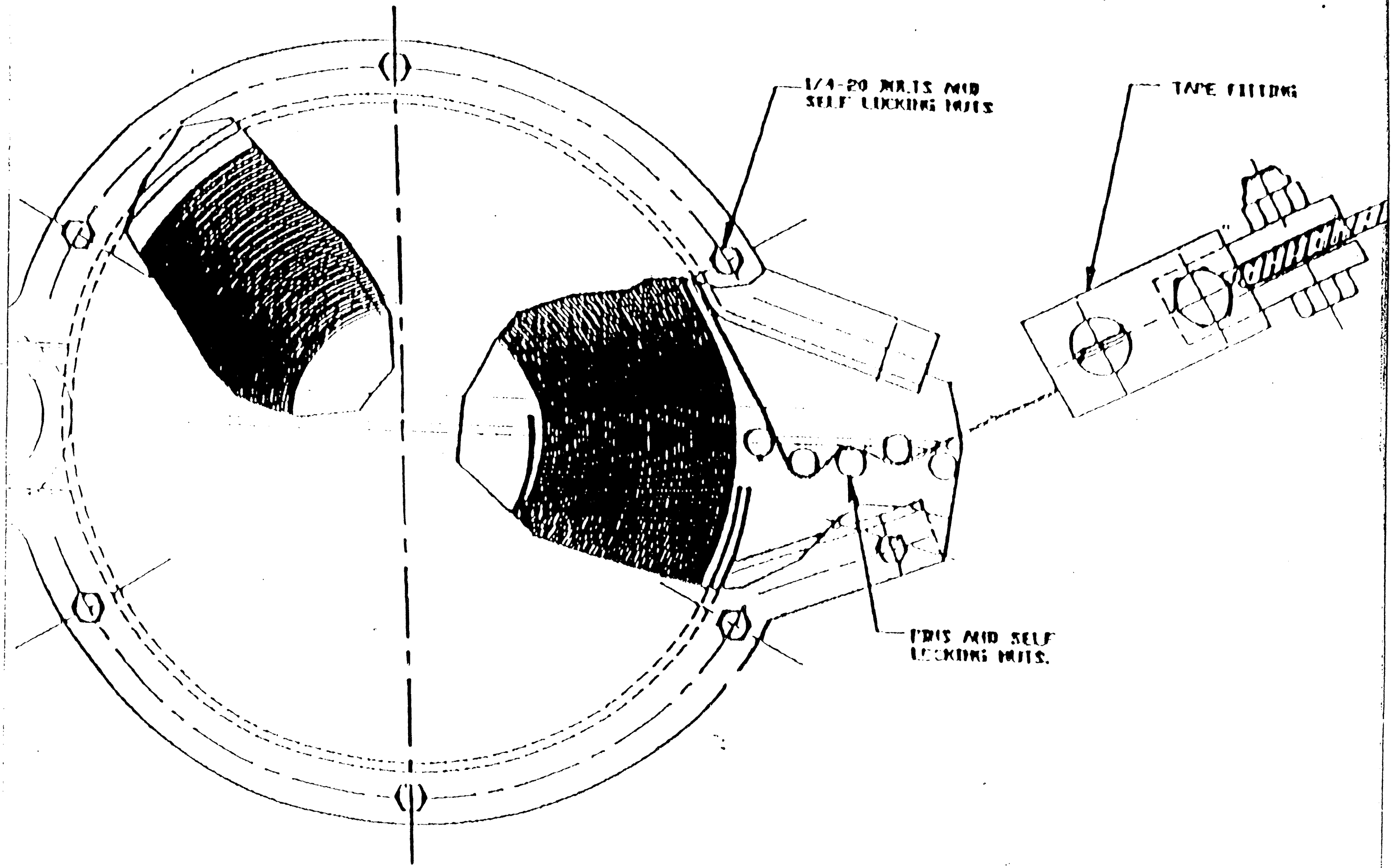

Figure 2 – Cut-a-way View of Energy Absorber

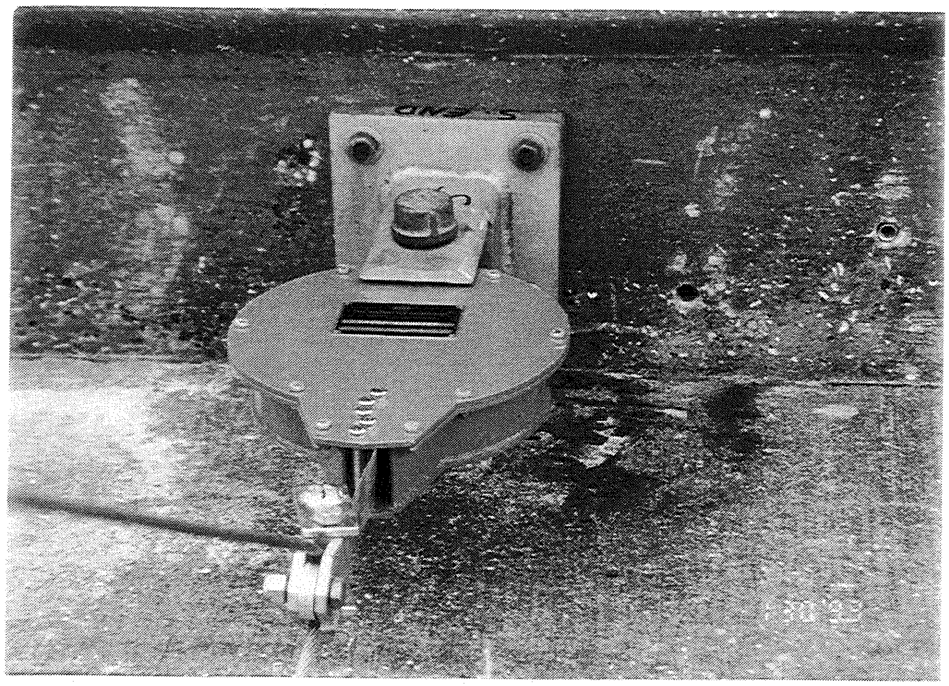

