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"STRAIN GAGE METHOD FOR CLUTCH ADJUSTMENT OF VERTICAL LIFT BRIDGES"

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STRAIN GAGE METHOD FOR CLUTCH ADJUSTMENT OF VERTICAL LIFT BRIDGES

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MECHANICAL SECTION

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TABLE OF CONTENTS

I DESCRIPTION OF THE BRIDGE

Roosevelt Island Bridge is a tower drive vertical lift type bridge spanning the East Channel of the East River between Roosevelt Island (New York City) and the borough of Queens. The length of the span is 418 feet supporting a roadway (34 feet wide) and a sidewalk (6 feet wide). The bridge was open to traffic in 1955. The bridge is operated infrequently. Fig. 1 shows the bridge location. For convenience of description the bridge is considered to be oriented East - West.

II DESCRIPTION OF THE MECHANICAL MACHINERY

Each corner of the lift span is suspended from wire ropes which are looped over sheaves located at the top of corresponding corners of the towers. The other ends of the ropes are attached to the main counterweights. At each tower there is one main counterweight. There are also two auxiliary counterweights for balancing the weight of the main ropes. Raising and lowering the span is accomplished by rotating the sheaves. The sheaves are rotated by the tower drives located on the top of each tower. (see Fig. 2, 3, and 4).

Each drive (see Fig. 5) has two normal motors (125 HP,AC) and two emergency motors (30 HP,AC). One of the two normal motors is used for driving while the other is part of the syncro-tie system which keeps the moving span level in the longitudinal direction. Both the normal and the emergency motors are coupled to the same parallel shaft gear reducer but at different locations in it's gear train. The emergency motors and their extra gear sets are decoupled and are stationary when the lift span is driven by the normal motors. The decoupling (or coupling) of the emergency drive is achieved by means of an electro-mechanical clutch. The emergency drive is used in the event of the malfunctioning of the normal system.

A spring set, thruster released brake is installed at each non-drive end of the double extended motor shafts. These are designated as motor brakes. The main parallel shaft reducer has two output shafts. On each of these extensions is mounted an electro-mechanically operated clutch (see Fig. 5 and 6). These clutches, called warping clutches, are intended to be used when the leveling of the end of the movable span in the direction transverse to the centerline of the bridge is necessary. From here down along the "driving line" on each side of the parallel gear reducer is a friction type torque coupling (controlled torque coupling), a shaft, "a machinery brake" and another gear reducer (open type). This last open gear reducer is made up by two sets of parallel gears, the second set being the final "pinion and rack assembly". The rack is a segmented ring gear bolted to a flange of a main counterweight sheave. The main counterweight sheave shafts are supported by sleeve bearings. A selsyn height indicator is driven from this shaft. The span stabilizing system, in addition to the main counterweights, has four auxiliary counterweights, two at each tower. The system also at each tower. The system also has centering devices and span locks, live load supports and air buffers. The moveable span, during a rising or lowering, is prevented to move longitudinally or laterally by a system of rollers and guides.

III DESCRIPTION OF THE MEASUREMENT

The imbalance of the Roosevelt Island Bridge was experimentally measured using the electrical resistance strain gage method on July 28 and July 29/93.

The gages were installed in a Full Wheatstone Bridge configuration. This circuit cancels any strain produced from shaft bending, compression/tension or direct shear. It is also temperature compensated and produces four times the output of a single gage.

The July 28 measurement was done for the west end, while the July 29 test determined the imbalance of the east end of the bridge. A two channel amplifier/conditioner and recorder were used for each of the two tests. The original scope of the test was to investigate the existing state of balance of the bridge and to compare the acquired data with the original design numbers and normally accepted values for bridges of this type. During the test performed at the east end of the bridge some unexpected results were obtained.

It should be mentioned here that this type of bridge does not have a differential mechanism. Because of the lack of the differential mechanism, the way the load/torque is shared between the two final transmission shafts of the bridge lifting mechanism when rising or lowering the bridge span, depends mainly on the accuracy of the adjustment of the warping clutches and controlled torque couplings "inserted" in the transmission line. The equalization of the load is in fact a proper geometrical alignment of the rack and pinion assemblies achieved by means of above mentioned clutches. This geometrical alignment should preferably be done under load. Therefore, prior to making any measurements, the proper alignment of the rack and pinion assemblies was performed. To achieve the alignment the following procedure was employed: (see Fig. 5).

(1) The left side warping coupling was disengaged by using its own electro-mechanical mechanism.
(2) The motor brakes and the right machinery brake were manually released.
(3) A heavy-duty pipe wrench was attached to the hub of the coupling installed on the main electrical motor shaft.
(4) Using the pipe wrench a known torque was applied to the transmission (right side), in the direction that would raise the bridge's span.
(5) With "the torque in place" the right side machinery brake was manually set.

(6) The torque "was removed" by releasing the wrench.
(7) The motor brakes were manually set.
(8) The left side warping clutch was engaged.
(9) The right side warping clutch was disengaged by using its own electro-mechanical mechanism.
(10) The motor brakes and the left machinery brake were manually released.
(11) Using the pipe wrench a known torque was applied to the transmission (left side). The torque had the same value and direction as for the right side.
(12) With "the torque in place" manually set the left side machinery brake.
(13) The torque "was removed" by removing the wrench.
(14) The right warping clutch was engaged.
(15) The motor brakes were manually set.

Due to the steps undertaken above, the components of the lifting machinery from the machinery brakes to the main cable sheaves were equally stressed.

