Main Heads of Accounts.	Sub-heads of Accounts.	Quantity.	Cost per unit.	Total Expenditure.
IV. Bridge-work—*contd.*	*(A) Major Bridge—contd.*	C. ft.	Per 100 c. ft.	
	(9). *Brick masonry in lime mortar—*		Rs. A. P.	Rs.
	(a) Kiln charges	247,034	2 3 10	5,535
	(b) Ballast train charges, etc.	...	2 10 10	6,611
	(c) Cost of bricks, lime and putting in work ...	...	32 0 9	79,172
	(d) Carriage of lime	...	0 13 3	2,041
	(e) Depreciation on plant, stores, and tools ...	...	3 2 11	7,872
	(f) Workshop charges	...	0 11 11	1,840
	(g) Supervision	...	0 5 2	799
	(h) Miscellaneous	...	1 0 6	2,545
	(i) Rain and flood damages	...	3 6 0	8,344
	(j) Janeshnagar Station	...	2 6 3	5,906
	Total ...	247,034	48 13 5	1,20,665
	(10). *Arch masonry in cement—*			
	(a) Cost and freight of cement	2,522	22 10 11	572
	(b) Kiln charges	...	2 14 11	74
	(c) Cost of bricks and putting in work ...	...	38 3 7	964
	(d) Workshop charges	...	4 12 2	120
	(e) Supervision	...	2 6 0	60
	Total ...	2,5	70 15 7	1,790
	(11). *Steel work for joining wells*	Nil	Nil	Nil
	(12). *Corbelling stones—*			
	(a) Cost of Beas bridge rejected bed stones and setting same	300	Per c. ft. 1 2 8	350
	(b) Freight from quarries	...	0 2 3	43
	(c) Miscellaneous	...	0 1 10	34
	Total ...	300	1 6 9	427

	Tons.	Per ton.	Rs.
(13). *Girders (cost)*—			
(*a*) Cost at Karachi	3,316·86	217 4 0	7,20,597
(*b*) Freight from Karachi	...	18 7 8	61,293
Total ...	3,316·86	235 11 8	7,81,890
(14). *Girders (erecting)*—			
(*a*) Unloading, erecting, and rivetting ...	3,316·86	22 6 9	74,380
(*b*) Janeshnagar Station	...	0 10 11	2,258
(*c*) Depreciation on plant, staging timber, stores, tools etc.	...	2 6 9	8,039
(*d*) Freight on ditto ditto ...	...	6 1 7	20,237
(*e*) Dismantling staging due to late arrival of girders	...	1 5 3	4,401
(*f*) Labour in driving piles for staging ...	...	0 11 3	2,335
(*g*) Workshop charges	...	2 5 6	7,764
(*h*) Supervision	...	0 10 7	2,188
(*i*) Miscellaneous	..	3 5 5	11,076
Total ...	3,316·86	40 0 0	1,32,678
	Weight of girders Tons.		
(15). *Girders (painting)*—			
(*a*) Cost of oil in Lahore	3,316·86	3 4 10	10,946
(*b*) Freight on oil from Lahore	...	0 1 5	300
(*c*) Scraping and painting	...	3 13 2	12,679
(*d*) Depreciation on stores, tools and plant ...	...	1 7 2	4,799
(*e*) Freight on ditto ditto ...	...	0 4 7	947
(*f*) Workshop charges	...	0 1 9	373
(*g*) Supervision	...	0 0 10	173
(*h*) Miscellaneous	...	0 2 3	470
Total ...	3,316·86	9 4 0	30,687

