Technical Report Documentation Page

1. REPORT No.
W.O. R-61259

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE
Instrumentation for Webber Creek Bridge Tests

5. REPORT DATE
April 1963

6. PERFORMING ORGANIZATION

7. AUTHOR(S)
W. Chow

8. PERFORMING ORGANIZATION REPORT No.
W.O. R-61259

9. PERFORMING ORGANIZATION NAME AND ADDRESS
State of California
Department of Public Works
Division of Highways
Materials and Research Department

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

12. SPONSORING AGENCY NAME AND ADDRESS

13. TYPE OF REPORT & PERIOD COVERED

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT
At the request of the Bridge Department, the Materials and Research Department instrumented Webber Creek Bridge, Span 1, right bridge for a series of moving load and static load tests. Webber Creek Bridge, Span 1, left bridge was instrumented with a minimum amount of instrumentation and only occasional no-load static readings were taken. Thermocouples were installed in both bridges to measure concrete curing temperatures and concrete and structural steel temperatures during the load tests.

The test work was performed to determine load distribution in the structure and to determine the effects of different concrete material combinations on concrete bridge deck performance in service.

Webber Creek Bridge (Br. No. 25-05 R/L) is a welded plate girder bridge about 551 feet long composed of separated and parallel structures, each consisting of 4 spans supported on concrete piers and abutments, and providing a clear roadway width of 28 feet. The bridge is located in El Dorado County between 0.4 mile west of Perks Corner and Placerville, III-ED-11-C, Plcr., on U.S. Highway 50.

The instrumentation was installed concurrently with the construction of both structures by Contract 61-3T13C37. Contract special provisions provided for this experimental work.

17. KEYWORDS
W.O. R-61259

18. No. OF PAGES:
45

19. DRI WEBSITE LINK
http://www.dot.ca.gov/hq/research/researchreports/1961-1963/63-12.pdf

20. FILE NAME
63-12.pdf

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

INSTRUMENTATION FOR WEBBER CREEK BRIDGE TESTS

APRIL 1963

63-12

MATERIALS & RESEARCH DEPARTMENT

State of California
Department of Public Works
Division of Highways
Materials and Research Department

April 1963

Proj. W. O. R-61259

Mr. James E. McMahon
Asst. State Highway Engineer--Bridges
California Division of Highways
Sacramento, California

Attention: Mr. John J. Kozak

Dear Sir:

Submitted for your consideration is a report of:

INSTRUMENTATION

FOR WEBBER CREEK BRIDGE TESTS

Instrumentation performed by . . . Structural Materials Section
Under direction of . . . . E. F. Nordlin
Work supervised by . . . . J. E. Barton and W. Chow
Report prepared by . . . . W. Chow

Very truly yours,

F. N. Hveem
Materials and Research Engineer

WC:mw

INTRODUCTION

At the request of the Bridge Department, the Materials and Research Department instrumented Webber Creek Bridge, Span 1, right bridge for a series of moving load and static load tests. Webber Creek Bridge, Span 1, left bridge was instrumented with a minimum amount of instrumentation and only occasional no-load static readings were taken. Thermocouples were installed in both bridges to measure concrete curing temperatures and concrete and structural steel temperatures during the load tests.

The test work was performed to determine load distribution in the structure and to determine the effects of different concrete material combinations on concrete bridge deck performance in service.

Webber Creek Bridge (Br. No. 25-05 R/L) is a welded plate girder bridge about 551 feet long composed of separated and parallel structures, each consisting of 4 spans supported on concrete piers and abutments, and providing a clear roadway width of 28 feet. The bridge is located in El Dorado County between 0.4 mile west of Perks Corner and Placerville, III-ED-11-C, Plcr., on U. S. Highway 50.

The instrumentation was installed concurrently with the construction of both structures by Contract 61-3T13C37. Contract special provisions provided for this experimental work.

Installation of instrumentation on the left bridge was started in the third week of August 1962 and on the right bridge during the second week in September. The instrumentation consisted of 16 thermocouples embedded in the deck slabs, 194 Baldwin AB-2 strain gages premounted in the laboratory on reinforcing steel bars, 30 Carlson concrete strain meters, 69 Baldwin A-9 concrete surface strain gages, 30 Baldwin Valore concrete embedment strain gages, 7 girder deflection-wire setups, and 7 Ames dials. All static readings were taken beneath the bridge on two platforms set up for that purpose.

Pictorial diagram, Figure 1, outlines some of the instrumentation, the truck used for the moving load tests, and a typical 8 channel oscillograph record. The dynamic recording equipment was housed in a trailer alongside of the right bridge abutment. Moving load tests were started in the last week of November on Span 1, right bridge. Final moving load tests were completed on December 12, 1962. This report covers only the instrumentation and data recording as performed by the Materials and Research Department. Reduction and analysis of data were performed by the Bridge Department.

HISTORY OF SR-4 STRAIN GAGE INSTALLATION ON REINFORCING STEEL

Static and dynamic strains in the steel reinforcement were measured with Baldwin AB-2 SR-4 strain gages premounted in the laboratory. The AB-2 strain gage consists of a strand of wire cemented between two pieces of thin bakelite. The bakelite serves as protection for handling ease and as an insulator when bonded to a metal surface. The AB-2 gages were self-temperature compensated gages with a coefficient of 6 parts per million per ° F. The overall gage length was 2" and the active gage length was 1.5". The width was 0.15".

To measure strains the bakelite-backed wire is cemented to the surface in question. The bonded wire resistance strain gage operates on the principle that the electrical resistance of the gage varies with strain. In order to make use of the gage it must be connected to a resistance measuring device. The instruments used to measure static strains throughout this test with these gages were two Baldwin Type M strain indicators. The dynamic strains were recorded on two optical type oscillographs. Signal conditioning equipment, amplifiers, and the oscillographs are shown in a block diagram, "Instrumentation System for Webber Creek Bridge", Figure 2.

Concrete deck slab reinforcing steel bars were instrumented in advance with AB-2 strain gages in the laboratory as shown in Figures 3 and 4. Each location was instrumented with two AB-2 gages located back to back. See Figure 5.

Prior to installing the strain gages on each reinforcing steel bar, each back to back location was machined on a shaper to remove a portion of the rebar deformation. This is shown on Figure 6 where a #6 reinforcing steel bar is photographed. The machined flat surface, approximately 4.5" x 0.25" wide facilitated the installation of the AB-2 gages.

Prior to the actual gluing of the gage each location was sanded with #180 silicon carbide paper to remove rough edges and burrs left from the machining process. Each location was then rigorously cleaned and degreased with a cheesecloth soaked in acetone. This procedure was repeated until an acetone soaked cheesecloth came away clean after wiping the gage area.

All gages were glued to the bars with Baldwin EPY-150 epoxy cement. The cement was applied in a thin layer to the back of the gage and to the prepared surface. The gages were placed on top of the cement and carefully aligned so that two gages placed back to back on opposite sides of the bar were positioned directly opposite each other. Excess cement was squeezed out with a rolling motion of the thumb and the gage realigned. A piece of drafting tape was then wrapped around on top of both of the strain gages to maintain their alignment and back to back positions. Several strands of rubber bands were then wrapped around and stretched on top of the drafting tape. The rubber bands served to maintain a constant pressure on the gages during the curing cycle and the tape maintained the gage alignment.

Insulated thin copper terminals were also glued alongside of the ends of each strain gage. The copper terminals served as terminations for joining the strain gage lead out wire and the hookup extension cable. The curing cycle for the cement-gage-terminals combination consisted of approximately 24 hours under a 250 watt infrared heat lamp. The lamp was placed 12 to 14 inches from the gage. Figure 7 shows a completed gage and terminal installation.

The gages were now ready to be electrically wired with hookup-extension cable. The hookup-extension cable used was Belden #8434 strain gage cable. The #8434 cable was wrapped tightly with waxed string about 2" outside of the machined area. The wrappings of waxed string minimized any mechanical motions from being transmitted to the soldered joints of the gage and cable. The #8434 cable consists of four conductors color coded black, white, red, and green. The black and white conductor pair was always used to hook up one strain gage, and the red and green conductor pair was always used to hookup the opposite back to back strain gage. Figure 8 shows a completed wired-up gage installation on a #6 reinforcing steel bar.

The next step was to protect the strain gage and surrounding area from moisture and mechanical damage. An epoxy type waterproofing material was chosen for the job.

The waterproofing epoxy was a two part epoxy-Thiokol mixture purchased from Mark-A-Line, Inc., 95 Gage 5 Road, Sausalito, California. It consisted of two separately bulk packaged mixtures of the following composition by weight:

<u>Mixture #1</u>:	Shell Epon Resin 828	91.0%
	Cab-O-Sil, Uncompressed	9.0%
<u>Mixture #2</u>:	Thiokol LP-3	86.8%
	DMP-30	5.1%
	Cab-O-Sil, Uncompressed	8.1%

One part by weight of Mixture #1 was mixed with two parts by weight of Mixture #2. The mixture in its uncured stage is like a heavy grease paste and does not sag. It cures to a solid elastic material. The uncured mixture was applied over the completed wired up gage installation and the entire machined flat area with a wooden tongue blade. Reinforcing steel deformations on the sides of the machined area were left exposed for maximum concrete bond.

The edges of the mixture were feathered out with the tongue blade just past the machined area. Extra care was made to insure that the mixture completely surrounded the connecting #8434 cable.

ON-SITE INSTALLATION OF GAGED REINFORCING STEEL

Figures 9 and 10 show the instrumentation installed on the right Webber Creek Bridge. The same installation procedures and methods were used on the right bridge at the 1/4 and 1/2 span points and on the left bridge at the 1/2 span point.

Figure 11 is a view of the partially completed Webber Creek Bridge in the background.

After strain gaging in the laboratory the reinforcing steel bars were delivered to the bridge site and installed by the steel subcontractor prior to the concrete pour.

The #6 transverse reinforcing steel bars were 34 ft. long and strain gages were installed on the full length bars. Since the #6 reinforcing steel bars were full bridge deck width, no splicing was required at the bridge site. The strain gaged #4 longitudinal bars were 20 ft. long. These #4 bars were spliced to the other appropriate #4 bars at the bridge site by conventional tying with tie wire to provide the continuous length required.

Figure 12 is a view of two typical strain gaged #6 transverse reinforcing steel bars in the bridge deck prior to concrete pouring. This figure also shows three Carlson strain meters installed for embedment at different depths in the deck.

The ends of all the strain gage cables on the reinforcing steel were passed through strategically located 4" x 5" x 6" conduit boxes. The conduit boxes were installed through the bottom plywood soffit form, projecting only slightly through the plywood form and into the deck. All of the instrumentation cables at the 1/4 and 1/2 span points were routed to one of the 8 appropriate conduit boxes and passed down through the box into the bottom bays of the bridge. One of the conduit boxes and the instrument cables passing through the box from the bridge deck are shown in Figure 13. The plywood soffit forms are still in place.

The instrument cable entrance way in the conduit box was sealed with 3M-EC1167 putty after all instrumentation cables had been passed through. This was to prevent grout leakage during the concrete deck pour.

Ends of all the instrumentation cables terminated on terminal strips mounted on racks. One rack was placed at the 1/4 span point and one rack at the 1/2 span point. Platforms directly beneath these points were built to accommodate the terminal racks and were used to work from.

A view of one of the terminal strip racks is shown on Figure 14. The terminal racks facilitated the reading of any instrument by merely connecting the desired test equipment to the desired instrument on the racks. Figure 15 is a view of the static data gathering operation.

The four wires emanating from all two strain gage setups mounted back to back on opposite sides of reinforcing bars were brought out and individually terminated on the terminal strip-relay rack. This was so that the two gages could be read individually for static test measurements whereas during dynamic testing the two gages would be recorded in series. See Figure 5.

Locations of strain gages on the rebars are shown in Figures 3 and 4. Designations of the various rebars are as follows:

S = #6 bottom straight rebar - transverse

H = #6 top hook rebar - transverse

T = #6 truss rebar - transverse

L = #4 straight longitudinal rebar

Six compensation "dummy" gages were made in the laboratory for installation in the concrete deck slab. Each "dummy" gage consisted of an AB-2 strain gage attached to a 5" length of #6 reinforcing steel. The reinforcing steel was then placed into a steel tube, longer than the reinforcing steel, with a suitable length of cable attached to the gage coming out of the steel tube. Ends of the tube were sealed with epoxy. The strain gaged reinforcing steel was thus free to thermally expand or contract unrestrained inside of the tube.

The dummy gage formed a part of the Wheatstone electrical bridge circuit used in statically reading all of the strain gages.

The dummy gage also served to cancel out false strain changes due to temperature changes. This is because strain gages are sensitive to temperature changes as well as strain changes.

Static strains on the reinforcing bars were read with two Baldwin Type M strain indicators as shown in Figure 15.

<u>VALORE GAGES</u>

Valore ES-9S embedment type strain gages were placed at the locations shown on Figures 9 and 10 prior to the concrete pour. The Valore gages are made by Baldwin-Lima-Hamilton and consist of a strain gage encapsulated in a brass shim foil envelope. The Valore rosette consists of three Valore gages placed at 45° to each other at the apex. Figure 16 shows a view of one of the Valore rosettes. With the three strain readings from the Valore rosette the direction of principle strain in the concrete can be determined.

The three Valore gages were attached to a 1/8" diameter brass rod form to facilitate ease of placement in the wet concrete and to maintain correct alignment. Only one end of each of the Valore gages was secured to the brass rod form.

No compensation "dummy" gages were embedded with the Valore gages as only dynamic tests were anticipated with these gages. Static readings were not taken on the Valores. The cables from the Valore gages were passed through the conduit boxes and terminated on the terminal racks in the same fashion as previously explained under reinforcing steel bar installation.

GIRDER GAGES

Prior to the concrete deck pour, steel bridge girders were instrumented with Baldwin FAB-50-12-S6 strain gages. Figures 17, 18, and 19 show the location of the girder gages. Surface preparation consisted of grinding off loose scale until a clean shiny surface was obtained. The surface was then wiped clean with acetone. FAB-50-12-S6 strain gages were glued to the selected locations and cured with heat lamps. After heat curing the extension cables were attached to the strain gages and an epoxy type waterproofing was applied over and beyond the entire gaging area.

Figure 20 shows the completed girder gage installation for gages #G43 and G44, and the temperature compensation dummy blocks. The dummy block consists of a piece of steel block approximately 1¼" x 1¼" x 3½" long with an FAB-50-12-S6 strain gage glued to one surface. The opposite side of the gaged surface was glued to the girder with plastic steel (steel filings in an epoxy carrier). The glue line between the girder and the dummy block was kept small and at one corner of the block. This was so the girder would not transmit stresses into the dummy block.

Each gage location on exterior girder H had its own dummy gage block for temperature compensation. This was necessary because of the rapid temperature fluctuations due to the exterior face facing the sun. Interior girders F and G had one dummy gage at each 1/4 and 1/2 span girder location as shown on Figures 18 and 19.

All of the girder gages terminated on the terminal racks and at regular time intervals static no-load readings were taken.

CARLSON STRAIN METERS

Horizontal strains in the concrete roadway slab were measured with 26 embedded Carlson electrical resistance-wire strain meters. The meter is shown in Figure 21. The strain meter is described in "Measurement of Structural Action in Dams" by R. W. Carlson and J. M. Raphael, James J. Gillick & Co., Berkeley, Calif., 1956.

Essentially the meter consists of two tightly stretched coils of steel wire so that when the meter ends are elongated or shortened one coil is tightened while the other is slackened. Ratio of the resistance of one coil to the other is observed by a modified Wheatstone Bridge called a Carlson Test Set. The test set is shown in Figure 22. The Carlson Test Set is used to measure static strain and static temperature only. The change in resistance ratio is proportional to strain. The effect of temperature on the strain ratio is eliminated because the two coils are used as adjacent arms in the Wheatstone Bridge Carlson Test Set. The strain meter is also used as a resistance thermometer when the two coils are connected in series. The Carlson meters used had a gage length of 10" and were equipped with three conductors. The meters installed in the roadway surface were Carlson meters Model SA-10.