FIGURE 3- PHOTO OF ENERGY ABSORBER

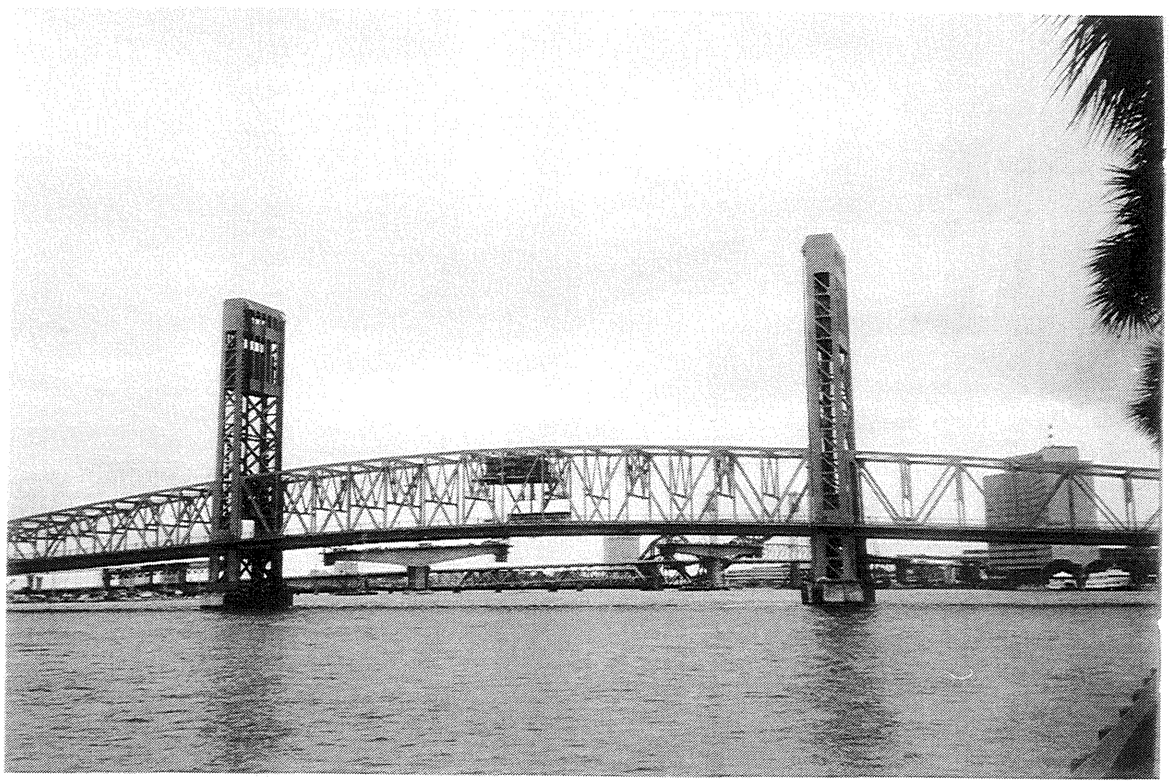

FIGURE 5- THE MAIN STREET BRIDGE