As a result, when the motor starts to rotate to move the bridge in the upward direction, the motor torque is equally shared by both lifting sheaves located on the same tower. All these adjustments being made we proceeded to perform the actual test by lifting and lowering the bridge several times. The recordings obtained at the West Side Tower machinery, the first to be tested, were as expected (see Fig. 7). Both halves of the machinery were approximately equally sharing the motor torque when the span was raised or lowered. The test was repeated several times. Then we moved to the East Tower and repeated the same procedure both for geometrical "alignment" and testing. From the very beginning it was noticed that the load was not equally shared by the two halves of the lifting machinery (see Fig. 8). The strain gage installation was checked and everything was found to be in proper order. The test was repeated but the recording showed that the right side (south) shaft was not loaded.

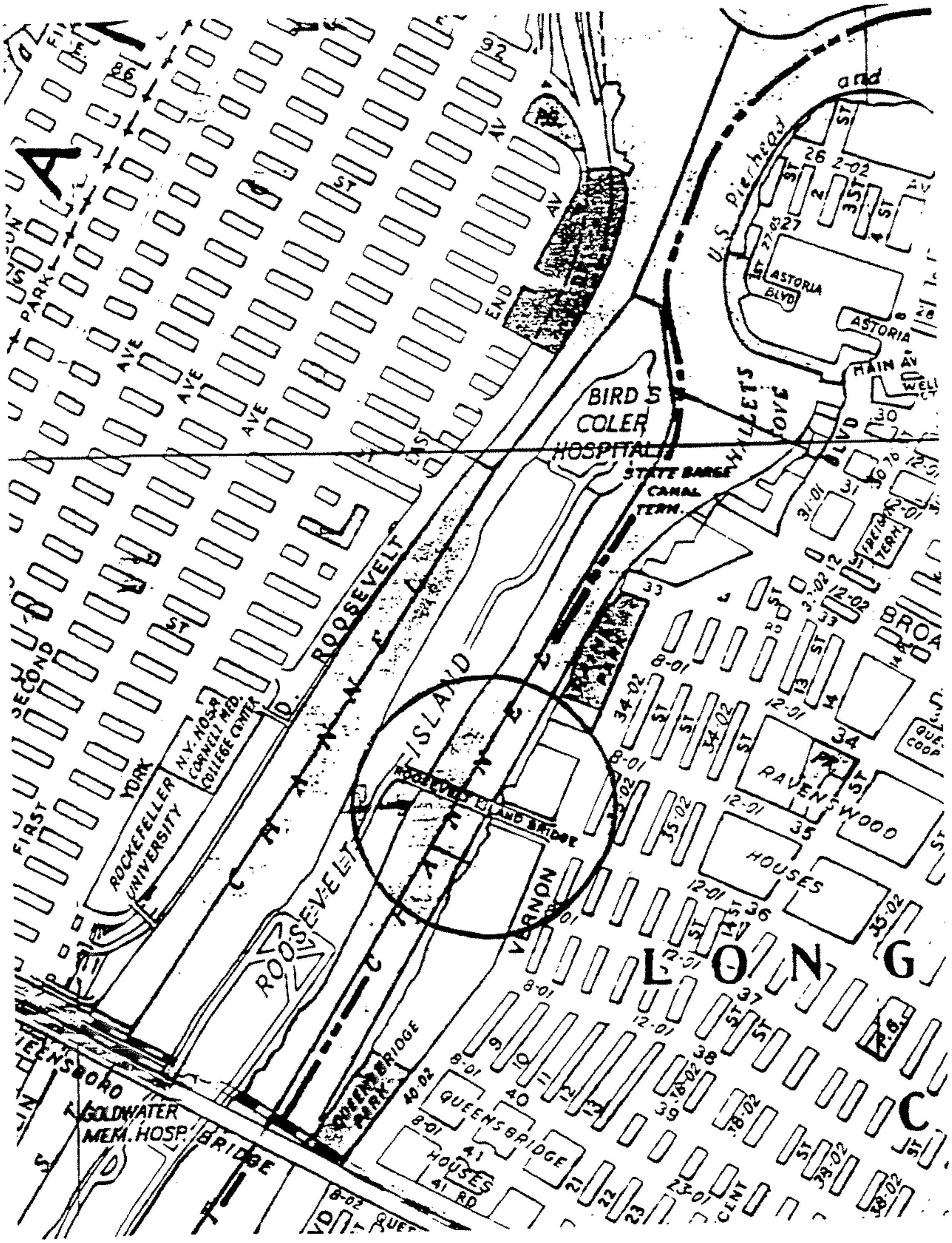
The rack and pinion assemblies were realigned using the same procedure as described above. The test was repeated, but once again the right side (south) shaft did not take any load. After a number of repetitions of alignment and testing, which invariably ended in unequal loading of the shafts we concluded that one of the items in the transmission chain from the motor to the wire rope sheaves was slipping. A very thorough visual inspection of the transmission did not yield any clue regarding the malfunctioning item. The most likely components subject to slippage were the warping clutches or controlled torque couplings. Since we engaged and disengaged the warping clutches several times they were our first transmission's components to suspect. Despite the fact that no sign of slippage was detected by visual inspection we decided to increase the clamping force of the right side (south) warping clutch. After we increased the clamping force by turning the adjustment nut, we repeated the test, going first through all the rack and pinion assemblies alignment procedure described above.

The test that followed showed that both shafts shared the load, (see Fig. 9), proving that the cause of the "no-loading" of the right shaft, was the right side warping clutch slippage.