For no-load and static load strain observations, the resistance ratio was measured to 0.01%. This corresponds to a strain of approximately 4 micro-inches/inch. The temperature change was measured to a tenth of a degree F.

No load static strains were taken beneath the bridge alongside of the terminal racks so as to maintain short cable lengths.

The Carlson strain meters were converted into dynamic strain meters by adding two 100 ohm resistors to form a 4 arm Wheatstone Bridge. This is shown in Figure 23.

The Wheatstone Bridge configuration is the input accepted by all of the dynamic strain equipment. To calibrate the Carlson meters a parallel resistor of 31.5K ohms was placed across the 30 ohm arm at the red and green terminals. This simulated a compression strain of 0.1%. The value of the calibrate resistor, 31.5K ohms, was determined with a resistance decade box placed across the white and green terminal on the Carlson Test Set. The Carlson strain meter was hooked up to the test set and the decade resistance was varied until a 0.1% change in strain was indicated on the test set. The value of resistance on the decade box was the calibration value used to simulate a change in strain of 0.1%. The value of resistance used for all 26 strain meters to simulate a 0.1% change in strain was 31.5K ohms.

By necessity and practical considerations the shunt calibration resistor was located at the end of the transmission cable in the instrument trailer. This involved a long transmission cable with calibration error due to lead wire resistance. The strain on the oscillograph graph trace is multiplied by $1+4R_1/R$ to correct for the lead wire calibration error. R_1 is the lead wire resistance of one wire to the Carlson meter. Resistance of the Carlson arm is 30 ohms. Resistance of each of the 12 transmission cables to the terminal racks from the dynamic equipment was measured. Figure 24 lists the dynamic cable resistances and the correction factors to be applied to the oscillograph traces to obtain true strain.

Figure 12 shows three Carlson meters in place prior to the concrete pour.

CONCRETE SURFACE STRAINS

Concrete surface strains on the bottom of the deck slab were measured with Baldwin A-9 strain gages. The gages are located at the 1/4 and 1/2 span and are shown on Figure 10.

The surface preparation prior to the bottom gage installation consisted of grinding off loose cement dust and cleaning the ground area with acetone. Two gages crossing one another at the mid-point and at an angle of 90° were then glued to each location at the bottom concrete surface with Baldwin EPY-150 cement and cured with heat lamps. After curing and attachment of cables, the gages were waterproofed with Budd GW-1 silicone grease. Two of these crosses are visible in Figure 25. The cables terminated on the terminal racks as previously explained for reinforcing bar strain gages.

Concrete surface strains on the top of the deck slab were also measured with Baldwin A-9 strain gage crosses. Slots were cut into the top of the deck slab with a diamond saw so that the A-9 gages would be installed and embedded below the wearing surface. The saw cuts were approximately 9 inches long by ½" wide and ¼" deep. Cables were attached to the A-9 gages and passed through holes in the deck. Eighteen ½" holes were drilled through the concrete deck at the appropriate locations in which the A-9 cables were to pass through. Figure 25 shows one of the cables passing through the concrete deck holes. Concrete deck slab thickness at the holes was also measured and is shown on Figures 26 and 27.

Like the Valore gages, only dynamic strains were considered so that no dummy gages were used with the A-9 gages.

STATIC GIRDER DEFLECTIONS

Static steel girder deflections were measured prior to and after pouring of the concrete deck. The static measurements were taken on girders F, G, and H at Spans 1, 3, and 4. Measurement locations were at the 1/4 and 1/2 spans of the above girders.

The measuring system consisted of a piano wire stretched the full length of the girder. One end of the piano wire was securely fastened to one end of the girder. The other end of the wire had a 30# weight attached to it and was hung over a roller attached to the end of the girder. Figure 28 shows the piano wire and the 30# weight supported by the roller.

CONCRETE BAY DEFLECTIONS

Concrete bay deflections between and relative to the girders were measured by seven Ames dial gages accurate to 0.001 inches. Figure 29 shows the seven dial gage setup for a set of static deflection measurements.

A Sterling truck and a Materials and Research Department drill rig were used as loads for the deflection measurements. Concentrated loads were obtained by jacking these vehicles over prescribed 12" x 12" areas.

TEMPERATURE MEASUREMENTS

A total of sixteen thermocouples were placed in the left and right bridges to measure concrete curing temperatures. The thermocouples were placed at the locations specified in the Bridge Department plans.

The thermocouples were made of iron-constantan Honeywell #9B3N4 wire. Concrete curing temperatures were automatically recorded on several multipoint potentiometer strip chart recorder. The recorders were installed beneath the bridge and were battery operated. Figure 30 is a view of one of these temperature recorders.

Two of the sixteen thermocouples were placed at the locations as shown on Figure 10. The thermocouples were used to record the concrete curing temperatures and also the temperature variations during the moving load dynamic tests.

PLACEMENT OF CONCRETE

After all of the instrumentation had been installed, photographs and physical measurements of instrument locations were taken for the record. Figures 31 and 32 are typical pictures of two completed instrumented locations. Visible are Carlson strain meters, Valore gages, dummy gage, gages on reinforcing steel, and the conduit box in which the instrument cables passed down into the work platform.

During the concrete deck placement the concrete around the instrumented area was hand placed and hand rodded in. Occasionally a small hand vibrator was also used. Large aggregates were removed by sieving through a ½" sieve to facilitate concrete placement around the instruments.

STATIC LOAD TEST

Webber Creek right bridge was subjected to numerous static load tests at the 1/4 and 1/2 span. The first static load was the Materials and Research Department foundation drill rig shown on Figure 33.

The rear duals of the drill rig were jacked up and the load was concentrated over an approximate 12" x 12" area. The jack, load cell, and the concentrated loading area is shown in Figure 34.

Static readings on selected strain gaged rebars and concrete surface strains were taken at loads of 10 kips, 20 kips, and 30 kips. The static readings were taken from beneath the bridge at the two work platforms. Two Baldwin Type M strain indicators were used to read the static strains from the selected gages. Because of the short instrumentation leads beneath the bridge, no lead wire correction was necessary.

The Baldwin indicators are graduated to 10 micro-inches/inch and readable to that amount without estimation. With estimation the readings are considered to be reliable to 4 or 5 micro-inches/inch. On the whole, the static strain readings are reliable to within 10 micro-inches/inch.

A second larger load was obtained later consisting of a Sterling truck loaded with sand, Figure 35. The rear tires were jacked up with a hudraulic jack and the load measured with a hydraulic gage. Figure 36 shows the set up for obtaining the concentrated static loads. Selected static readings on strain gages were taken with the truck at various locations as previously described. The maximum concentrated load obtained by this method was 43 kips.

TEST LOADS

The individual weights on each truck tire were measured with a California Highway Patrol highway loadometer. Results are as follows:

Sterling Truck

LF tire	5,220 lbs.	RF tire	4,890 lbs.
LRD tire	23,590 lbs.	RRD tire	22,070 lbs.

Total 55,770 lbs.

Materials and Research Department Drill Rig Truck

Axle #1 - left	6,230 lbs.	Axle #1 - right	6,310 lbs.
Axle #2 - left	8,970 lbs.	Axle #2 - right	9,570 lbs.
Axle #3 - left	9,210 lbs.	Axle #3 - right	9,430 lbs.

Total 49,720 lbs.

In addition tire prints were taken on all tires of the Sterling truck.

All through the dynamic tests a constant check was kept on the Sterling truck tire pressures. Tire pressure was measured daily during the dynamic test runs.

DYNAMIC TEST DATA GATHERING AT THE BRIDGE SITE

The housing of all the dynamic instrument data gathering equipment and operations was in a 22' resident engineer's trailer. Figure 37 is a view of the test trailer at the bridge site. The instrument trailer was completely instrumented in the laboratory and checked out. The trailer was hauled out to the jobsite after grading was completed on the bridge approach fills.

The dynamic recording system consisted of 16 channels. The 16 channels of information were recorded on 2 oscillographs. Two channels on each of the 2 oscillographs were permanently used for 1 second time lines and event markers. These time lines and event markers were common to both of the oscillographs. Thus both oscillograph records could be tied together with respect to time and event. One second time lines were used throughout the tests.

The event markers were used to put identifying marks on the oscillograph paper with respect to the position of the truck wheels on the bridge. The event markers were made from Tapeswitch Corporation Contraflex RB electrical strip switch. The strip switch is a continuous electrical switch. Switch closure was accomplished by the pressure of a vehicle wheel on top of the switch. Four tape switches were installed across the bridge deck: one each at the beginning of the bridge, the 1/4 span, the 1/2 span, and the end of the bridge.

Coordination of truck runs and the engineers operating the test equipment in the trailer was accomplished by an intercom loud-speaker system between the bridge deck and trailer.

The dynamic recording in the instrument trailer required two operators. Each operator operated one oscillograph and its associated equipment. One engineer was in over-all charge and observed the operations in the trailer. A series of test runs, called a combination, consisted of 12 channels of information recorded on the two oscillographs. The Bridge Representative furnished the information as to which combination of strain gages or Carlson strain meters were to be hooked up for recording on the oscillographs.

The actual recording was accomplished by hooking up the 12 instrument circuits to be recorded into the signal conditioning equipment, amplifiers, sensitivity adjustments, and then into the oscillograph recorders. The 12 instrument circuit cables, from trailer to the 1/2 span terminal rack, were approximately 125 feet long.

Dynamic recordings of strain gages on the reinforcing steel were accomplished in two manners. As previously mentioned two strain gages were installed back to back. If one of the back to back strain gages failed, then only the good strain gage could be used. If both of the back to back gages were usable, then they would be recorded in series. This is shown in Figure 5. Case I is the recording setup for one gage and Case II is the recording setup for two gages in series.

The Wheatstone Bridge configuration is the input accepted by all of the dynamic strain equipment. One hundred twenty ohms precision 1% resistors were used to complete the bridge circuit for the reinforcing bar strain gages and the girder gages. Three hundred ohms precision 1% resistors were used to complete the bridge circuit for the Valores and A-9 gages. One hundred ohms precision 1% resistors were used to complete the bridge circuit for Carlson strain meters as shown on Figure 23.

The signal conditioning equipment was used to balance the Wheatstone Bridge prior to recording. Amplifiers were used to amplify the small signals coming from the different instruments.

The sensitivity adjustments were used to adjust the trace magnitude of the record calibration trace on the oscillograph film. Each channel was calibrated by shunting a resistor across the appropriate arm of the Wheatstone Bridge.

The calibration resistors simulate a strain based on the strain gage formula:

$$GF = \frac{\frac{DR}{R}}{u''/inch}$$

where GF = gage factor supplied by manufacturer.

DR = change in resistance accomplished by the shunting of the calibrate resistor across one Wheatstone Bridge arm.

R = resistance in ohms of the strain gage.

u"/inch = the simulated strain in micro-inches per inch.

Figure 38 tabulates the strain simulated with various calibrate resistor values used during the dynamic tests.

The 12 Wheatstone Bridges were ready for balancing when the correct data amplifying channels and calibration resistors are hooked up.

Data amplifier channels #1 - #5 were balanced resistively, only. This is because the amplifiers were D.C. amplifiers. The excitation to the Wheatstone Bridges was also D.C..

In Channels #6 through #12 the bridge must be balanced resistively and capacitively. This is because the amplifiers are A.C. carrier types. In many test runs an extra capacitor had to be added to the built-in capacitive balance of these amplifiers. The extra capacitance was needed for quite a few of the long cable runs.

After balancing the bridge the calibrate resistor switch was actuated and the signal fed into the amplifier. The size of the amplified signal was adjusted by a Helipot to cause approximately a 1½" deflection trace on the oscillograph. The mode of calibration for each channel, tension or compression was noted on a record sheet.

The actual data acquisition runs consist of first running a short calibration record of about 6" to 8". The data runs were then made with the truck crossing the bridge at a pre-selected transverse location. The truck made three crossings over this same transverse location, and a record was made each time. To insure that all the equipment was operating satisfactorily, another calibration record was made immediately after the three runs. This procedure was followed throughout the length of the tests with few variations.

As previously mentioned the 12 dynamic instrument cables from the trailer to the bridge 1/2 span were 125 feet long. The long instrument cables created calibration errors due to the lead wire resistances. The strain on the oscillograph record trace must be multiplied by $1 + 4R_1/R$ to correct for the lead wire calibration error. R_1 is the lead wire resistance of one wire of the instrumentation cable. R is the resistance of a particular gage. Figure 24 tabulates the multiplication correction factor to obtain true strain for each of the 12 channels.

DESCRIPTION OF EQUIPMENT USED IN THE INSTRUMENT TRAILER

The instrumentation signals from the bridge under dynamic tests were unusable as such. The signals must be conditioned, amplified, and recorded. The following is a description of the 12 channels of equipment used to accomplish the above. Figure 2 is a block diagram of the instrumentation system used.

The signal conditioning equipment or bridge balance for data channels #1 through #5 was a Consolidated Electrodynamic Corp. Model #8-108 bridge balance. The bridge balance served as a conditioning and control link between the instrumentation signals from the instruments and the amplifiers. The various controls and meters of the #8-108 bridge balance permitted the following operations:

1. Adjustment of the voltage applied across each bridge.
2. Balancing-out of residual signals from each bridge to a zero-stress level.
3. Changing the polarity of each channel.
4. Calibration of each channel.

The CEC bridge balance was powered by a Video Model SR-1000 D.C. power supply.

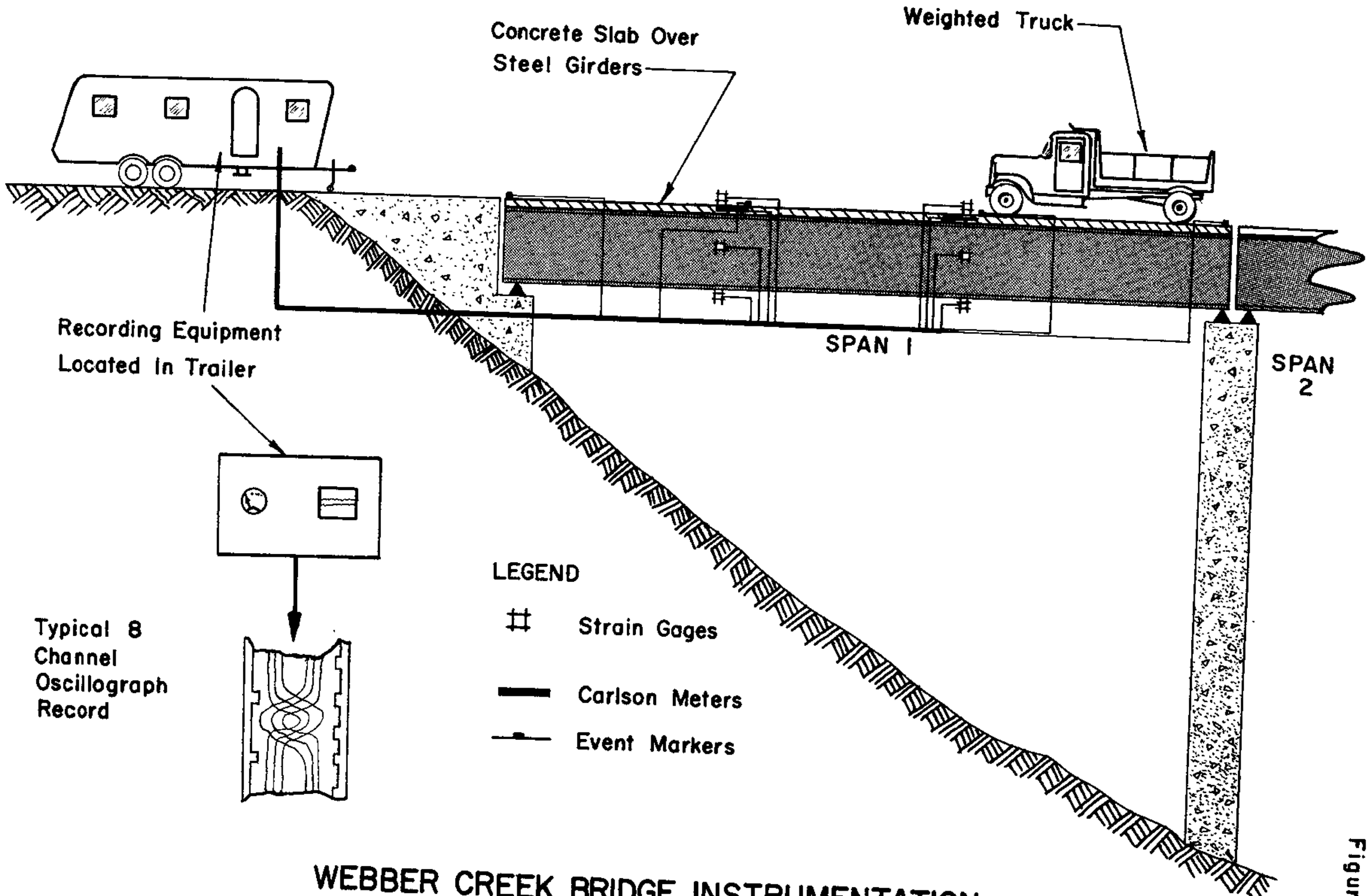
The amplifiers used with the CEC 8-108 bridge balance were five Video Model 72R D.C. amplifiers. They were completely transistorized with a frequency response of ± 1 db from DC to 20 KC. Output current was 5 ma maximum with an internal impedance of less than 50 ohms.