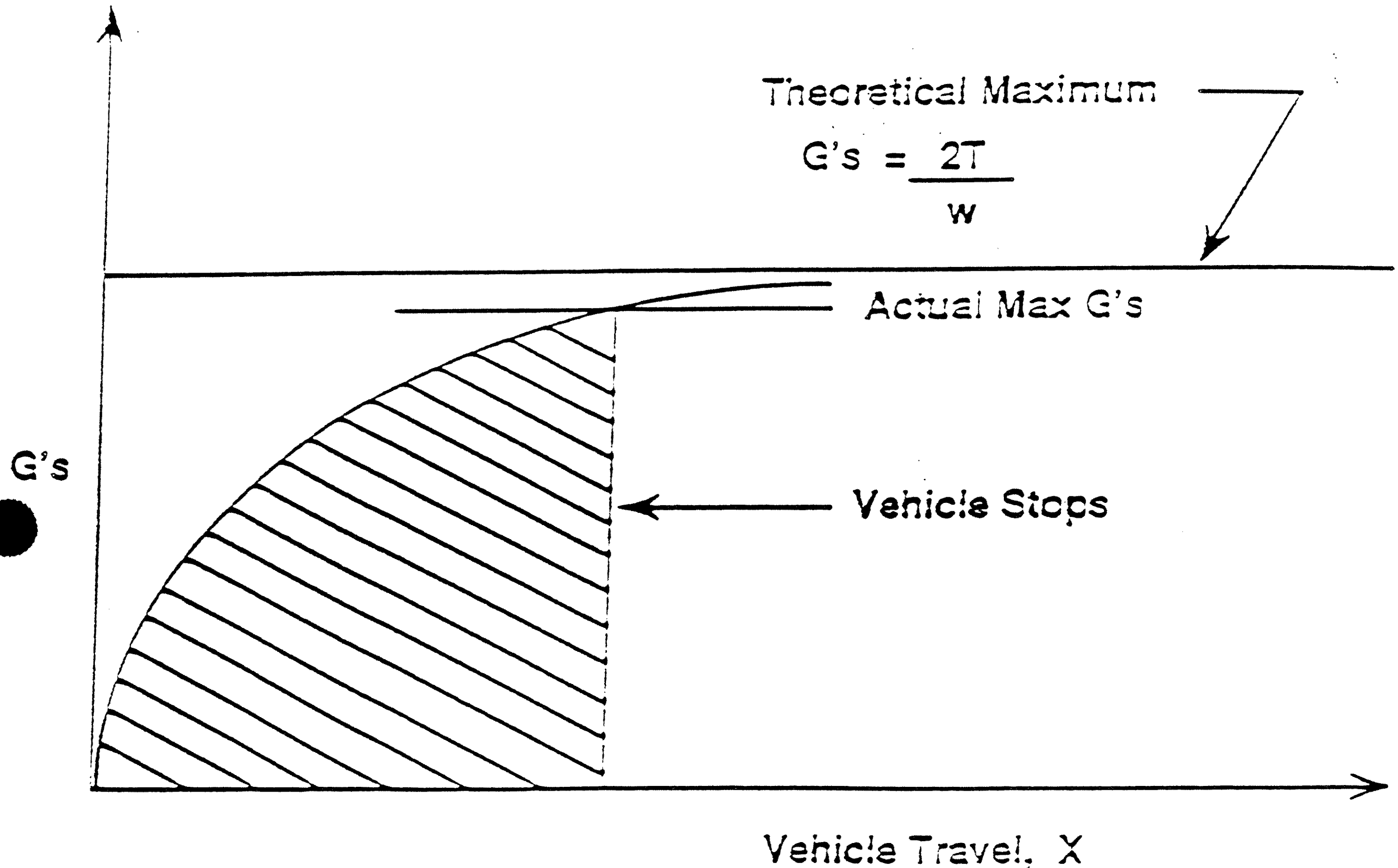

Figure 4 — Schematic of "G" onset as a function of distance travelled.