Main Heads of Accounts.	Sub-heads of Accounts.	Quantity.	Cost per unit.	Total Expenditure
IV. Bridge work--*contd* ...	(*A*) *Major Bridge – contd.*	C. ft.	Per c. ft.	
	(16). *Timber Guards*—		Rs. A. P.	Rs.
	(*a*) Cost of timber	2,152	2 6 2	5,132
	(*b*) Freight on ditto	...	0 1 1	142
	(*c*) Fixing in work	...	0 5 7	749
	(*d*) Depreciation on stores and tools ...	...	0 4 7	619
	(*e*) Freight on ditto ...	...	0 0 4	50
	(*f*) Workshop charges	...	0 0 7	78
	(*g*) Supervision	...	0 0 1	14
	(*h*) Miscellaneous	...	0 0 11	127
	Total ...	2,152	3 3 4	6,911
	(17) *Guide Banks, Right*—			
			Per 1,000 c. ft.	
	(*a*) Earth-work	2,950,696	5 2 8	15,255
			Per 100 c. ft.	
	(*b*) Pitching stone loaded in trucks at Delhi	1,371,360	5 1 9	70,076
	(*c*) Freight by ballast train	...	1 9 2	21,583
	(*d*) Lead in pitching	...	0 0 7	481
	(*e*) Unloading and pitching	...	1 4 8	17,715
	Total pitching stone from Delhi ...	1,371,360	8 0 2	1,09,855
	(*f*) Excavating stone from abandoned left guide bank and piers	595,417	1 7 2	8,630
	(*g*) Loading and unloading ditto ditto ...	...	0 6 9	2,515
	(*h*) Freight by ballast trains and bullock cart charges on ditto ditto	...	0 4 1	1,522

(*i*) Lead in pitching ditto ditto	...	0 7 6	2,779
(*j*) Pitching ditto ditto	...	1 7 6	8,743
Total cost of stone from abandoned bund	595,447	4 1 0	24,189
(*k*) Cost of ballast in trucks at Delhi ...	54,025	3 12 0	2,026
(*l*) Freight by ballast train ditto	...	2 5 8	1,272
(*m*) Unloading and spreading ditto	...	0 15 5	20
Total cost of ballast from Delhi	54,025	7 1 1	3.818
(*n*) Workshop charges	Feet length of bend 1,760	Per 1 ft. 0 4 6	496
(*o*) Stores and petty tools	..	0 7 9	49
(*p*) Freight on ditto	..	0 0 3	27
(*q*) Supervision	...	0 5 5	599
(*r*) Miscellaneous	...	2 2 0	3,741
Total Workshop Charges ...	1,760	3 3 11	5,712
Total Guide Banks, Right (Cost) ...	...	...	1,58,829
(18). *Guide Bank, Left—* (*a*) Earth-work	C. ft. 2,558,261	Per 1,000 c. ft. 5 5 2	13,626
(*b*) Pitching stone loaded in trucks at Delhi	C. ft. 600,386	Per 100 c. ft. 4 0 9	24,296
(*c*) Freight by ballast train from Delhi ...	...	2 2 2	12,833
(*d*) Lead in pitching ditto ditto	...	0 0 4	131
(*e*) Unloading and pitching ditto	..	1 6 3	8,344
Total cost of pitching stone ...	600,386	7 9 6	45,604

Main Heads of Accounts.	Sub-heads of Accounts.	Quantity.	Cost per unit.	Total Expenditure.
IV. Bridge-work—*contd.*	(A) *Major Bridge*—contd.	C. ft.	Per 100 c. ft.	
	(18). *Guide Bank, Left*—concld.		Rs. A. P.	Rs.
	(*f*) Excavating stone from abandoned portion of the guide bank	366,880	1 2 8	4,290
	(*g*) Loading and unloading ditto	...	0 5 9	1,311
	(*h*) Freight by ballast train	...	0 2 5	546
	(*i*) Lead in pitching ditto	...	0 1 8	385
	(*j*) Pitching ditto ditto	...	0 15 9	3,618
	Total cost of stone from abandoned bunds	366,880	2 12 3	10,150
		Feet length of bend	Per l. ft.	
	(*k*) Workshop charges	1,760	0 2 1	227
	(*l*) Stores and petty tools	...	0 10 10	1,193
	(*m*) Freight on ditto	...	0 1 1	120
	(*n*) Supervision	...	0 1 11	213
	(*o*) Miscellaneous	...	3 8 4	6,195
	(*p*) Janeshnagar Station	...	1 6 8	2,491
	Total of Workshop Charges ...	1,760	5 14 11	10,439
	Total Guide Bank, Left (Cost) ...	...	..	79,819
	(19). *Temporary Sidings*—	Total length, l. ft.		
	(*a*) Earth-work	18,400	0 4 4	5,016
	(*b*) Depreciation on permanent-way	...	0 2 2	2,447
	(*c*) Freight, loading and unloading	...	0 2 4	2,721
	(*d*) Laying and cutting up	...	0 5 5	6,231
	(*e*) Maintenance	...	0 4 0	4,660
	(*f*) Stores and petty tools	...	0 0 2	146