Data channels #6 through #12 used A.C. carrier type equipment built by Sierra Electronic Corporation of San Carlos, California. Two Model #118 power supplies furnished all the power for operating two Model #111 amplifiers and one Model #115 amplifier. Each amplifier channel contained the bridge and its associated controls and balancing network.

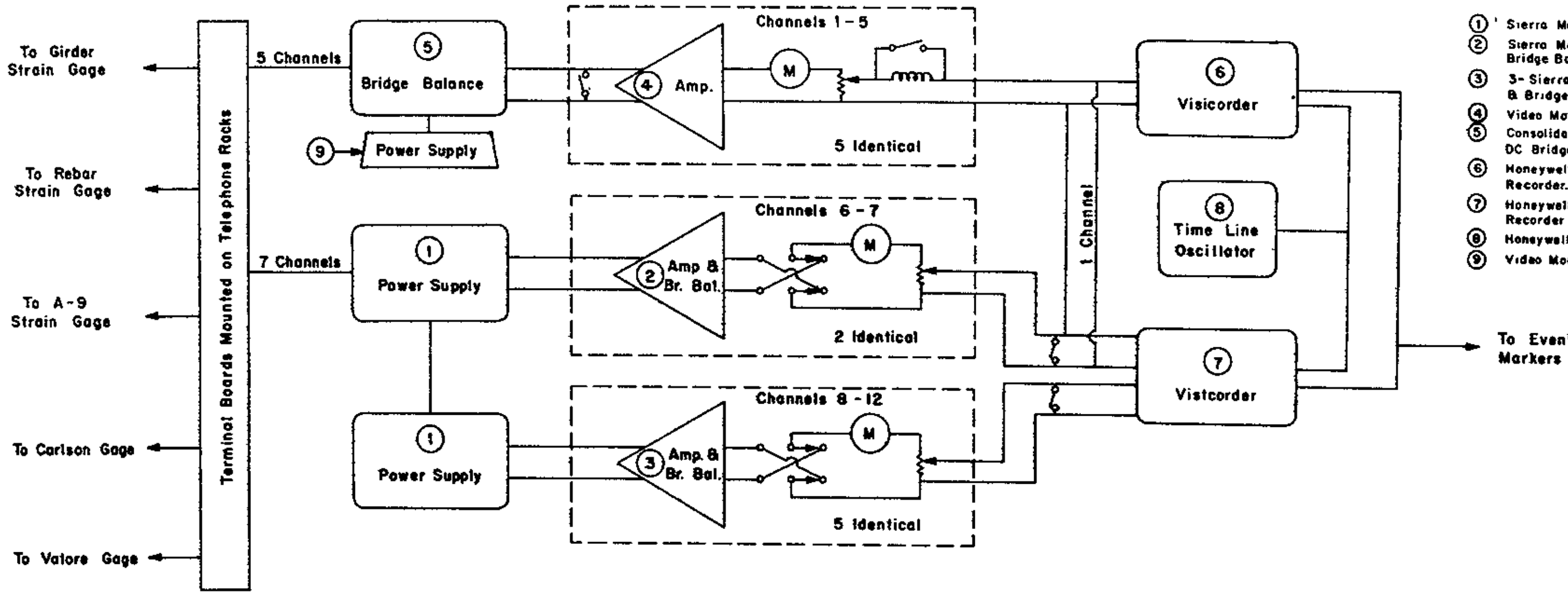
Two oscillograph recorders were used to record the dynamic information from the 12 data channels. The two oscillographs were eight channel Honeywell Visicorder Model 906.

Basically, the oscillographs consisted of a light source, mirror galvanometers, an optical system, and a photographic paper transport system. The mirror galvanometer was specially constructed so that its deflection would closely follow the instantaneous current coming from the amplified data channels. The mirror on the galvanometer projected a moving light beam onto a roll of moving photographic recording paper. This produced an immediately readable record without the inconvenience of developing the oscillograph record. The Visicorder records are permanent unless they are subjected to sunlight. Exposure to sunlight or long time exposure to fluorescent light will fade out the record.

The mirror galvanometers used in all the oscillographs were Heiland V40-350C galvanometers. The galvanometers had a natural frequency of 40 cps. With a damping resistor of 350 ohms in parallel, the galvanometers were linear within 5% at 24 cps.



WEBBER CREEK BRIDGE INSTRUMENTATION



IDENTIFICATION KEY

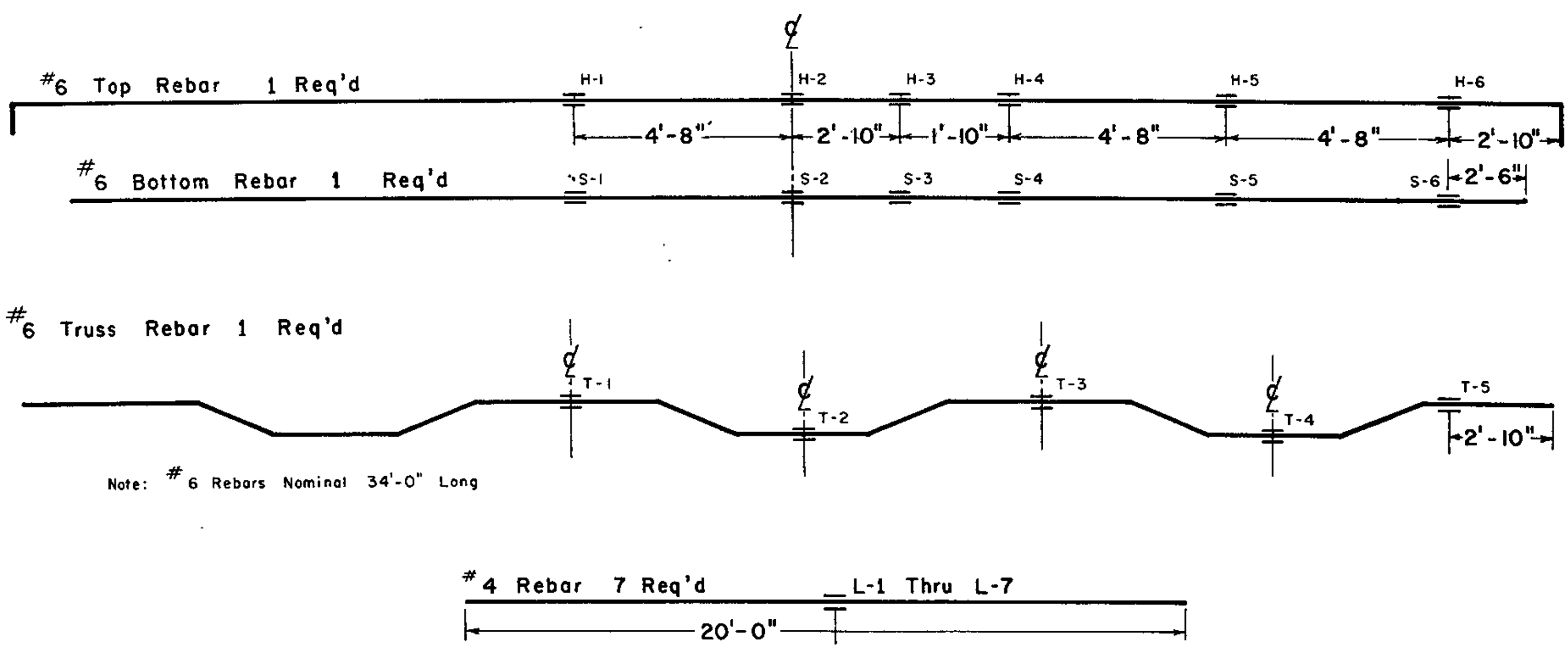
1. Sierra Model 118, Channel Carrier Power Supply.
2. Sierra Model 115, 2 Channel Carrier Amplifier & Bridge Balance
3. 3- Sierra Model 111, 2 Channel Carrier Amplifier & Bridge Balance.
4. Video Model 72R, DC Amplifier.
5. Consolidated Electrodynamics No. 8-108, 8 Chan. DC Bridge Balance.
6. Honeywell Visicorder Model 906 B, 8 Channel Recorder.
7. Honeywell Visicorder Model 906, 8 Channel Recorder
8. Honeywell Time Line Oscillator
9. Video Model SR 1000, Strain Gage Power Supply.

INSTRUMENTATION SYSTEM FOR WEBBER CREEK RIGHT BRIDGE

FIGURE 2

WEBBER CREEK BRIDGE

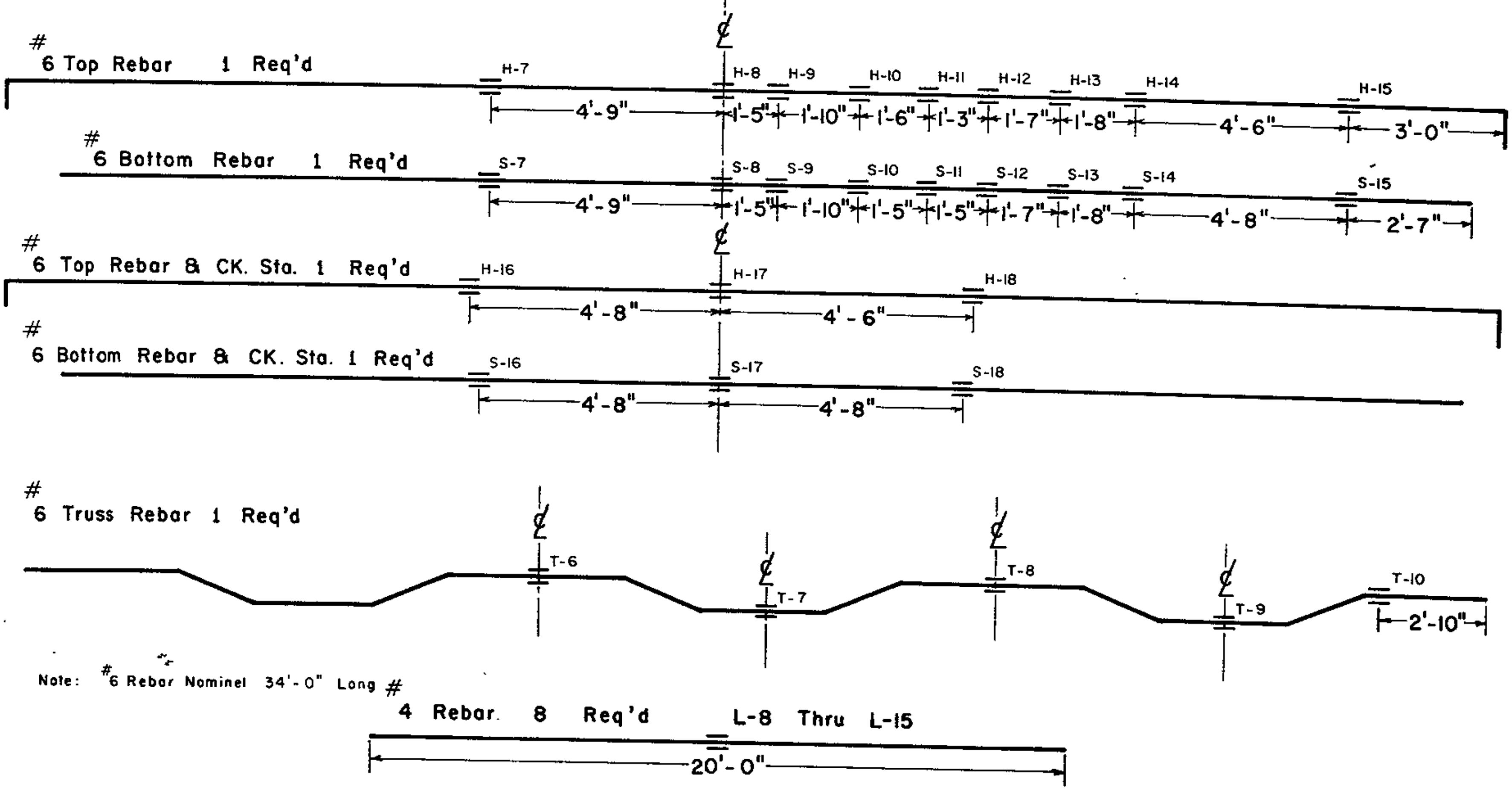
STRAIN GAGE LOCATIONS ON REBARS RIGHT BRIDGE 1/4 SPAN



SCALE – NONE

WEBBER CREEK BRIDGE

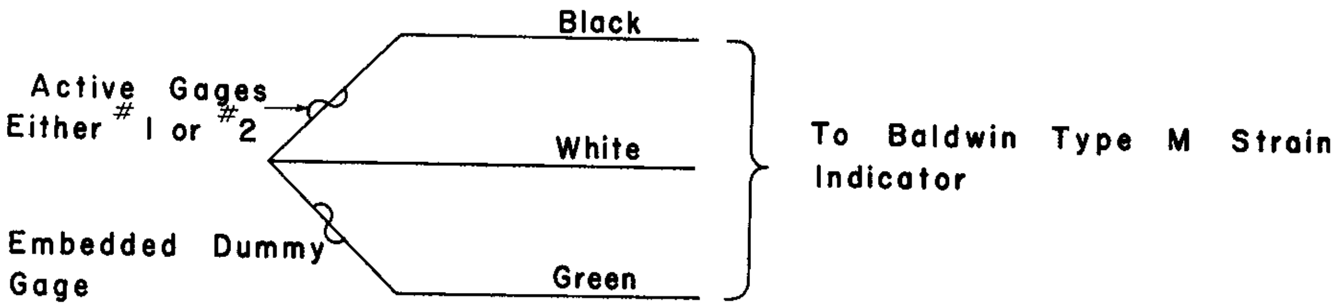
STRAIN GAGE LOCATIONS ON REBARS RIGHT BRIDGE 1/2 SPAN & CHECK STATION



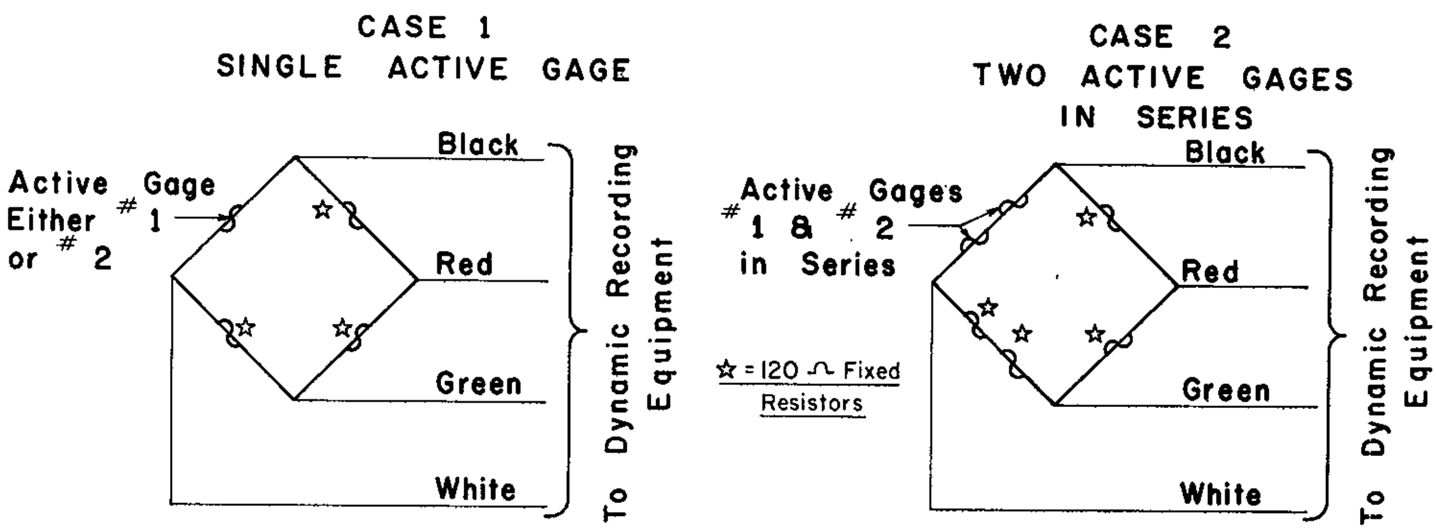
SCALE - NONE

Figure 4

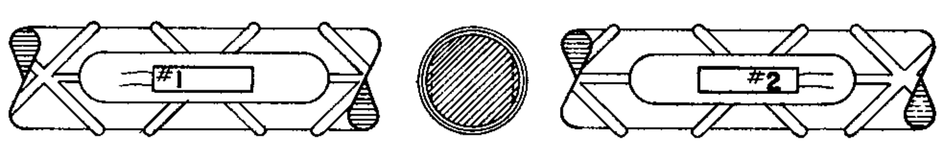
ELECTRICAL WHEATSTONE BRIDGE HOOK-UP AND PHYSICAL PLACEMENT OF STRAIN GAGES ON ALL REBARS USED ON THE WEBBER CREEK BRIDGE TEST.