IV SUMMARY

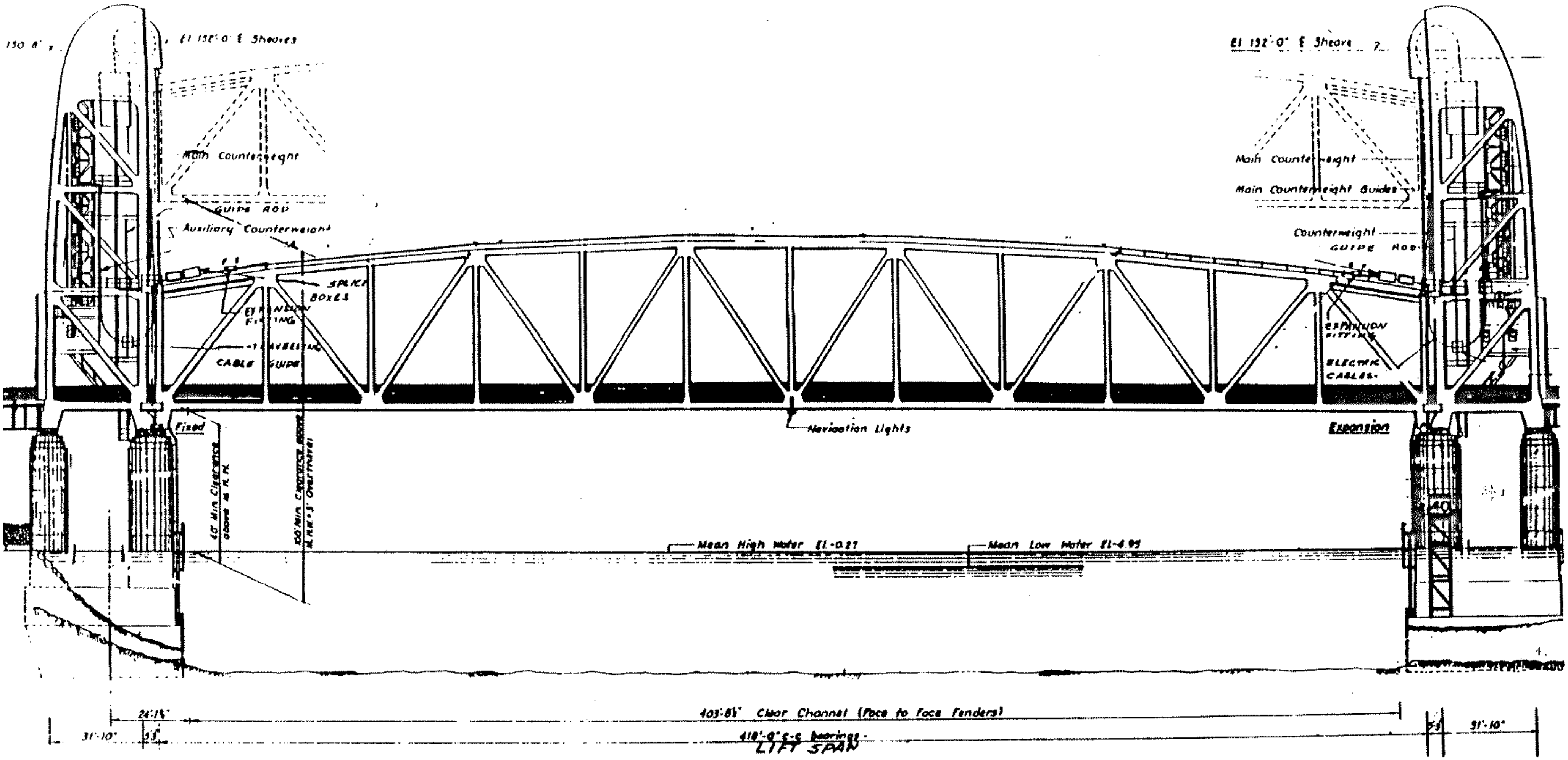
This presentation emphasizes the extreme usefulness of electric strain gage methodology in testing machinery on movable bridges.

It shows how maladjustment of a particular mechanical component in the transmission chain, that otherwise could not be detected at all, is singled out and then properly adjusted using strain gage technology.