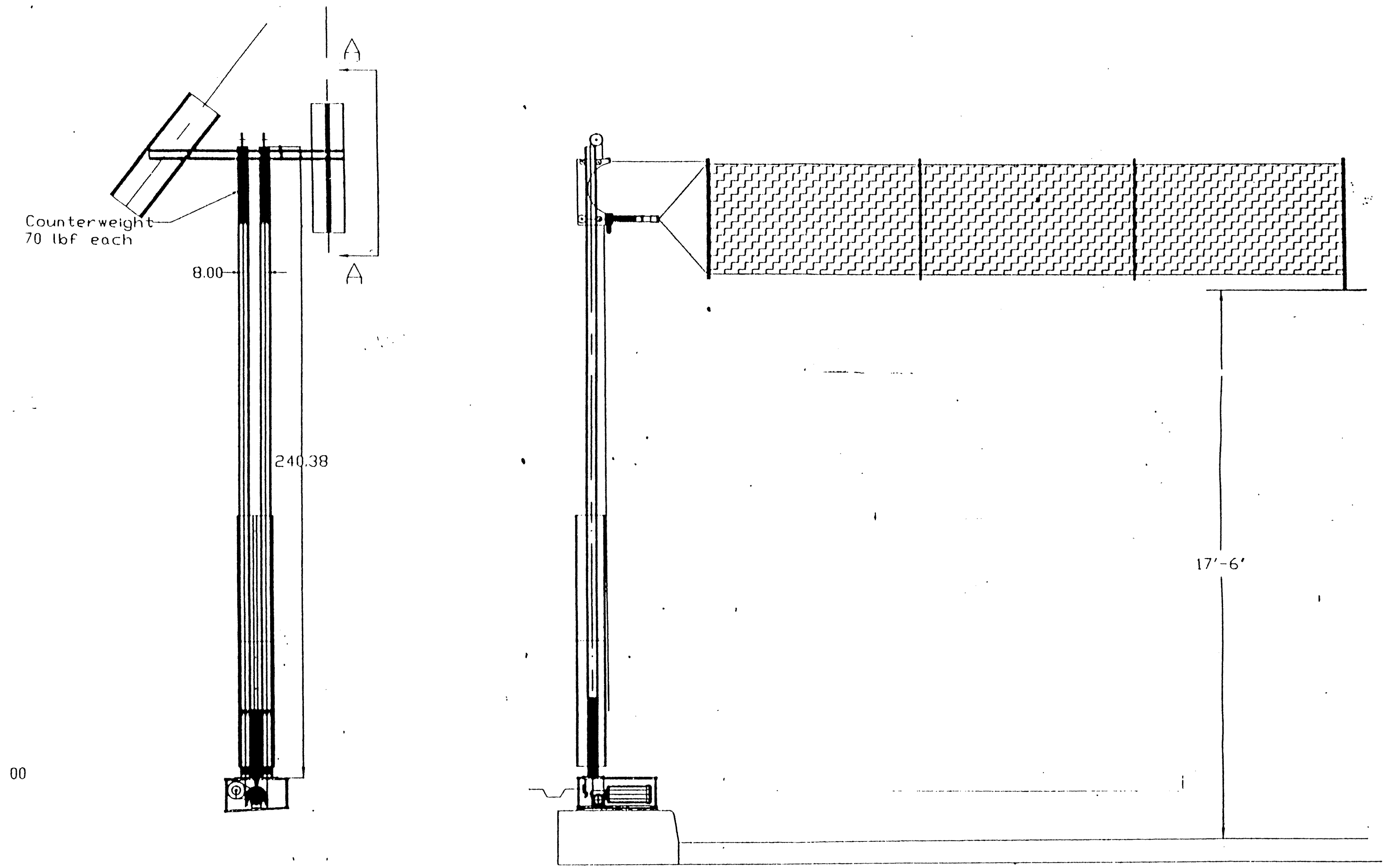

FIGURE 6- SCHEMATIC OF DRAGNET INSTALLATION WITHIN SUPERSTRUCTURE

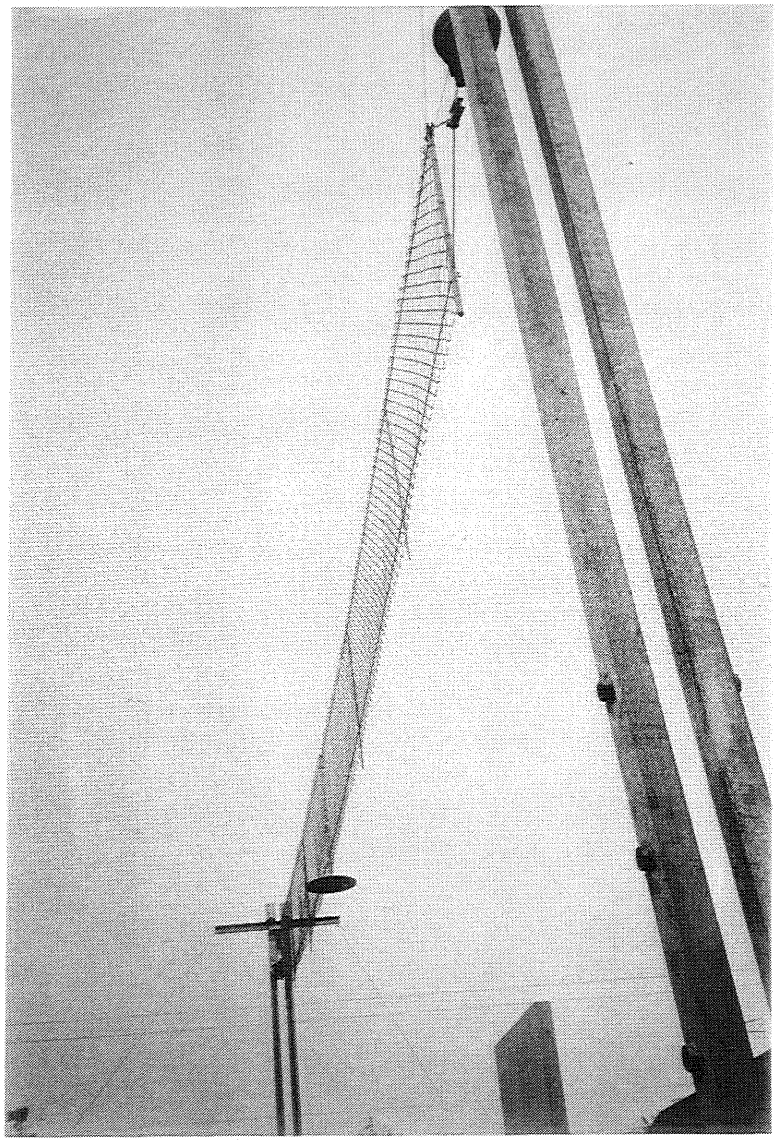