STATIC STRAIN MEASUREMENTS



DYNAMIC STRAIN MEASUREMENTS



PHYSICAL PLACEMENT OF STRAIN GAGES ON REBARS

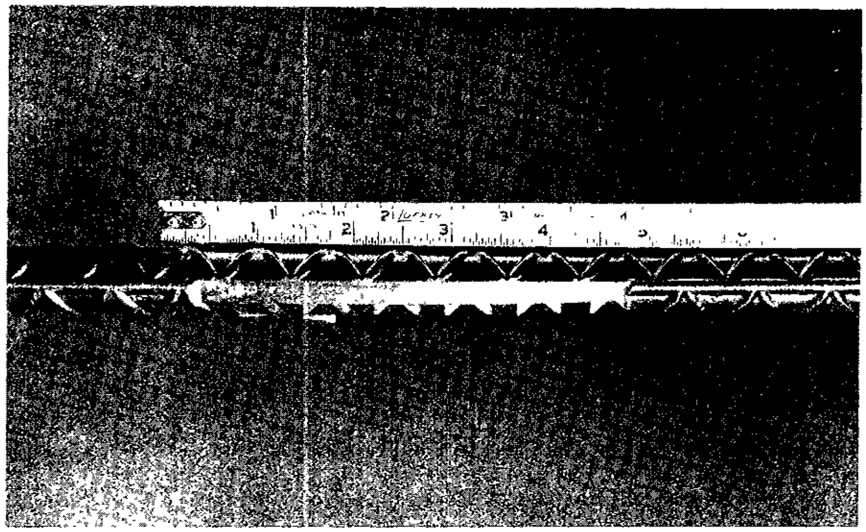


Figure 6

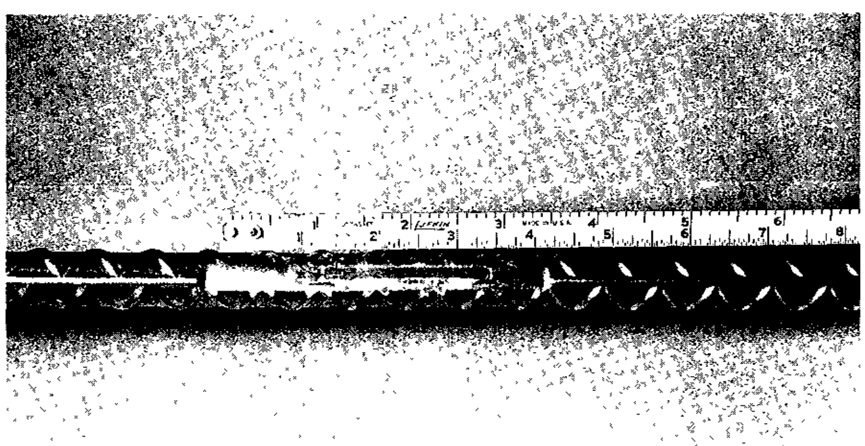


Figure 7

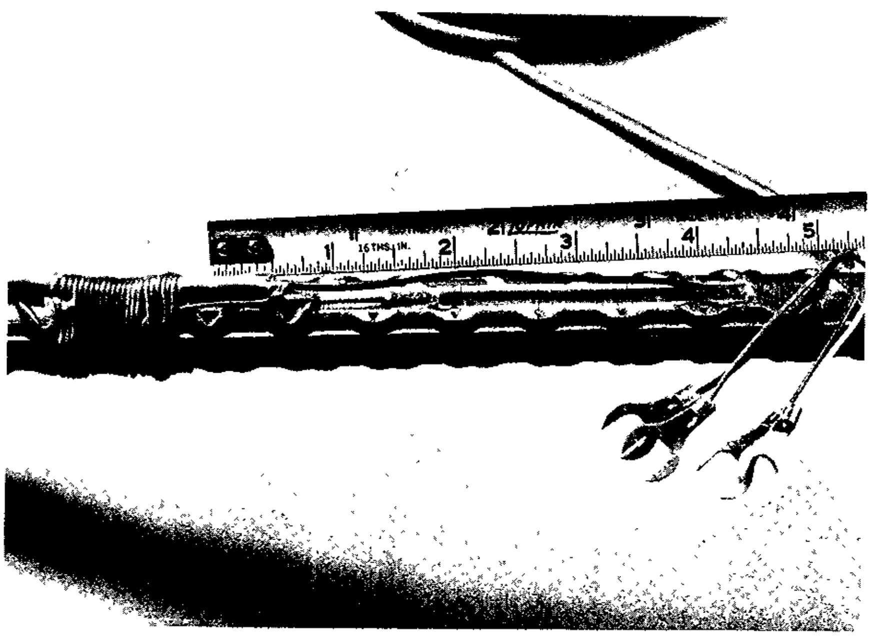
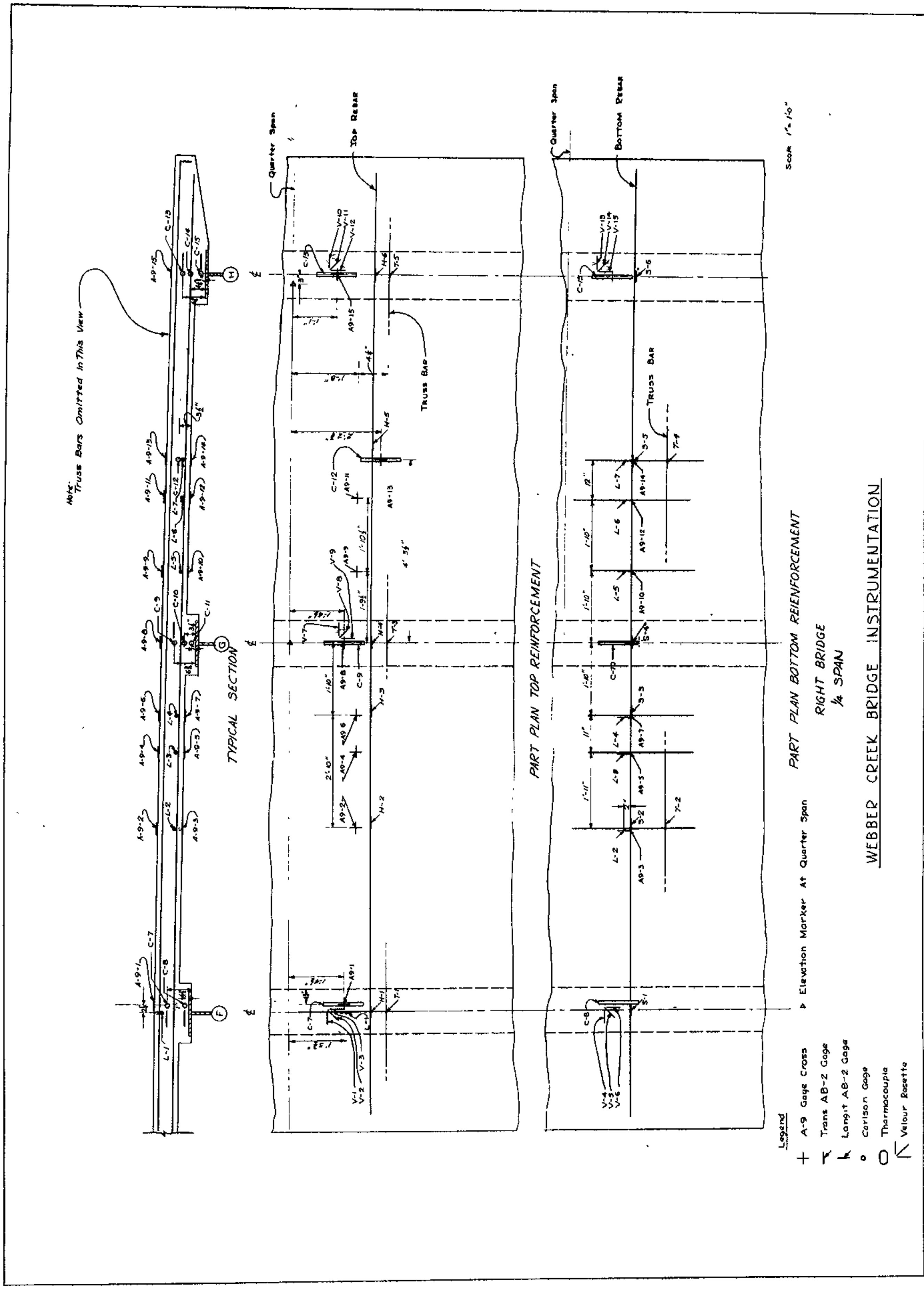


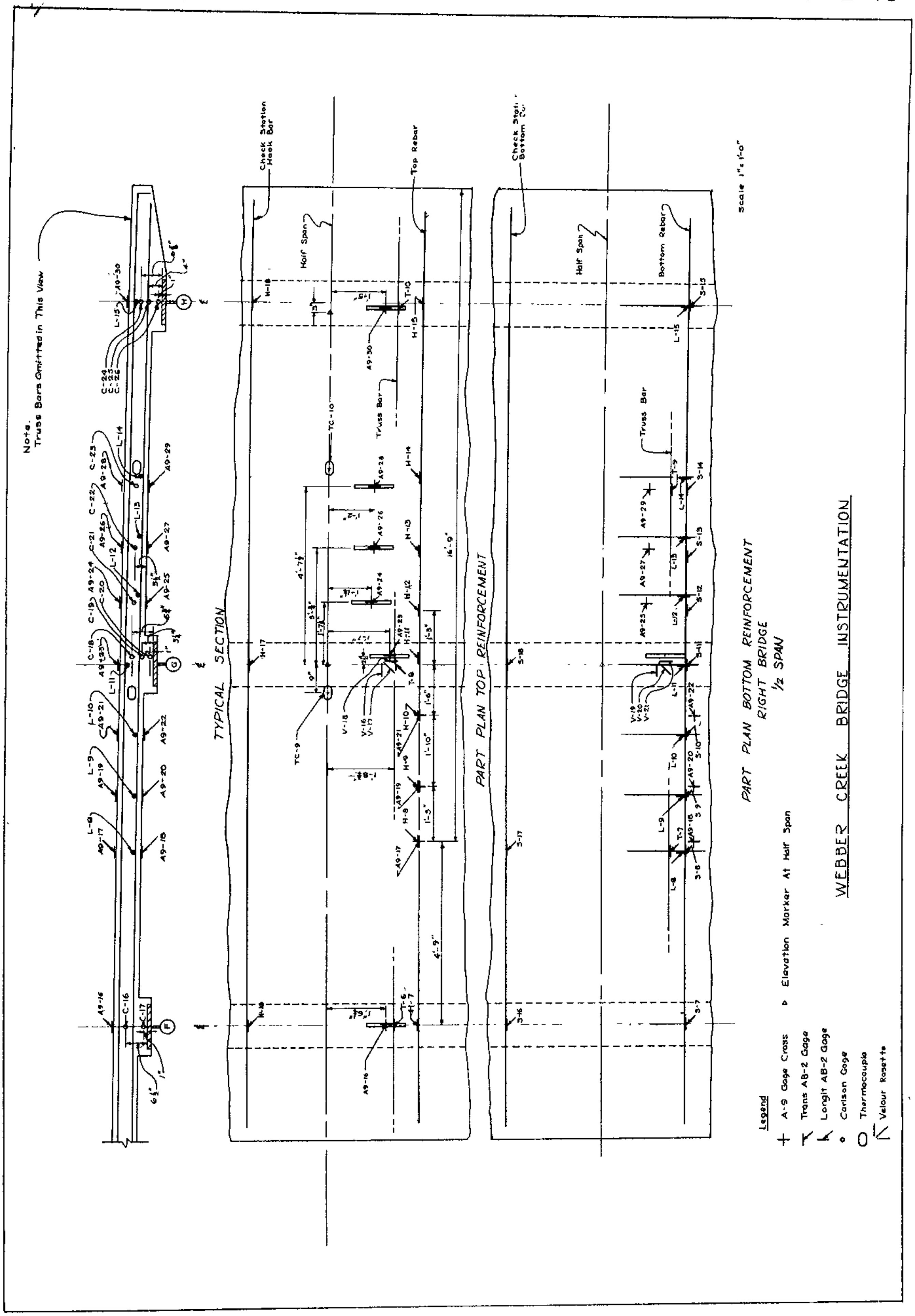
Figure 8

FIGURE 9



WEBBER CREEK BRIDGE INSTRUMENTATION
RIGHT BRIDGE
1/4 SPAN
TYPICAL SECTION
PART PLAN TOP REINFORCEMENT
PART PLAN BOTTOM REINFORCEMENT
Note: Truss Bars Omitted In This View
Top Rebar
Bottom Rebar
Truss Bar
Quarter Span
Scale 1"=1'0"
Legend
A-9 Gage Cross
Trans AB-2 Gage
Longit AB-2 Gage
Carlson Gage
Thermocouple
Valour Rosette
Elevation Marker At Quarter Span

FIGURE 10



WEBBER CREEK BRIDGE INSTRUMENTATION
PART PLAN BOTTOM REINFORCEMENT
RIGHT BRIDGE
1/2 SPAN
TYPICAL SECTION
PART PLAN TOP REINFORCEMENT
Note.
Truss Bars Omitted in This View
Check Station Hook Bar
Top Rebar
Half Span
Truss Bar
Bottom Rebar
Scale 1" = 1'-0"
Legend
A-9 Gage Cross
Trans AB-2 Gage
Longit AB-2 Gage
Carlson Gage
Thermocouple
Velour Rosette
Elevation Marker At Half Span