ROOSEVELT ISLAND BRIDGE LOCATION

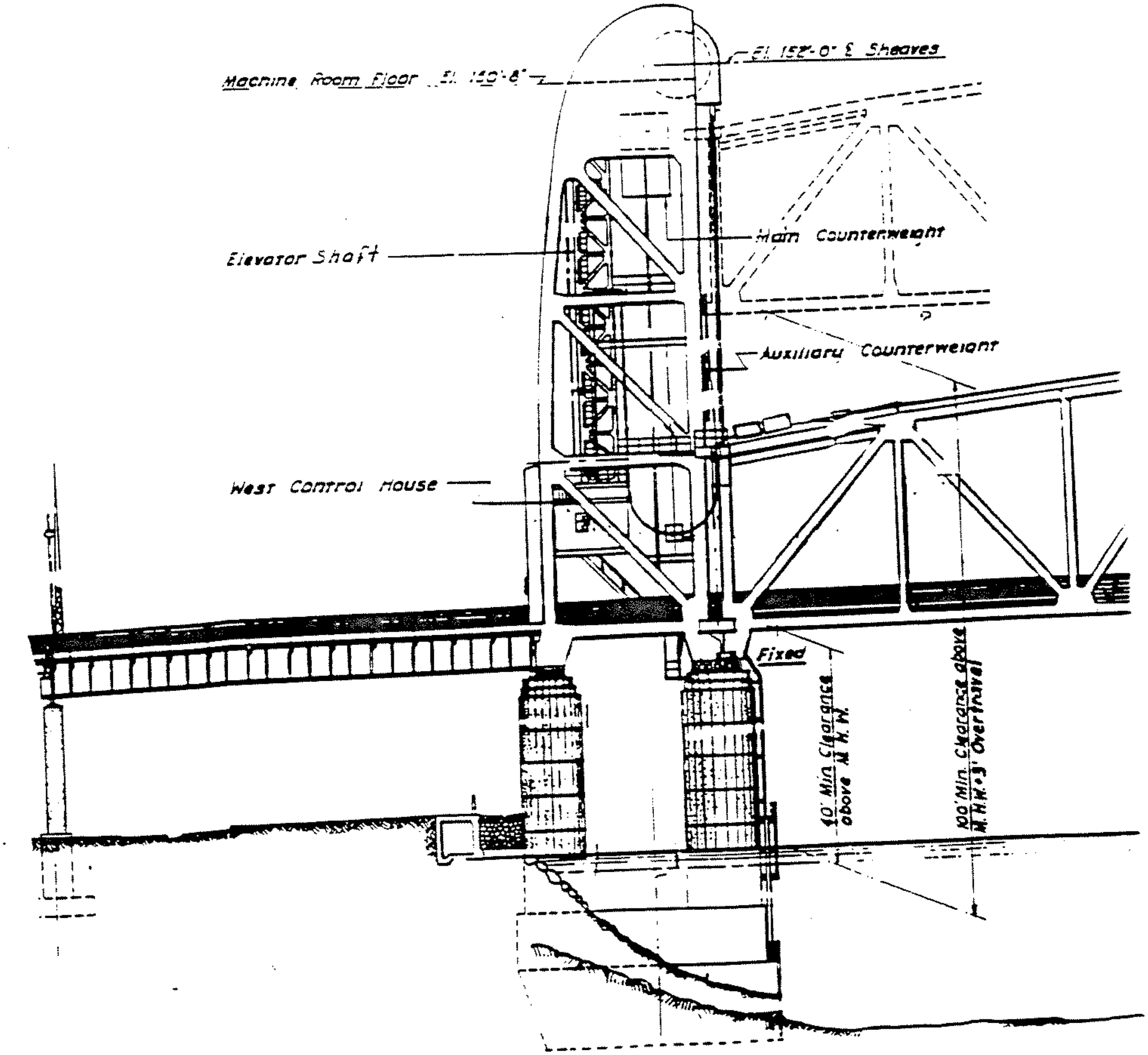
FIG 1



ELEVATION

ROOSEVELT ISLAND BRIDGE

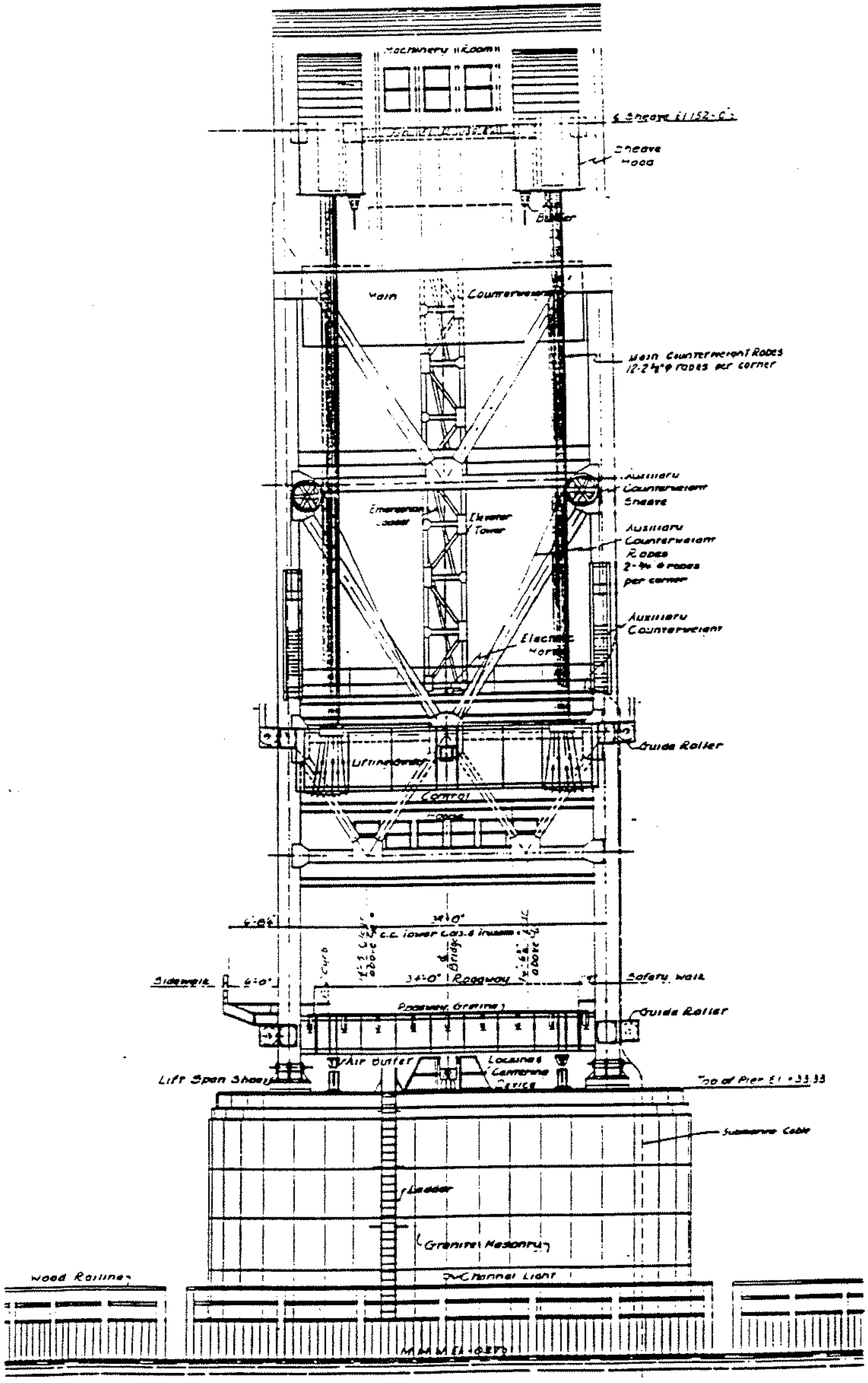