(*g*) Workshop charges	...	0 0 7	644
(*h*) Supervision	...	0 2 10	3,258
(*i*) Flood damages	...	0 0 9	855
Total ...	18,400	1 6 7	25,978
(20). *Pile Bridge*—	Actual length, ft. 714		
(*a*) Depreciation on timber, plant, stores and tools	Repairs 289+321=610 ft.	1 8 4	2,012
(*b*) Freight on ditto ditto ...	1,324 l. ft.	0 7 9	642
(*c*) Driving and bracing piles	...	0 7 1	587
(*d*) Extracting piles	...	0 11 10	977
(*e*) Workshop charges	..	0 9 10	813
(*f*) Supervision	...	0 9 2	763
(*g*) Miscellaneous	...	0 4 0	330
(*h*) Flood damages	...	0 14 5	1,193
Total ...	1,324 l. ft.	5 8 5	7,317
(21). *Diverting River*—			
(*a*) Supply of pilchi grass, etc.	...	...	114
(*b*) Depreciation on ballis, stores and tools ...	..	...	2,281
(*c*) Cost of and placing in position sand bags, brick bats, etc.	...	...	4,591
(*d*) Earth-work	...	...	4,521
(*e*) Workshop charges	...	...	4
(*f*) Supervision	...	...	241
(*g*) Miscellaneous	...	...	1,716
Total ...	...	...	13,468

Main Heads of Accounts.	Sub-heads of Accounts.	Quantity.	Cost per unit.	Total Expenditure.
IV. Bridge-work—*concld.*	(*A*) *Major Bridge*—concld.	600 tons (only 10 spans dismantled).	Per ton.	
	(22). *Dismantling Girders*—		Rs. A. P.	Rs.
	(*a*) Dismantling, etc., old girders	...	14 6 0	8,623
	(*b*) Depreciation on plant, stores and petty tools		6 0	226
	(*c*) Workshop charges	...	...	1
	(*d*) Supervision	...	1 3 3	722
	(*e*) Miscellaneous sidings, earth-work, etc. ...	...	3 11 5	2,230
	Total ...	600 tons.	19 10 8	11,802
	Credit for cost of old Jumna bridge girders ...	24 spans each weighing 60 tons =1,440 tons.	60 0 0	86,400
	Total IV ...	...	...	15,36,837
V. Fencing, etc. ...	(*a*) Removing and erecting, etc., fencing ...	...	...	2,216
	(*b*) Road and crossings	...	...	...
	(*c*) Mile and gradient posts	...	...	3
	Total V ...	...	...	2,219
VI. Electric Telegraph...	......	*Nil.*	*Nil.*	*Nil.*