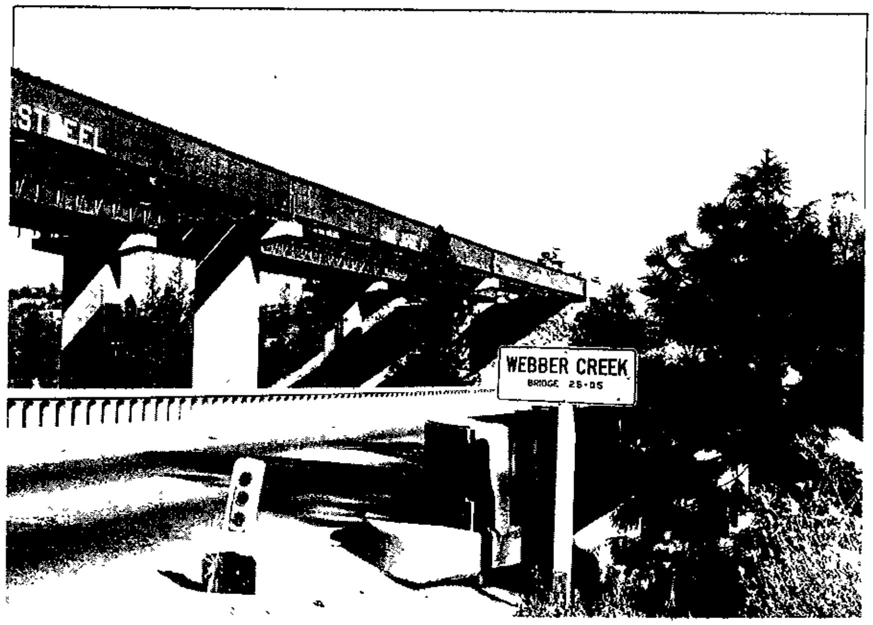


Figure 11

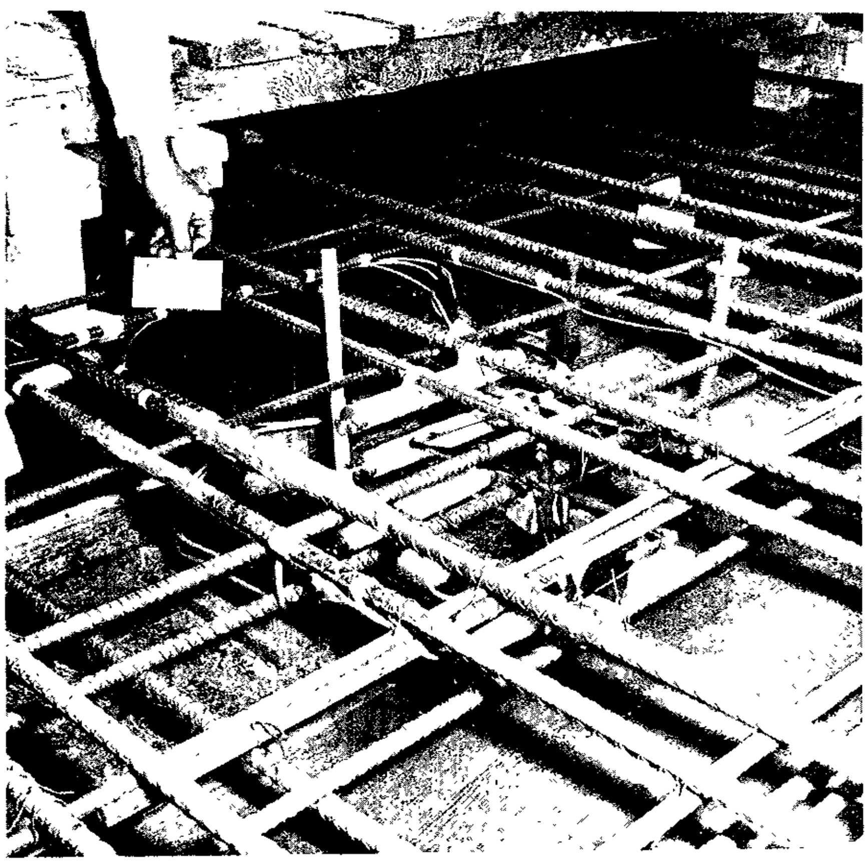


Figure 12

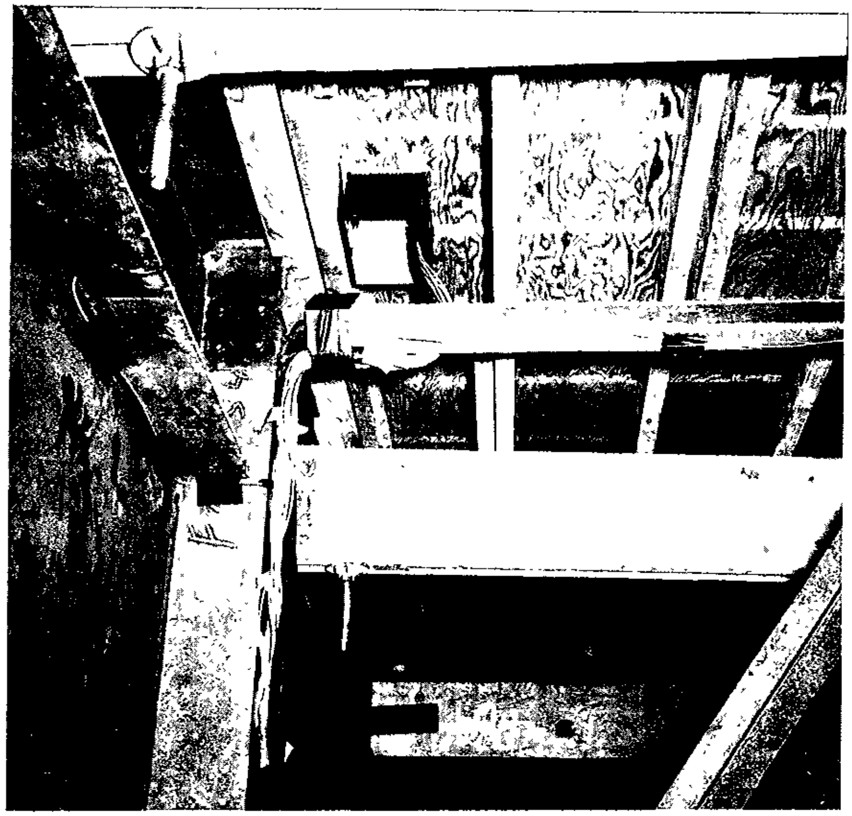


Figure 13

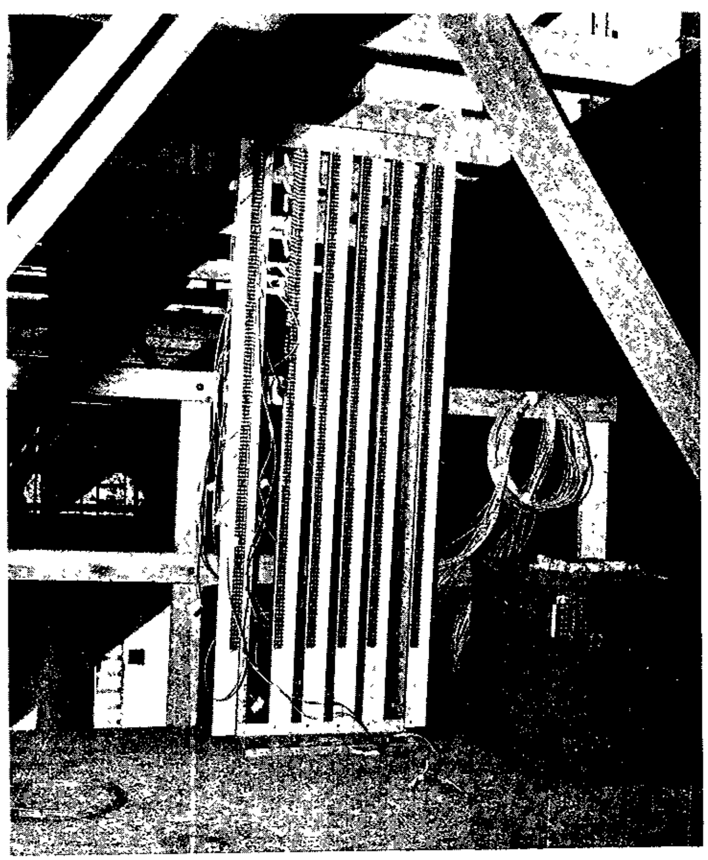


Figure 14

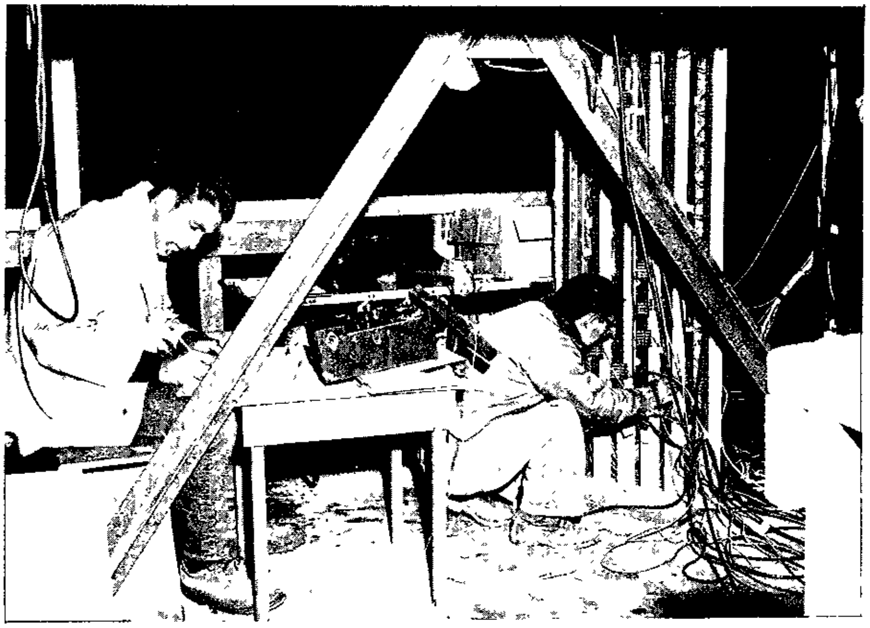


Figure 15

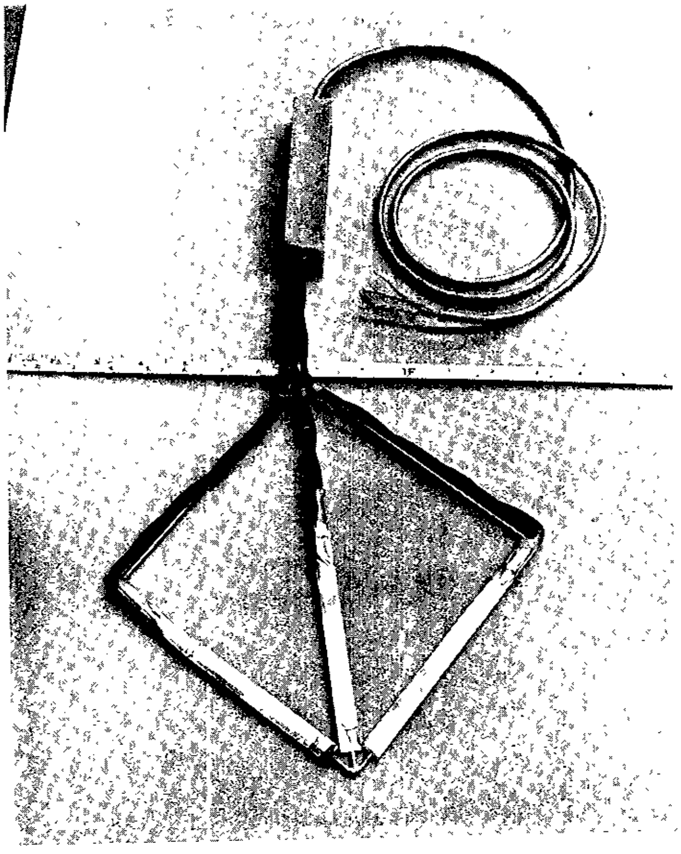
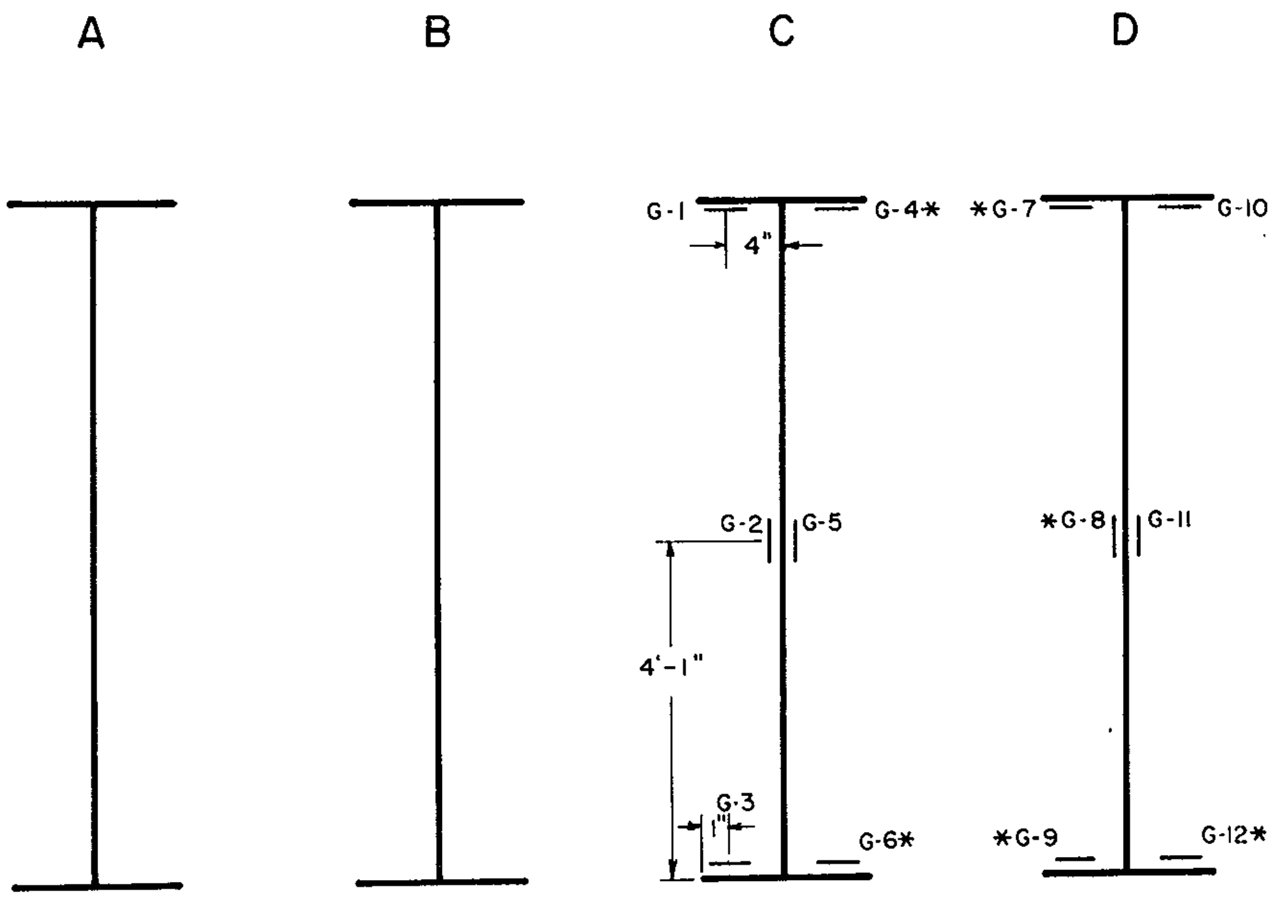