FIGURE 7 - DRAGNET IN RAISED POSITION
DURING TESTING

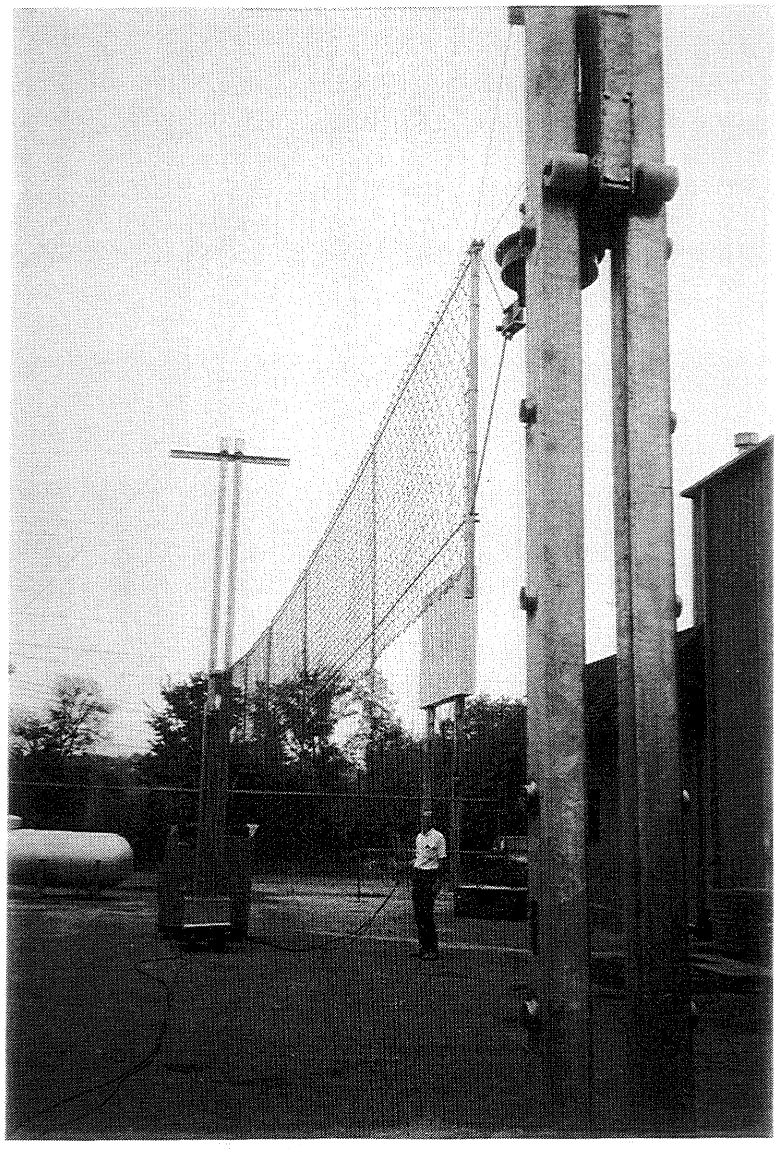

FIGURE 8- DRAGNET