VII. Ballast and Permanent-way.	*(A) Main Line—*			
	I. Permanent-way	1·67 miles	Per mile double track	
	(*a*) Cost of permanent-way (rails, sleepers and fastenings)	Double track	65,092 3 5	1,08,704
	(*b*) Freight on ditto ditto	...	5,232 14 11	8,739
	(*c*) Credit for old permanent-way	...	13,167 1 0	21,989
	(*d*) Linking	...	1,983 13 4	3,313
	(*e*) Stores and petty tools	...	599 6 4	1,001
	(*f*) Freight on ditto ditto	..	15 9 1	26
	(*g*) Maintenance	...	1,234 11 8	2,062
	(*h*) Workshop charges	...	622 2 6	1,039
	(*i*) Supervision	...	440 1 11	735
	(*j*) Miscellaneous	...	1,155 1 6	1,929
	Total ...	...	63,208 15 8	1,05,559
	II. Ballast—	C. ft.	Per 100 c. ft.	
	(*a*) Cost of ballast, including credit of old ballast	261,868	4 1 5	10,707
	(*b*) Loading and unloading and carriage from quarries	...	2 8 6	6,631
	(*c*) Spreading	...	0 11 6	1,884
	(*d*) Stores and petty tools	...	0 0 10	141
	(*e*) Workshop charges	...	0 0 1	15
	(*f*) Supervision	...	0 1 8	274
	(*g*) Miscellaneous	...	0 8 10	1,440
	Total ...	261,868	8 0 10	21,092

Main Heads of Accounts.	Sub-heads of Accounts.	Quantity.	Cost per unit.	Total Expenditure.
VII Balla t and Permanent-way—*concld.*	(*B*) *Sidings on Guide Banks*—	L.ft.	Per l. ft. Rs. A. P.	Rs.
	I. *Permanent-way*	6,320	...	...
	(*a*) Cost and freight of permanent-way 68th ...	..	0 5 9	2,286
	(*b*) Linking	...	0 0 8	268
	(*c*) Stores and petty tools	...	0 1 2	450
	(*d*) Maintenance	...	0 2 4	904
	(*e*) Workshop charges	...	0 0 6	178
	(*f*) Supervision	...	0 1 3	506
	(*g*) Miscellaneous	...	0 1 6	605
	Total ...	6,320	0 13 2	5,197
	(*C*) *Points and Crossings for Sidings*—			
	1. Cost and freight of new crossings	...	...	1,102
	2. Ditto 2nd hand ...	...	...	354
	3. Laying, etc.	...	...	151
	Total ...	...	...	1,607
	Total VII ...	...	...	1,33,455
VIII. Stations and Buildings	......	Nil.	Nil.	Nil.
IX. Plant	......	Nil.	Nil.	Nil.
X. Ferries	......	Nil.	Nil.	Nil.
XI. Rolling stock ...	......	Nil.	Nil.	Nil.

XII. General Charges ...	(*A*) *Direction*	...	...	27,714
	(*B*) *Engineering*—			
	1. Salaries and allowances	...	...	85,171
	2. Quarters	...	...	12,101
	3. Office accommodation	...	...	4,665
	4. Instrument	...	...	406
	5. Office expenses	...	...	4,847
	Total ...	...	...	1,07,190
	(*C*) *Stores*—			
	1. Salaries and allowances	...	...	6,995
	2. Quarters	...	...	905
	3. Office	...	...	100
	Total ...	...	...	8,000
	(*D*) *Audit and Accounts*—			
	1. Examiner's office share	...	...	5,000
	(*E*) *Medical and Sanitation*—			
	1. Salaries and allowances	...	...	4,588
	2. Quarters	...	...	4,101
	3. Office accommodation	...	...	116
	4. Instruments	...	...	208
	5. Office expenses	...	...	3,433
	Total ...	...	...	12,446
	Total XII ...	...	...	1,60,350
	GRNAD TOTAL ..	...	...	19,68,152