Figure 16

WEBBER CREEK BRIDGE
GIRDER GAGES

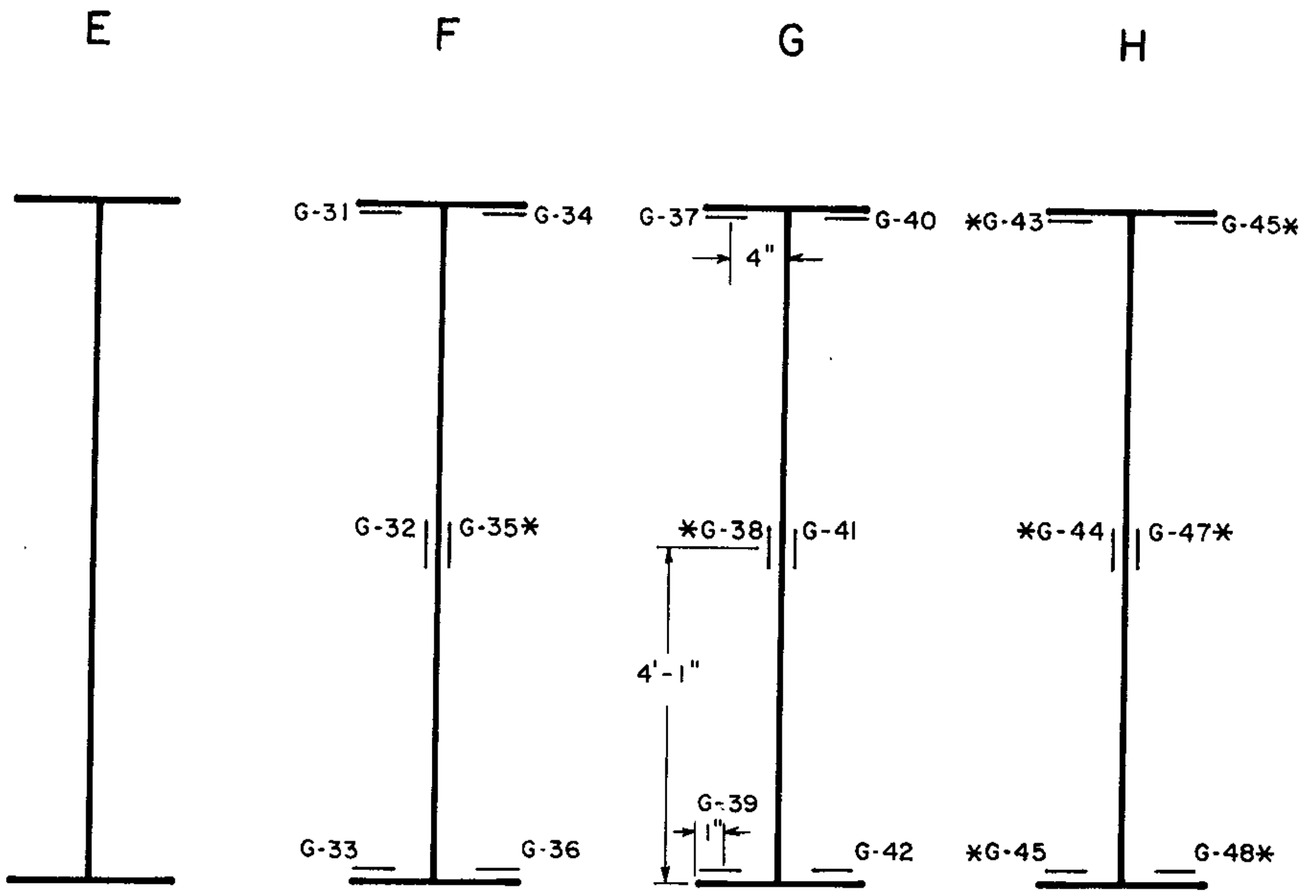
Location of Girder Strain Gages & Dummy Gages
on Left Bridge at Nominal Half Span
(Half Span = 67' - 9 5/8")



Gages Located 65' – 9 5/8" From Sacramento End.
* Indicates Dummy Gage in The Same Vicinity.

WEBBER CREEK BRIDGE
GIRDER GAGES

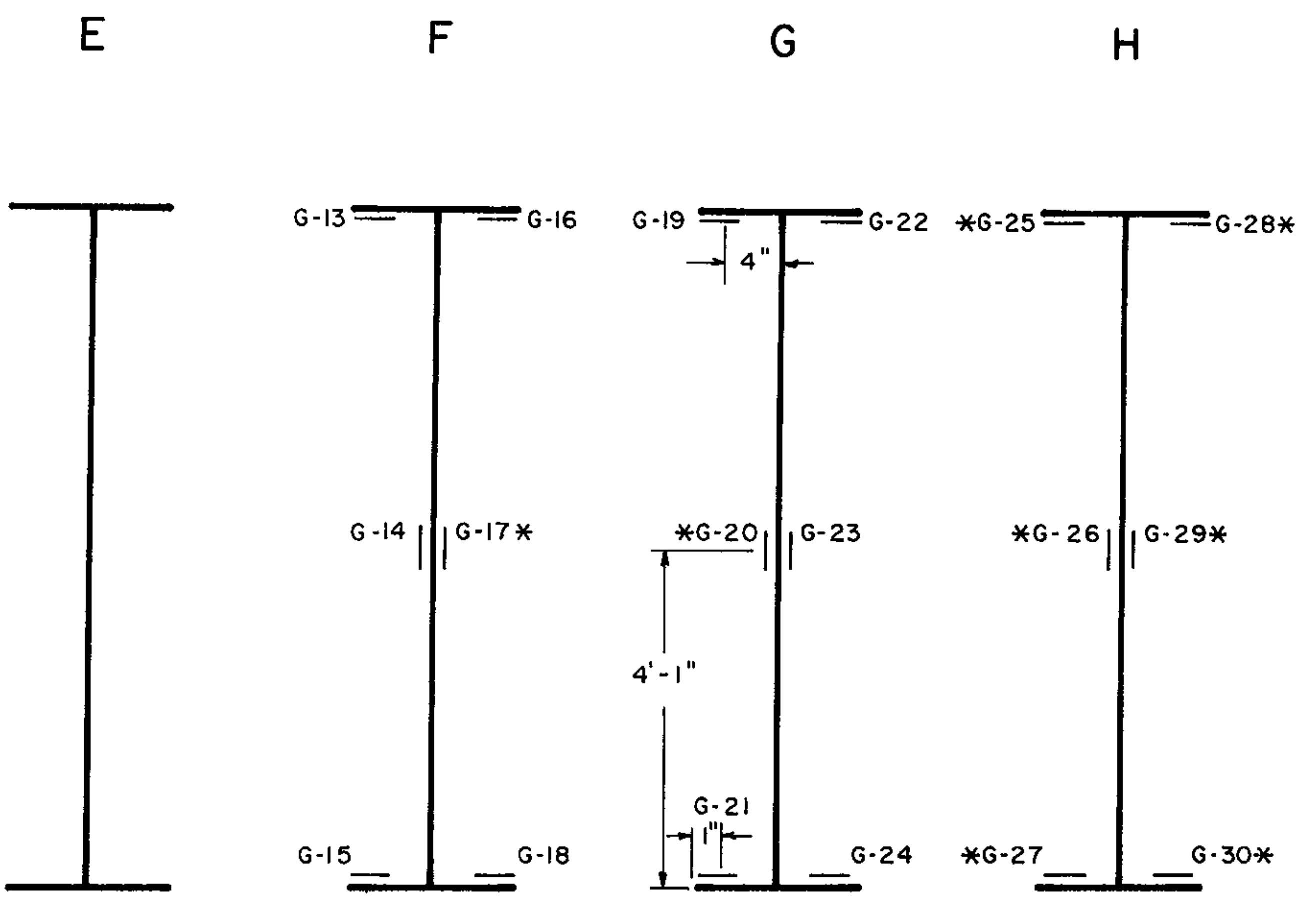
Location of Girder Strain Gages & Dummy Gages on Right Bridge at Nominal Half Span
(Half Span = 67'- 9 5/8")



Gages Located 65' - 9 5/8" From Sacramento End.
* Indicates Dummy Gage in The Same Vicinity.

WEBBER CREEK BRIDGE
GIRDER GAGES

Location of Girder Strain Gages & Dummy Gages on Right Bridge at Nominal Quarter Span.
(Quarter Span = 33'- 10 13/16")



Gages Located 31' - 10 13/16" From Sacramento End.
* Indicates Dummy Gage in The Same Vicinity.

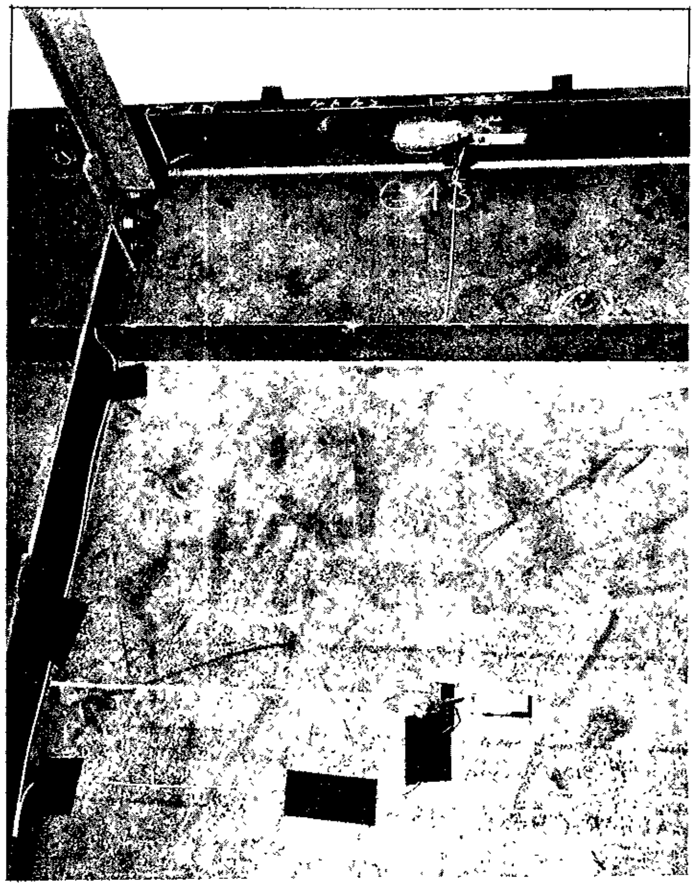


Figure 20

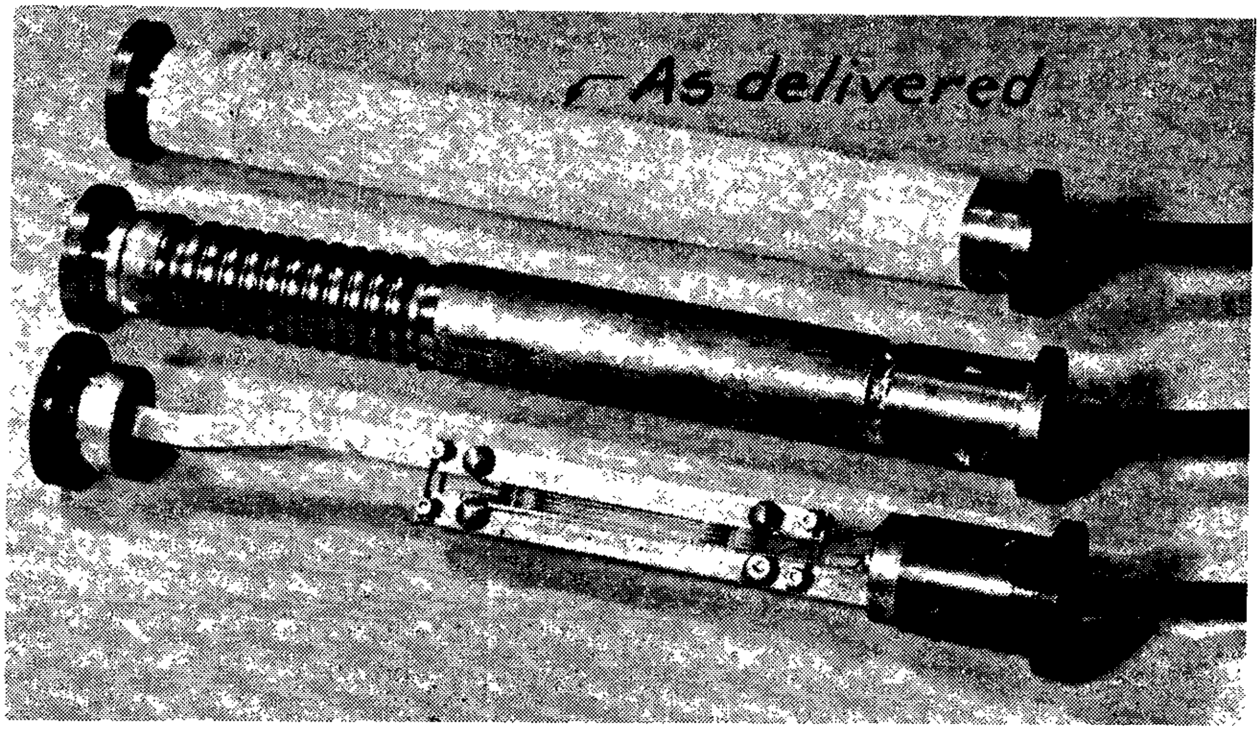


Figure 21

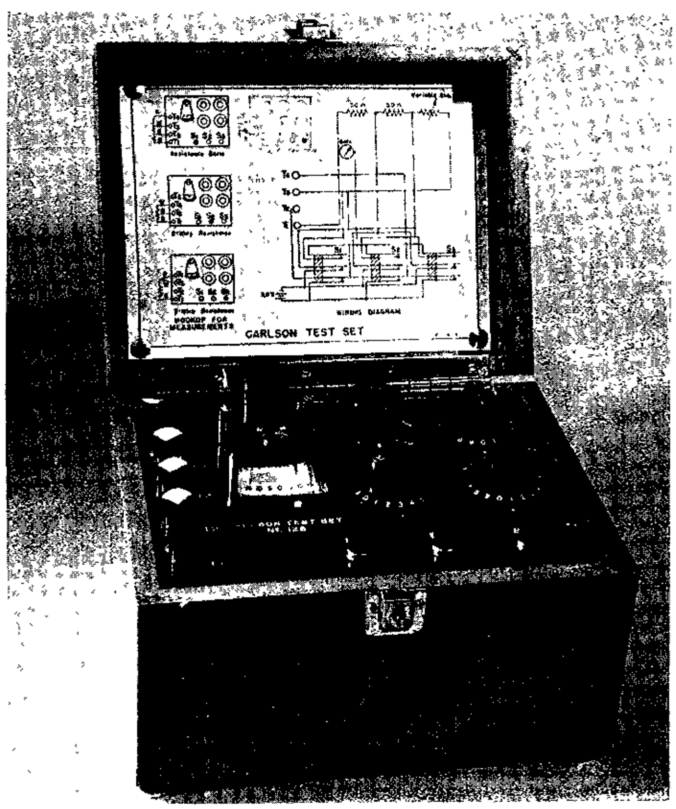
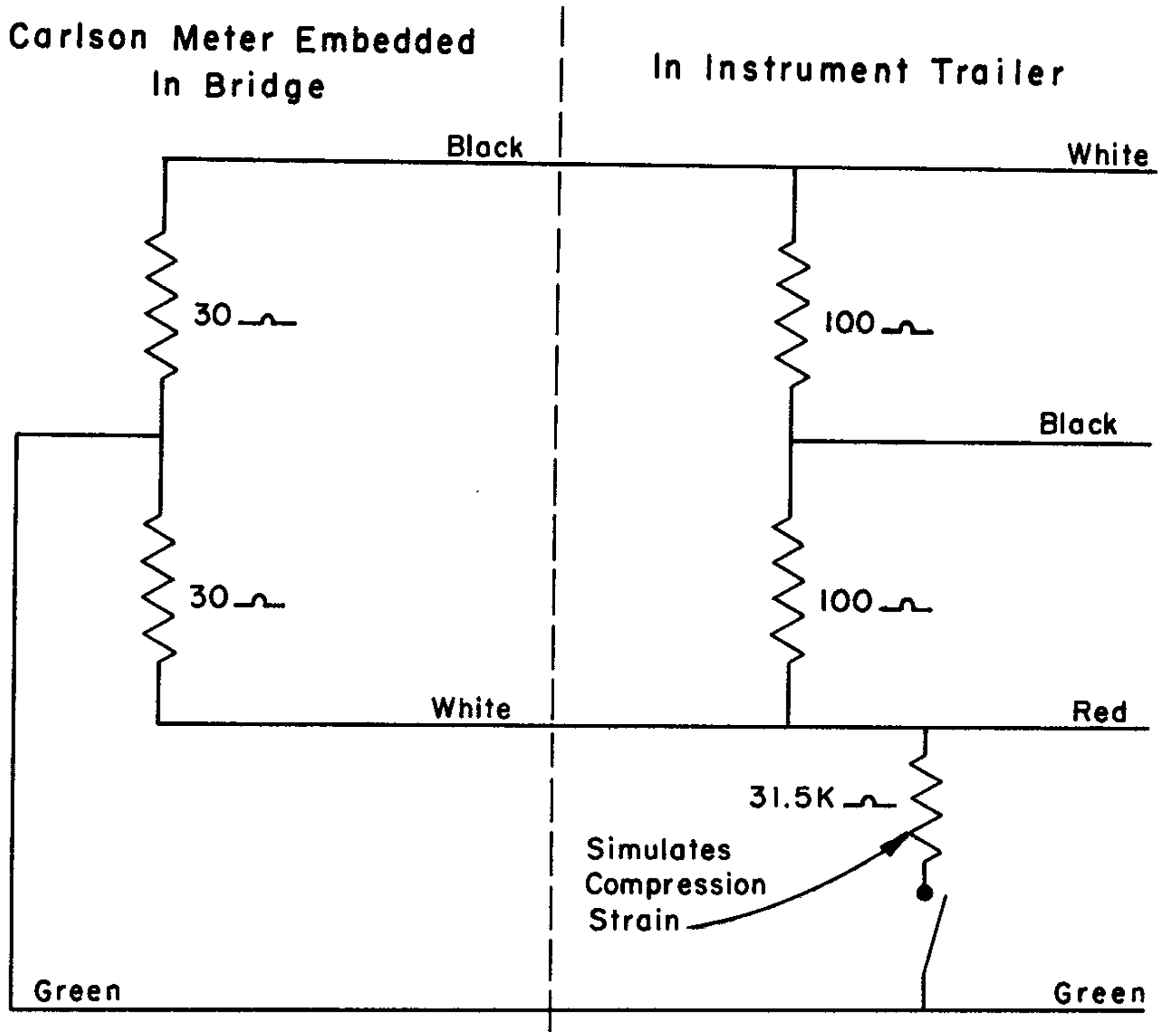