PROTOTYPE APPROACHING CLOSED POSITION

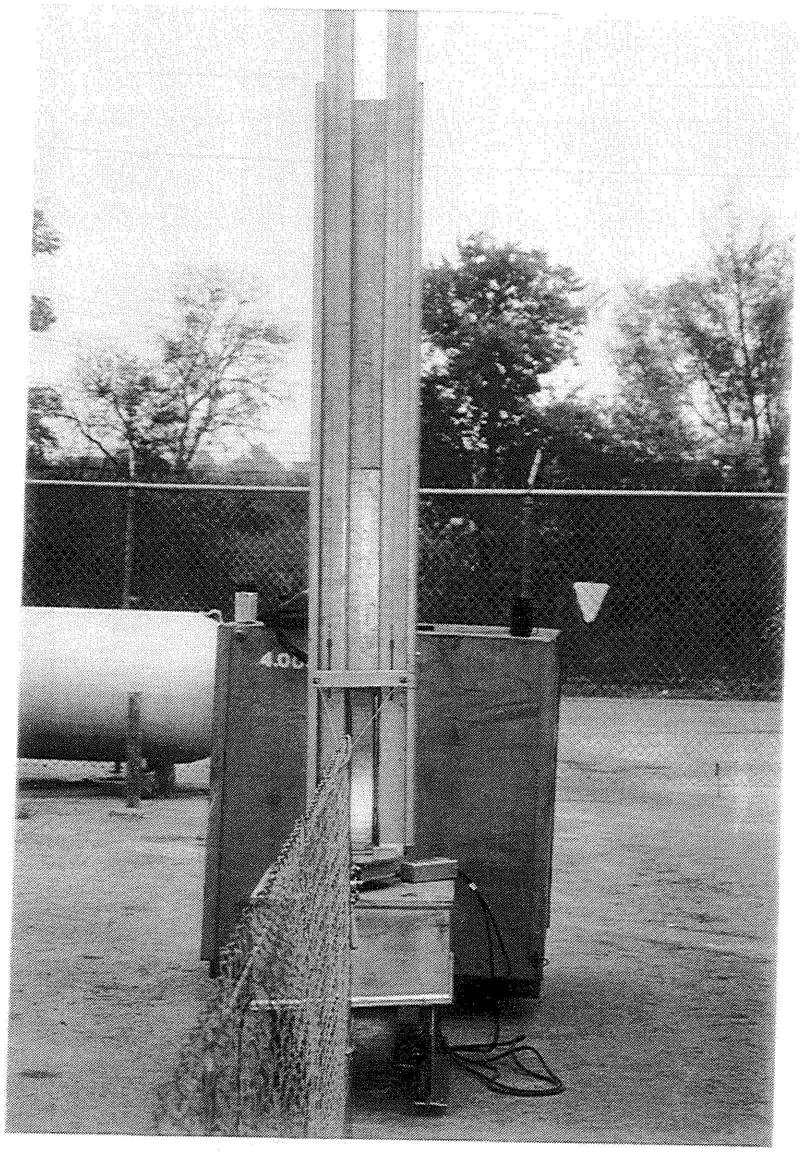

FIGURE 9 - VERTICAL POSTS WITH SAFETY ENCLOSURE