LIFT SPAN



ROOSEVELT ISLAND BRIDGE

WEST TOWER

FIG.3

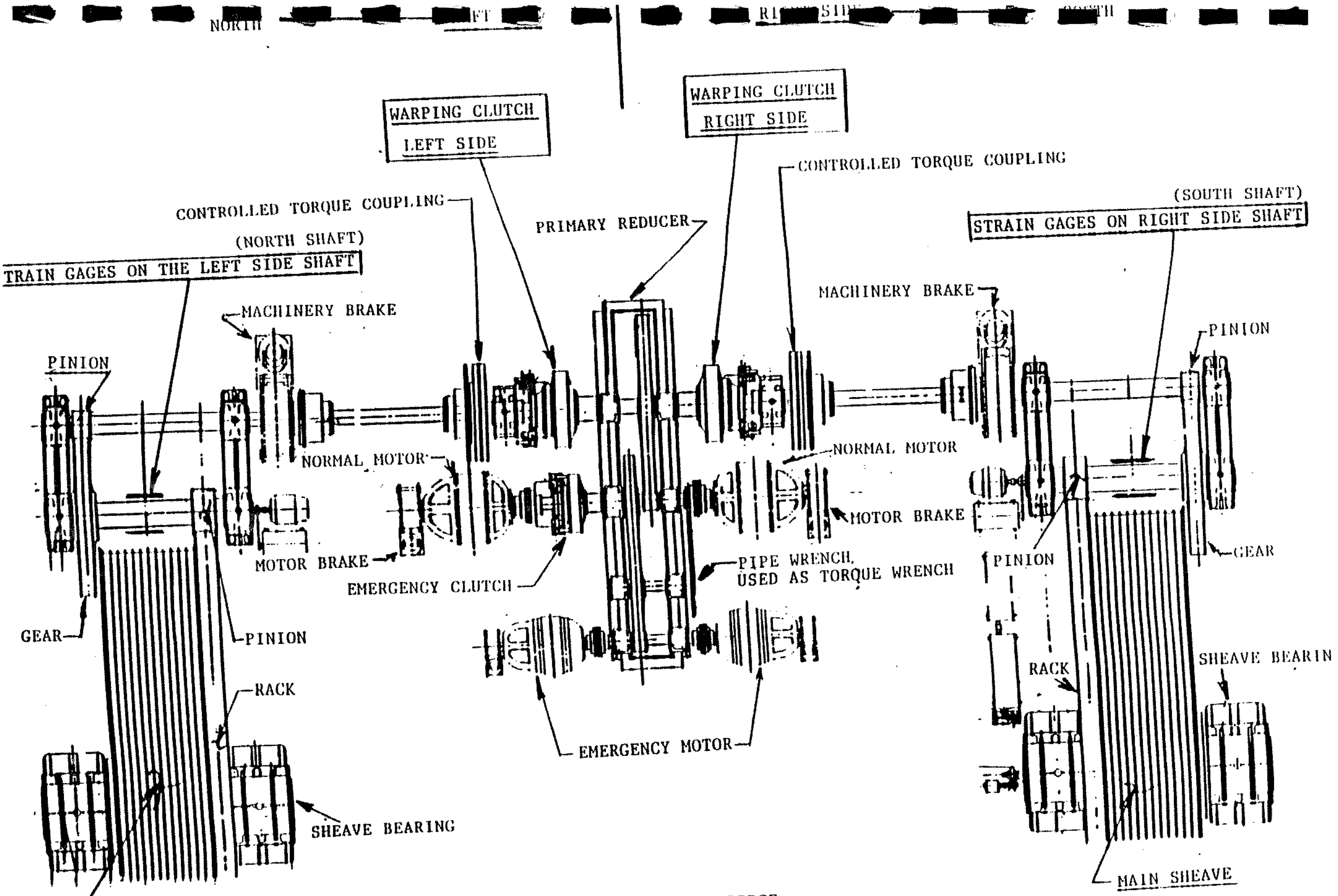


ELEVATION AT FACE OF EAST TOWER

WEST TOWER SIMILAR