Figure 22



ELECTRICAL HOOKUP OF CARLSON METERS
FOR
DYNAMIC RECORDING OF CONCRETE STRAINS

Figure 24

CORRECTION FACTOR FOR CABLE LENGTH RESISTANCES -- WEBBER CREEK BRIDGE

Channel	Girder Gages 120 Ω	Rebar Gages 120 Ω	Rebar Gages 240 Ω (Series)	Carlson Gages 30 Ω	A-9 Gages 300 Ω	Valore Gages 300 Ω	4 R_1 ohms
1	1.10	1.10	1.05	1.39	1.04	1.04	11.8
2	1.04	1.04	1.02	1.17	1.02	1.02	5.2
3	1.04	1.04	1.02	1.17	1.02	1.02	5.3
4	1.04	1.04	1.02	1.17	1.02	1.02	5.3
5	1.04	1.04	1.02	1.17	1.02	1.02	5.3
6	1.04	1.04	1.02	1.17	1.02	1.02	5.2
7	1.10	1.10	1.05	1.39	1.04	1.04	11.7
8	1.04	1.04	1.02	1.17	1.02	1.02	5.3
9	1.10	1.10	1.05	1.39	1.04	1.04	11.8
10	1.04	1.04	1.02	1.17	1.02	1.02	5.3
11	1.04	1.04	1.02	1.17	1.02	1.02	5.4
12	1.04	1.04	1.02	1.17	1.02	1.02	5.0

$$1 + \frac{4R_1}{R}$$

Strains read off oscillographs must be multiplied by $1 + \frac{4R_1}{R}$ to obtain true strains.

Multiplication factors are tabulated above for each channel and type of gages used.

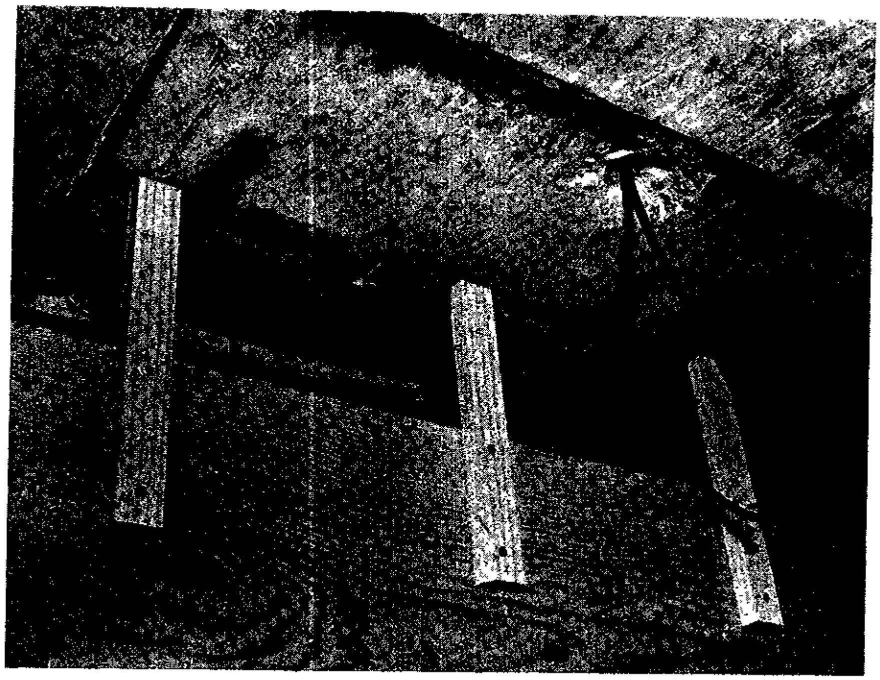
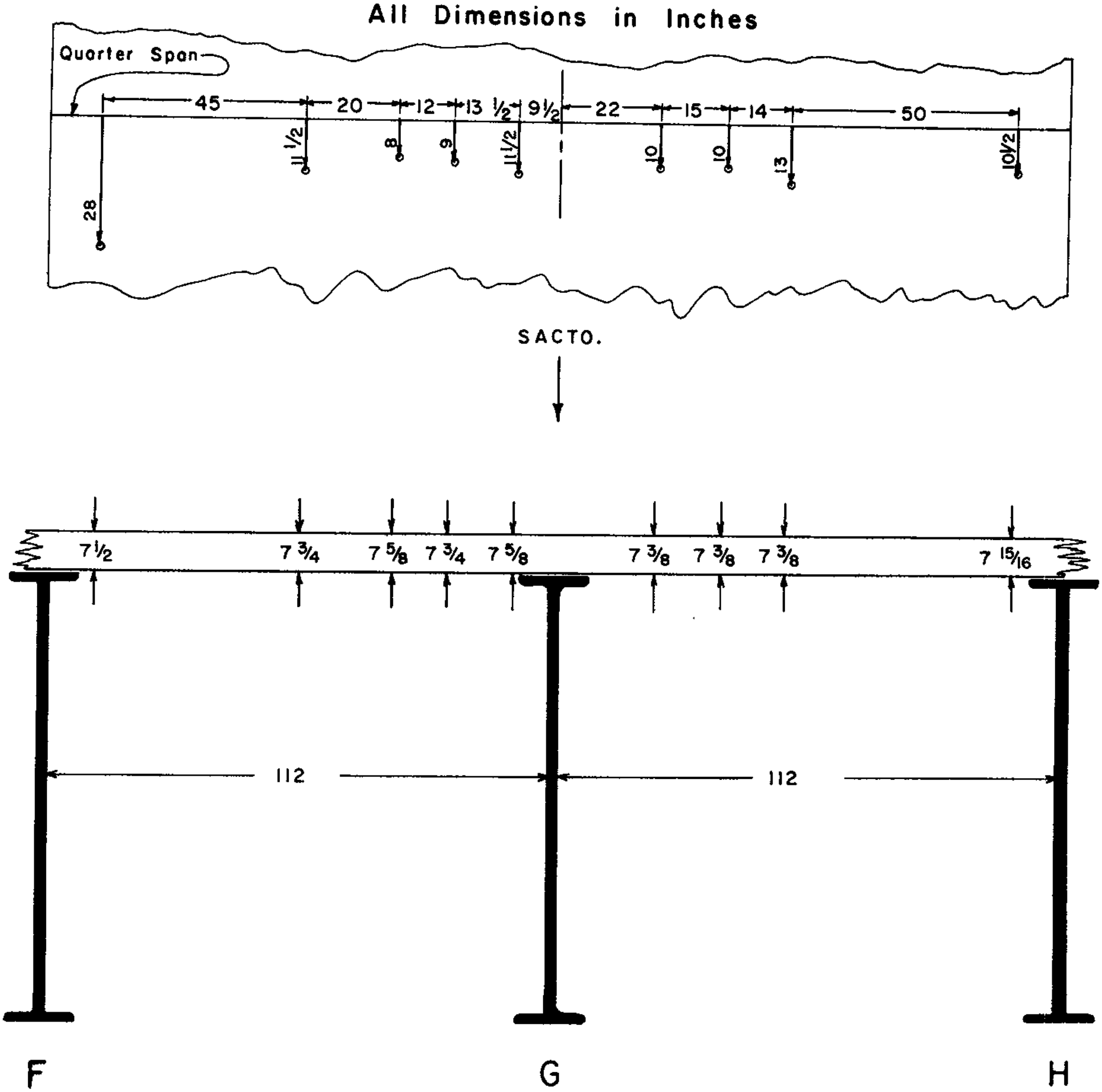