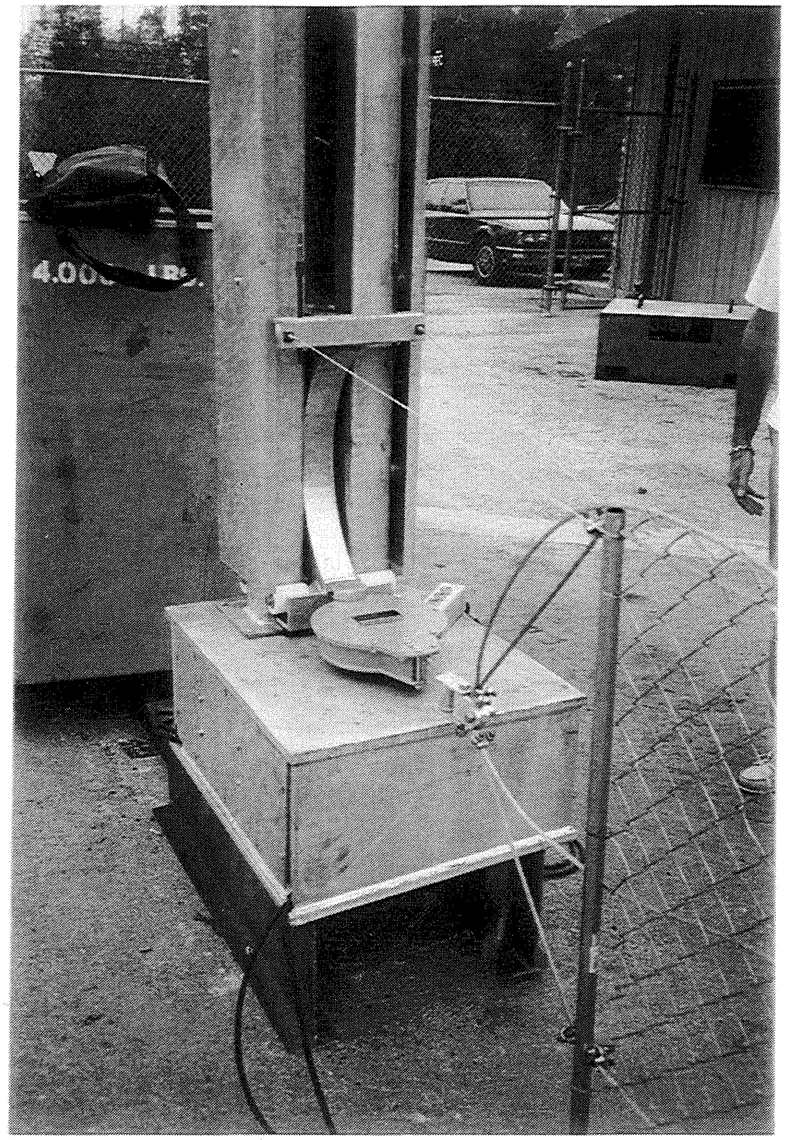

FIGURE 10 - CLOSE-UP OF CARRIAGE IN LOWERED POSITION

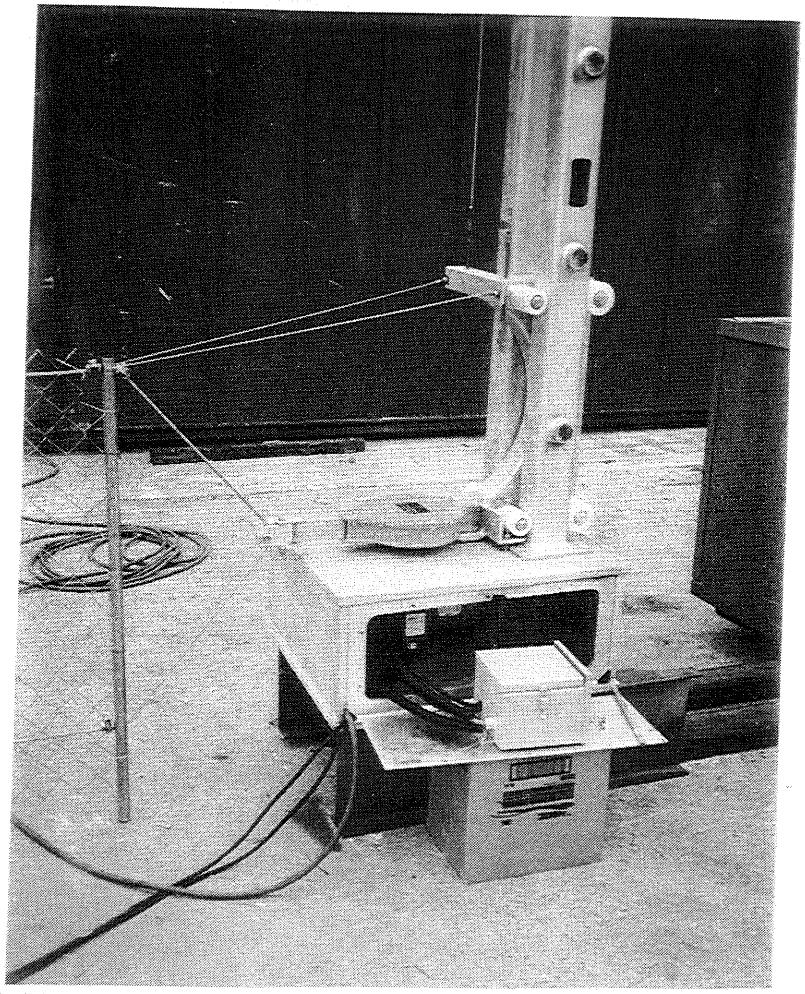