ROOSEVELT ISLAND BRIDGE

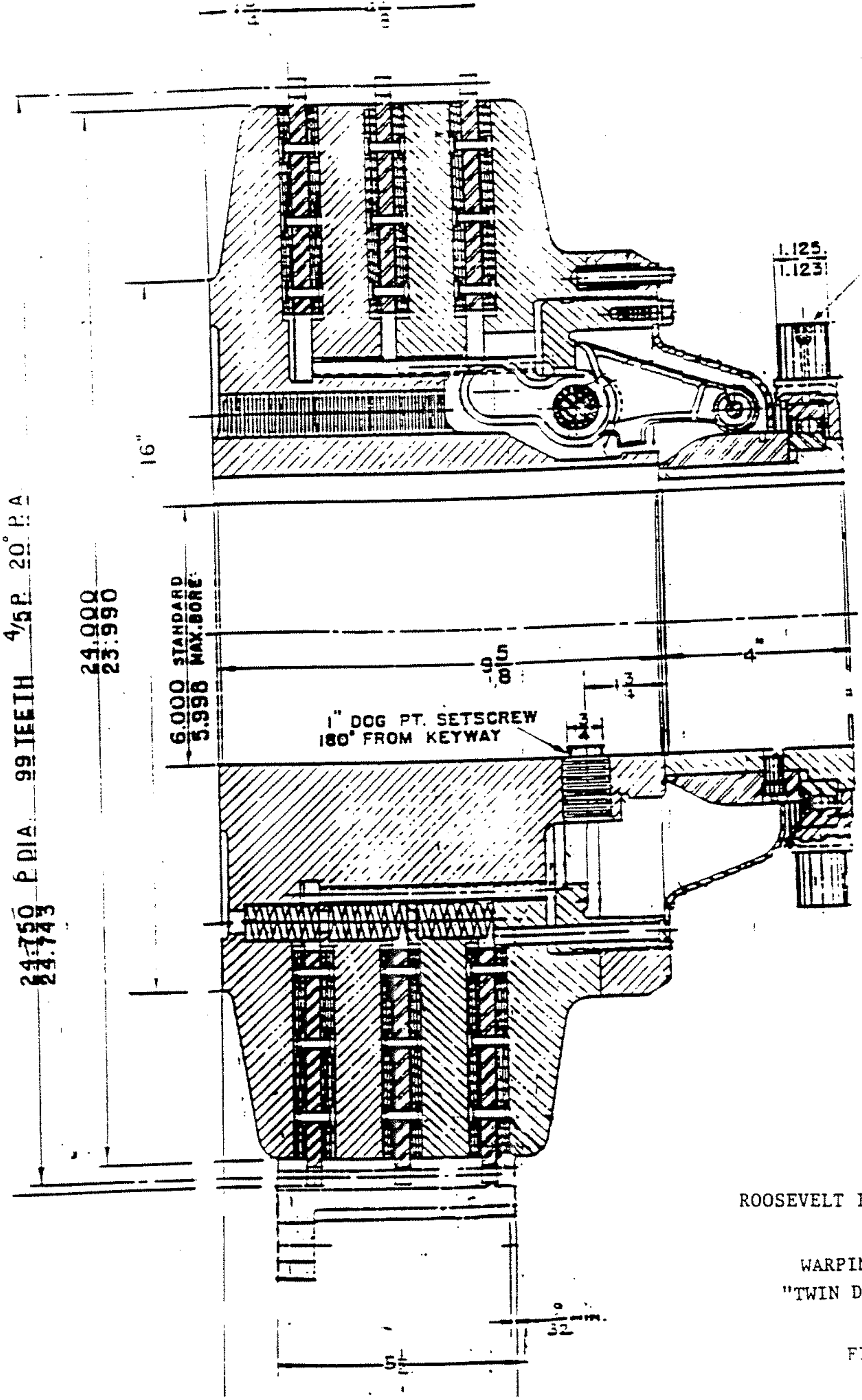
FIG.4



ROOSEVELT ISLAND BRIDGE

PLAN OF EAST TOWER OPERATING MACHINERY
(WEST TOWER SIMILAR)