Figure 25

WEBBER CREEK BRIDGE
CONCRETE DECK SLAB THICKNESS

And Locations From Quarter Span
All Dimensions in Inches



WEBBER CREEK BRIDGE
CONCRETE DECK SLAB THICKNESS

And Locations From Half Span
All Dimensions in Inches

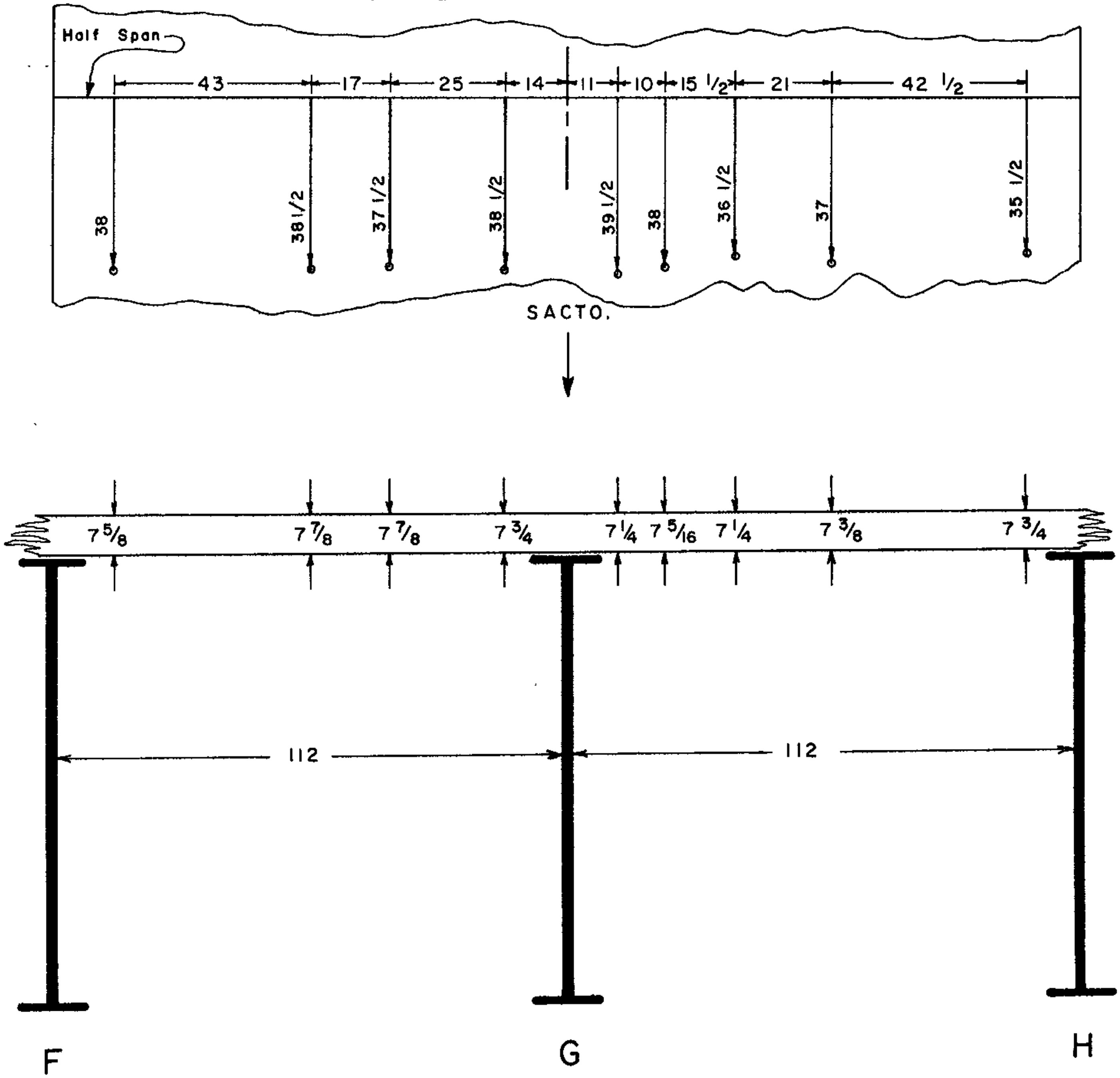


Figure 28

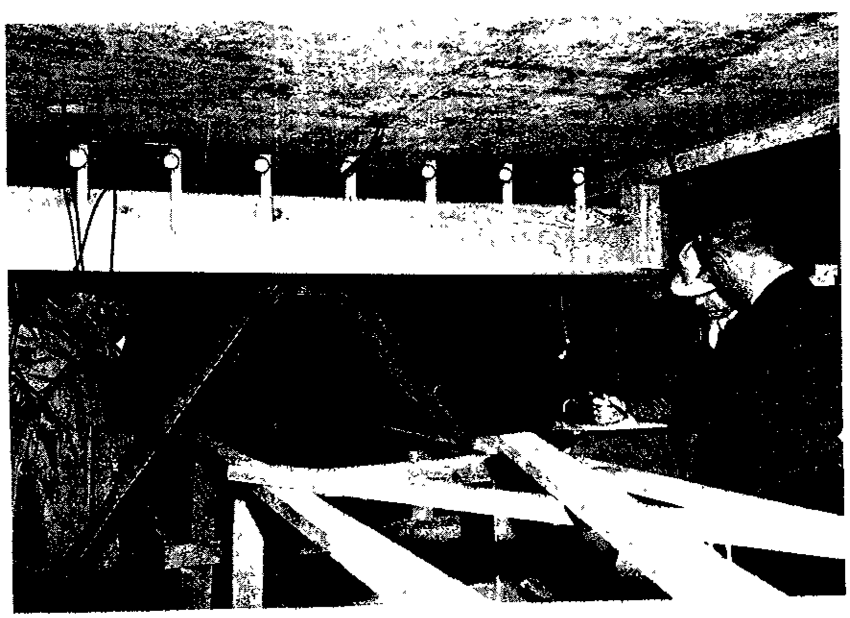


Figure 29

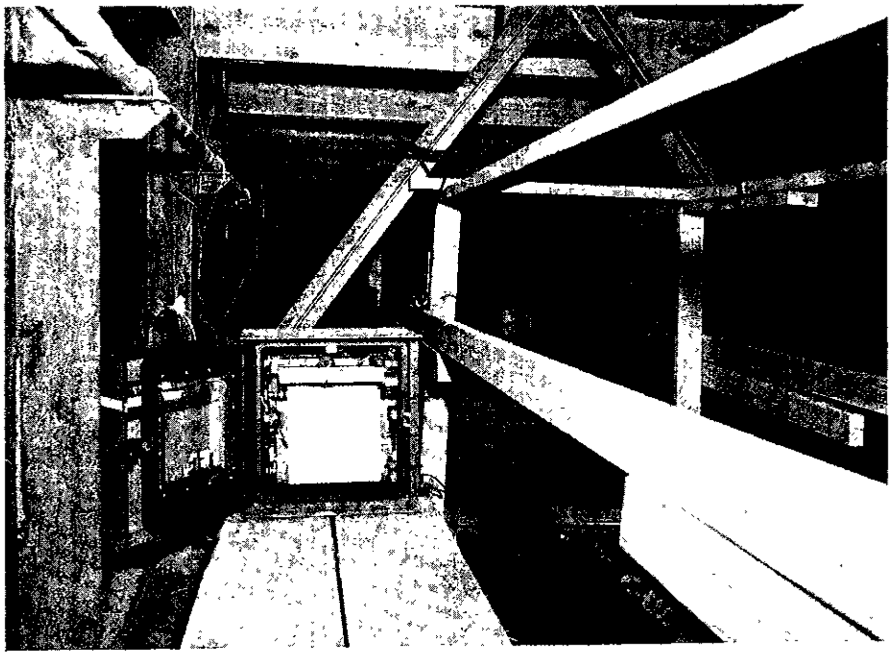


Figure 30

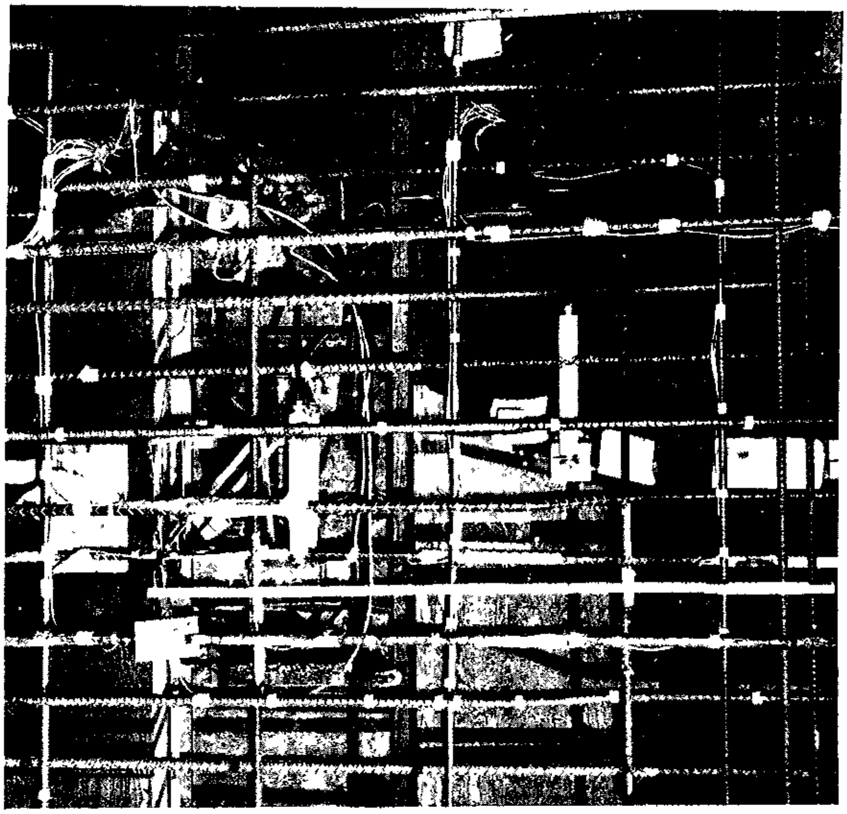


Figure 31

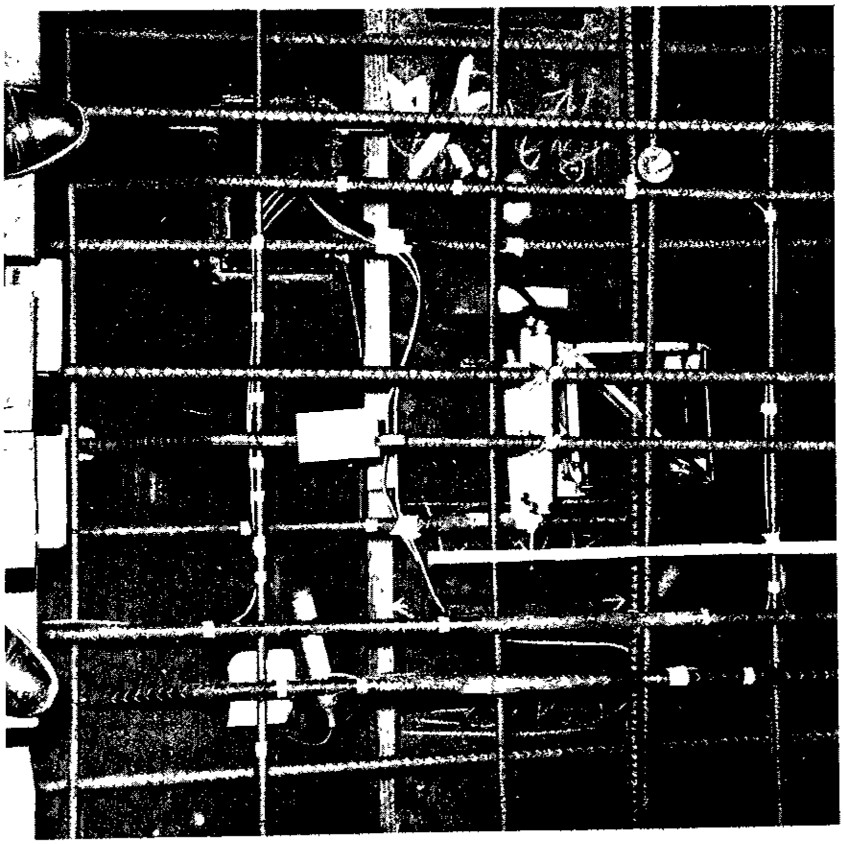


Figure 32

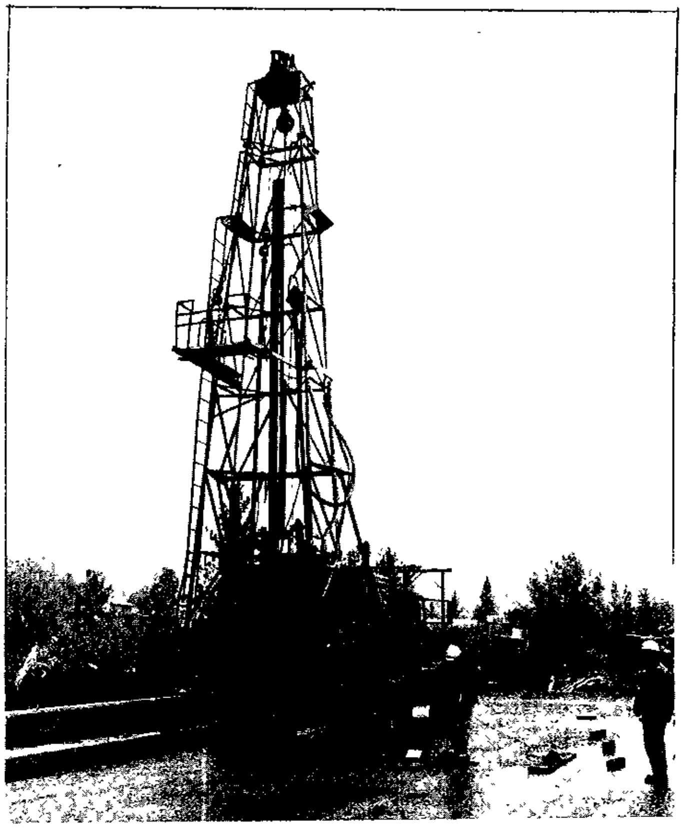


Figure 33

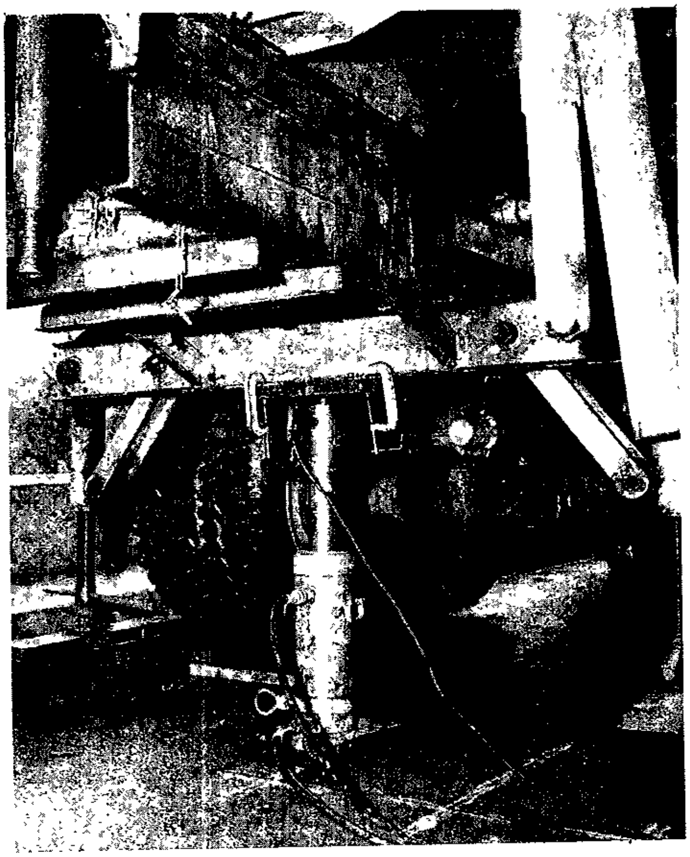


Figure 34

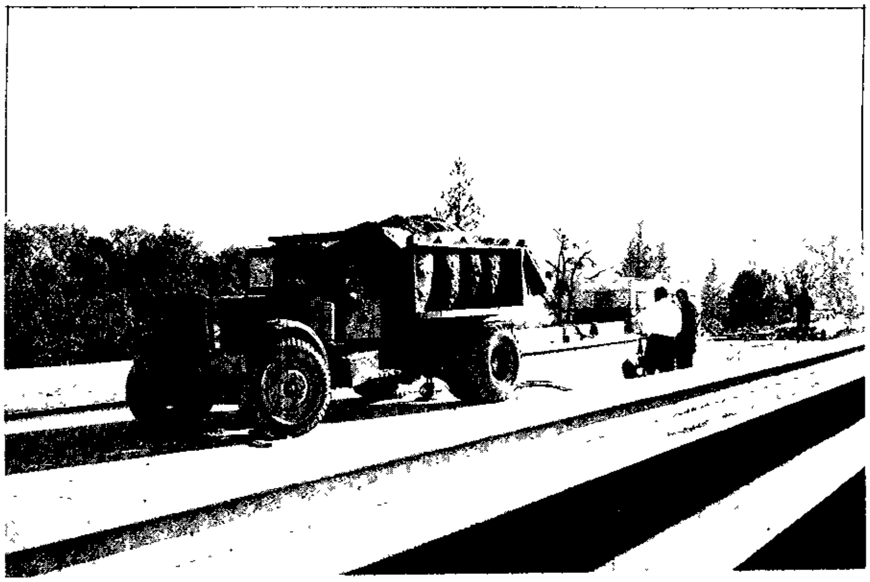


Figure 35

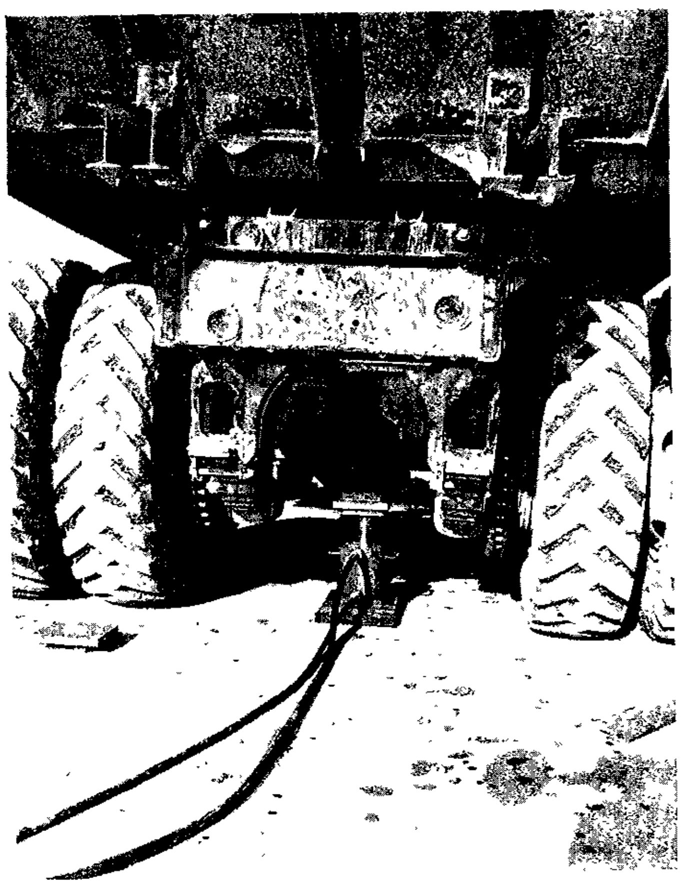


Figure 36

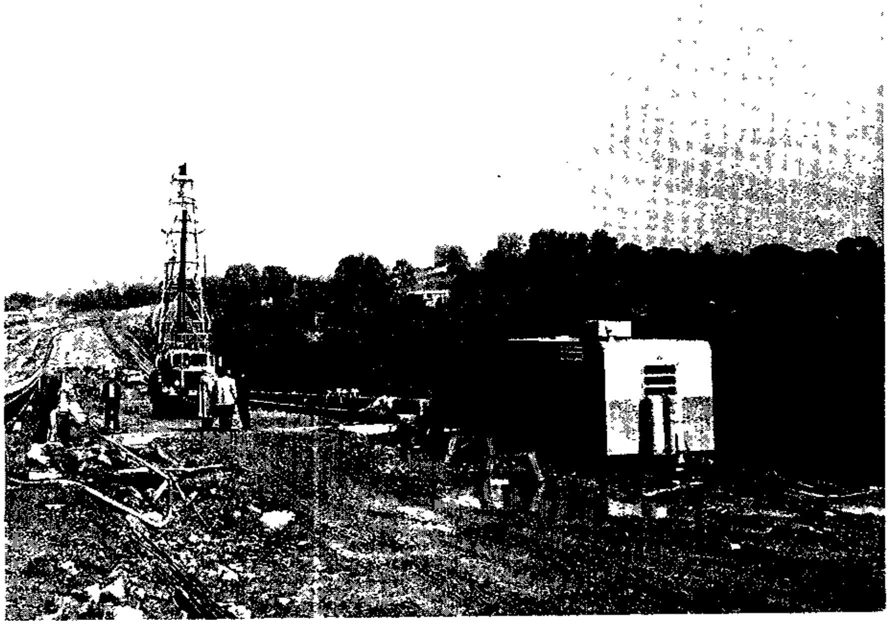


Figure 37

STRAIN SIMULATION

	Micro-inches per Inch			
	320 K	500 K	1 meg	2 meg
<u>Girder Gages</u>				
FAB-50-12-S6 (2.06 GF)	182	116	58	29
FAB-50-12-S6 (2.09 GF)	179	114	57	29
<u>Rebar Gages</u>				
AB-2 (120Ω) (2.10 GF)	177	114	57	29
AB-2 (240Ω) (2.10 GF)	354	228	114	58
A-9 crosses (2.09 GF)	448	287	144	72
A-9 crosses (2.13 GF)	439	281	140	70
Valore Gages (2.09 GF)	448	287	144	72