FIGURE 11 - BASE HOUSING WITH ACCESS DOOR OPEN

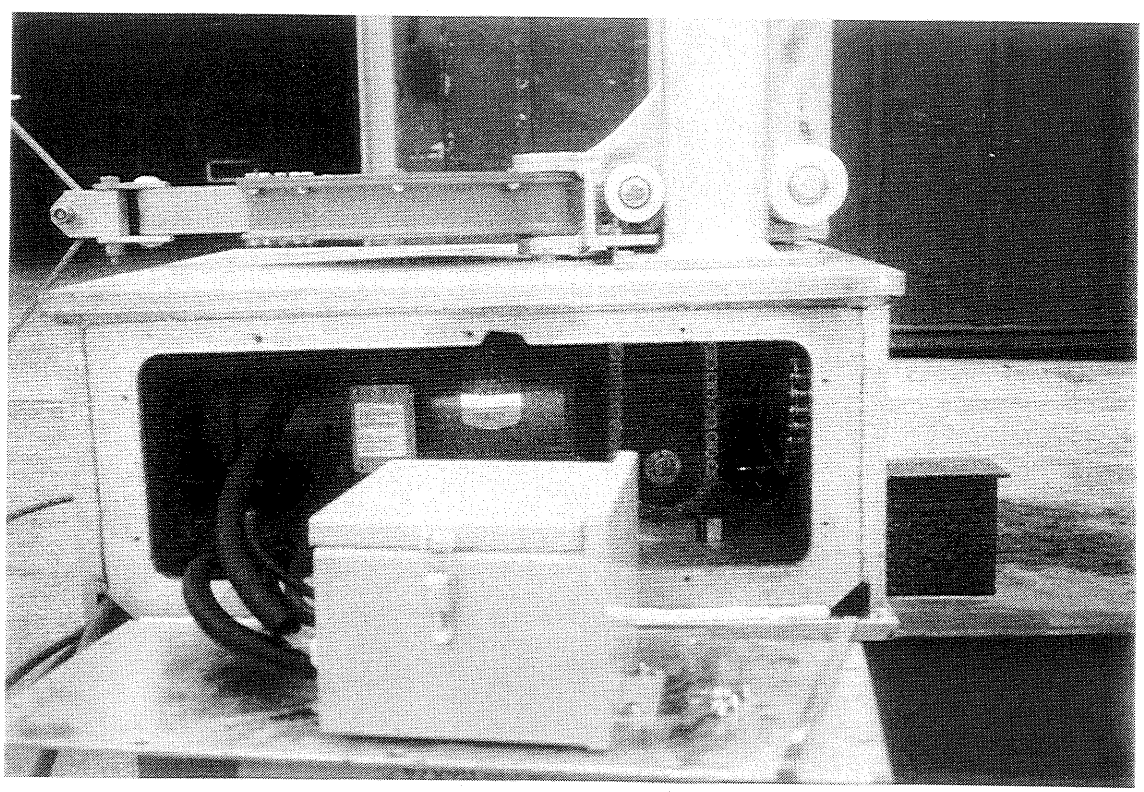

FIGURE 12 - CLOSE-UP OF MOTOR-DRIVE MECHANISM