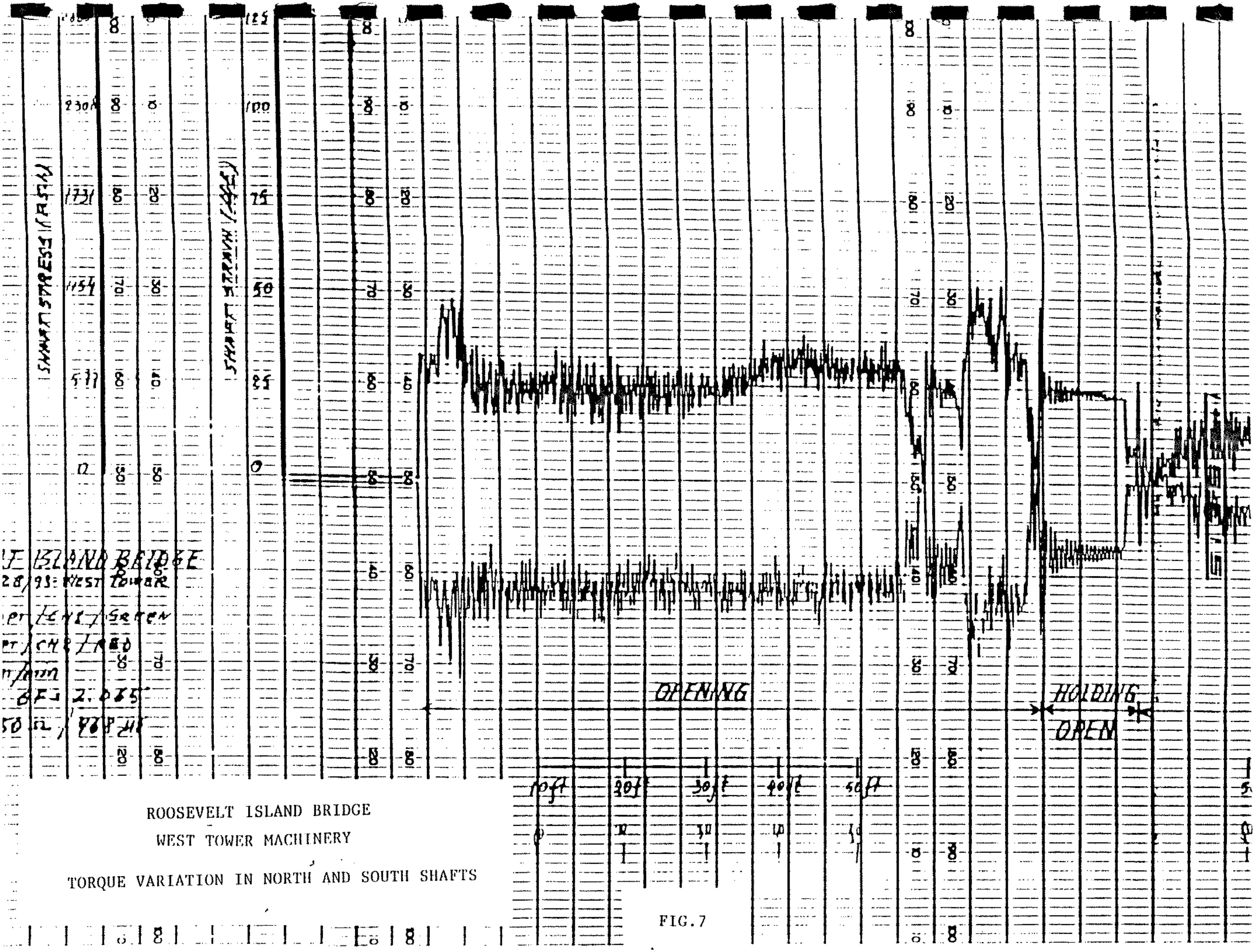
FIG. 5



ROOSEVELT ISLAND BRIDGE

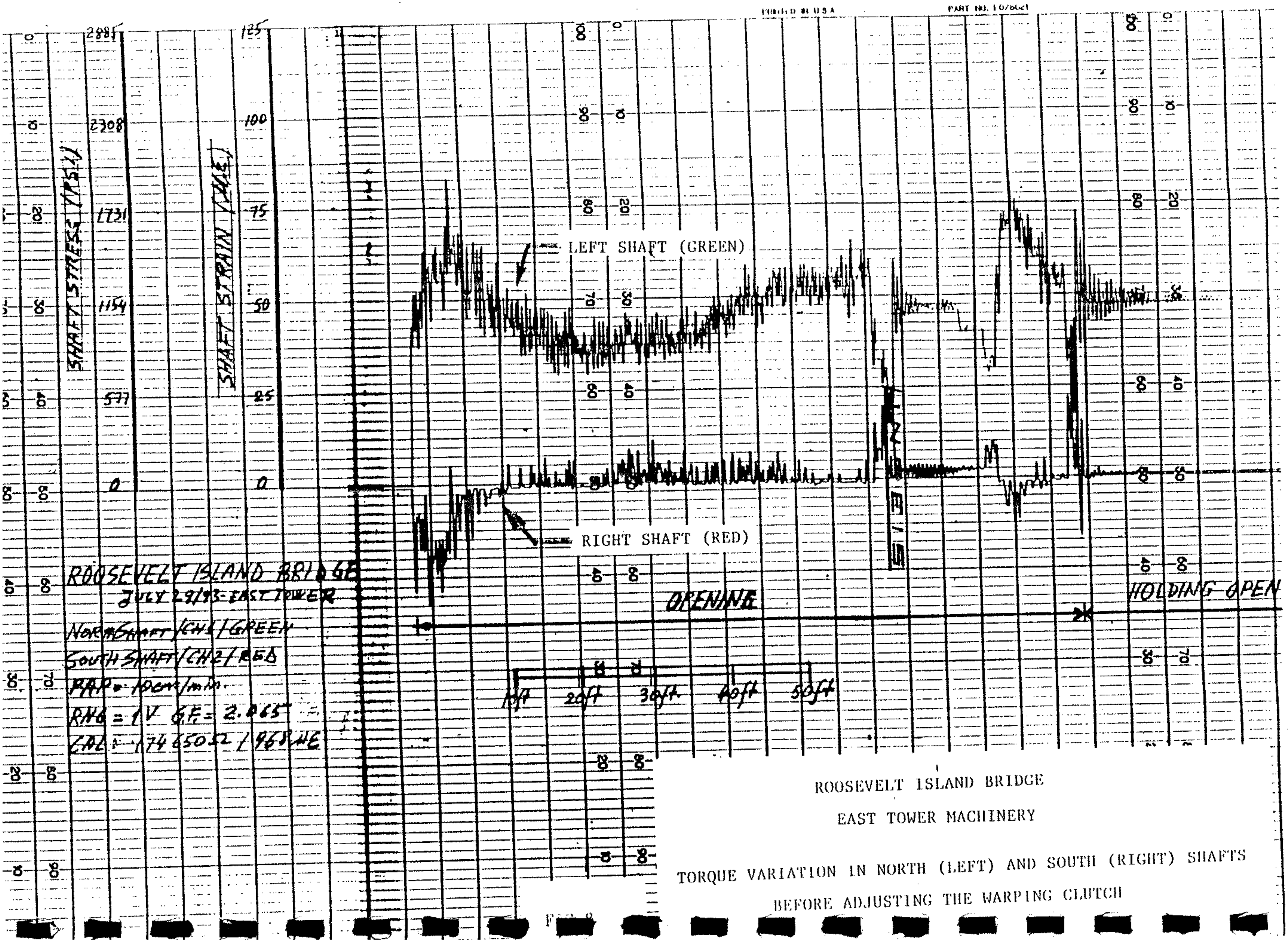
WARPING CLUTCH
"TWIN DISC" EH-324

FIG. 6



ROOSEVELT ISLAND BRIDGE
WEST TOWER MACHINERY
TORQUE VARIATION IN NORTH AND SOUTH SHAFTS

FIG.7



ROOSEVELT ISLAND BRIDGE

EAST TOWER MACHINERY

TORQUE VARIATION IN NORTH (LEFT) AND SOUTH (RIGHT) SHAFTS

BEFORE ADJUSTING THE WARPING CLUTCH

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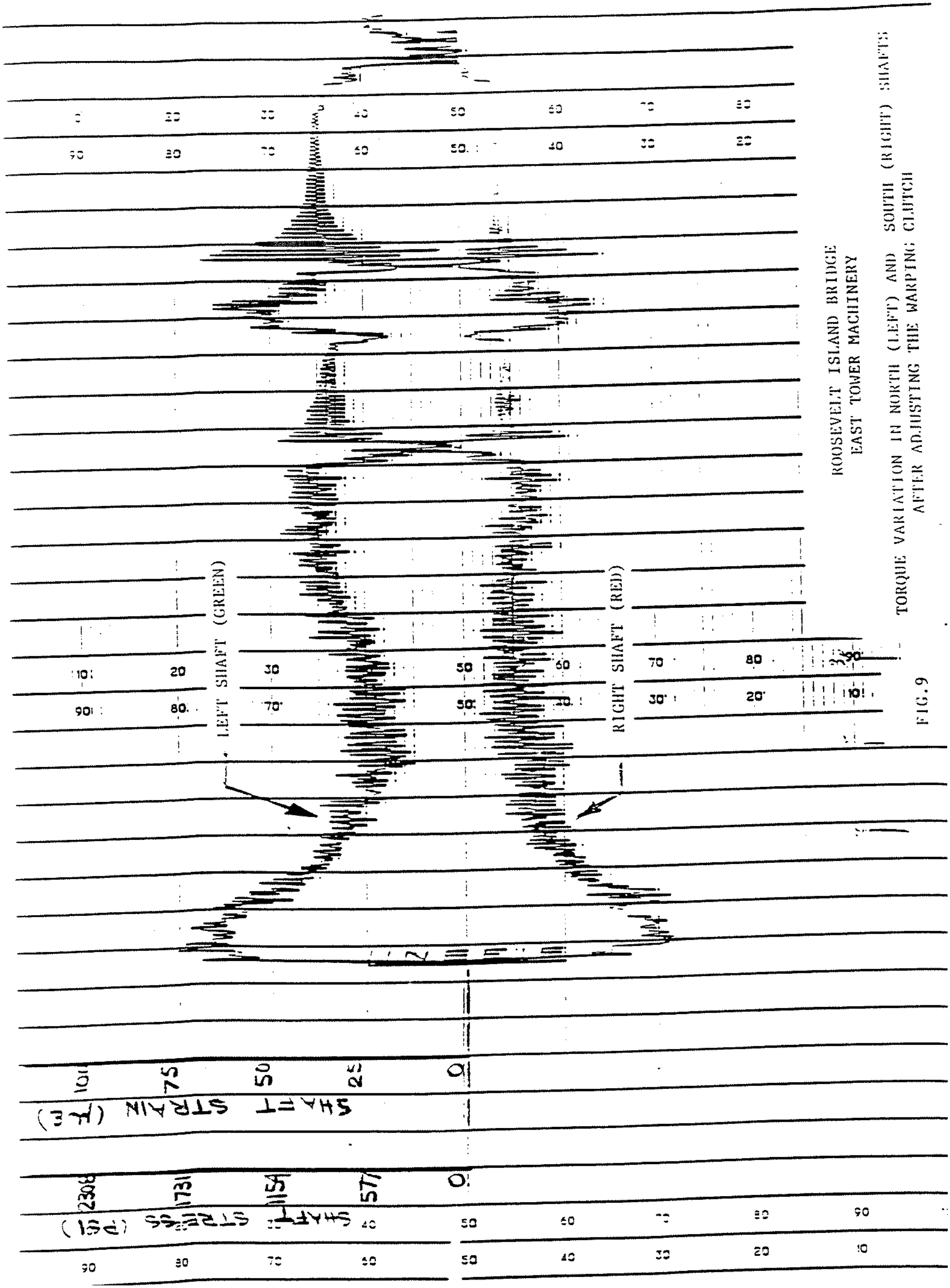

ROOSEVELT ISLAND BRIDGE
EAST TOWER MACHINERY

TORQUE VARIATION IN NORTH (LEFT) AND SOUTH (RIGHT) SHAFTS
AFTER ADJUSTING THE WARPING CLUTCH

FIG.9