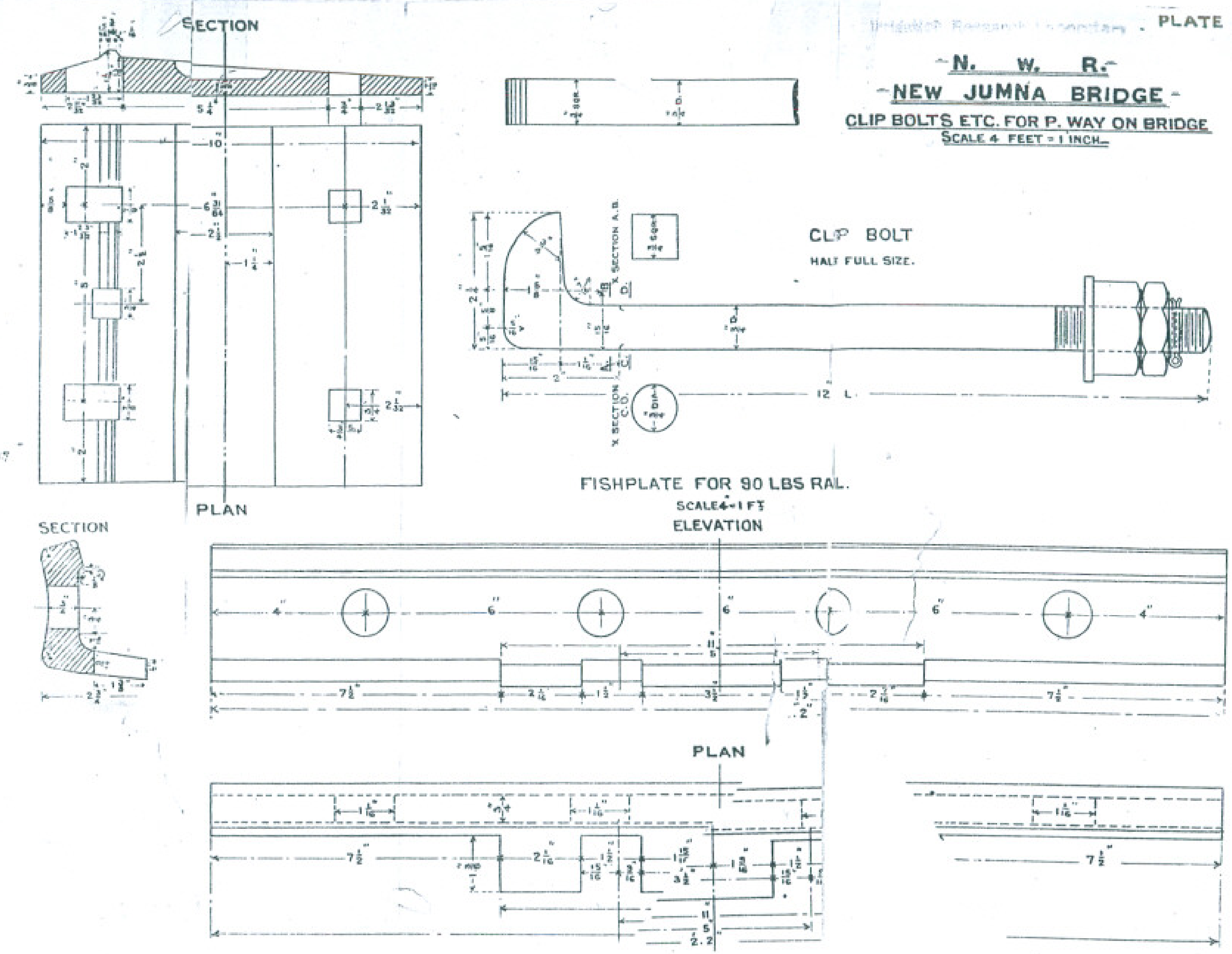
PLATE 16

N. W. R.

NEW JUMNA BRIDGE

CLIP BOLTS ETC. FOR P. WAY ON BRIDGE

SCALE 4 FEET = 1 INCH



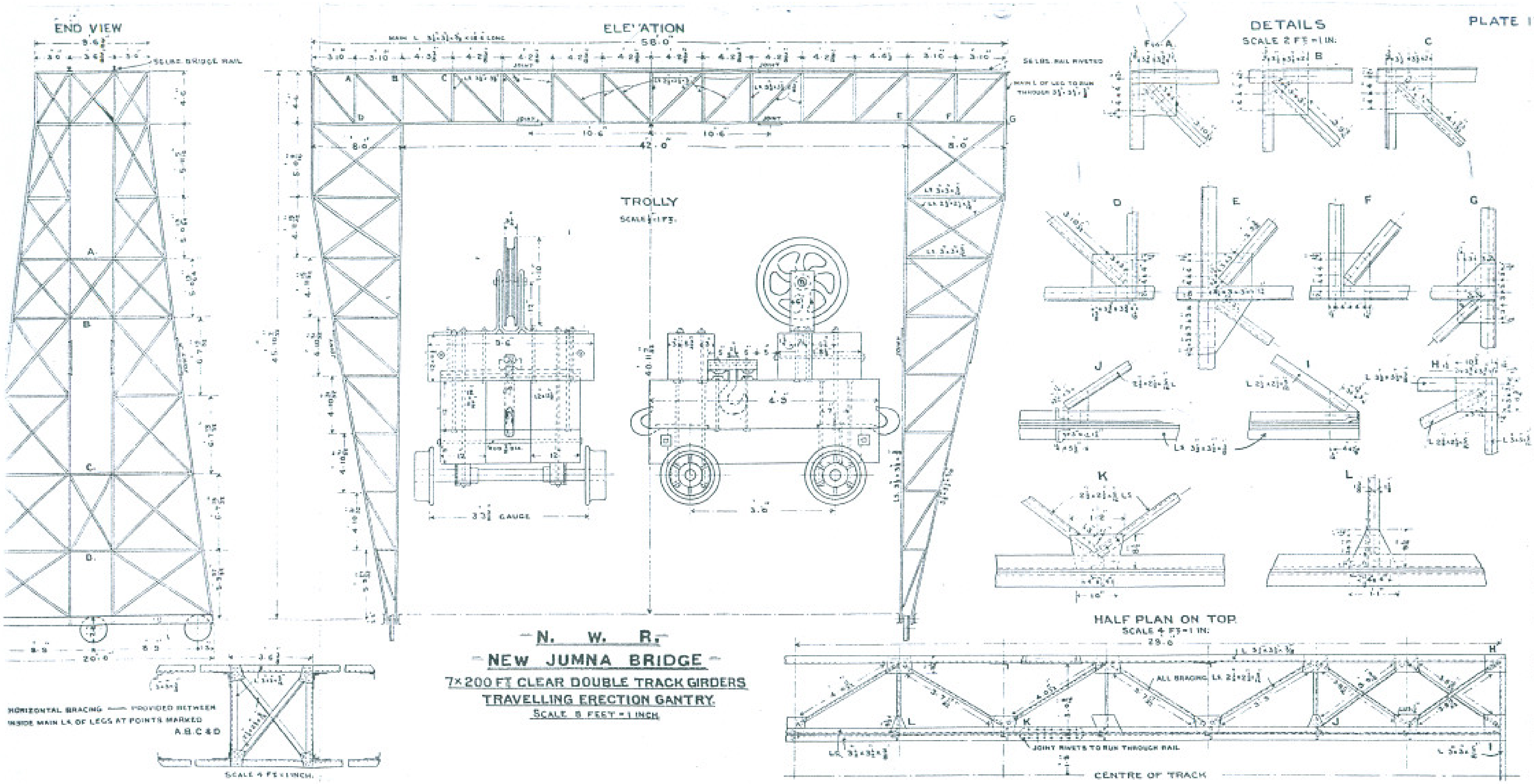


PLATE I
END VIEW
ELEVATION
DETAILS
SCALE 2 FT = 1 IN.
TROLLY
HALF PLAN ON TOP
SCALE 4 FT = 1 IN.
CENTRE OF TRACK
JOINT RIVETS TO RUN THROUGH RAIL
ALL BRACING
GAUGE
HORIZONTAL BRACING — PROVIDED BETWEEN INSIDE MAIN L's OF LEGS AT POINTS MARKED A.B.C & D
SCALE 4 FT = 1 INCH.
— N. W. R. —
— NEW JUMNA BRIDGE —
7×200 FT CLEAR DOUBLE TRACK GIRDERS
TRAVELLING ERECTION GANTRY.
SCALE 8 FEET = 1 INCH

PLATE

- N. W. R. -

- NEW JUMNA BRIDGE -

GANTRY LINE & SULLIVAN STAGING

SCALE 8 FEET = 1 INCH

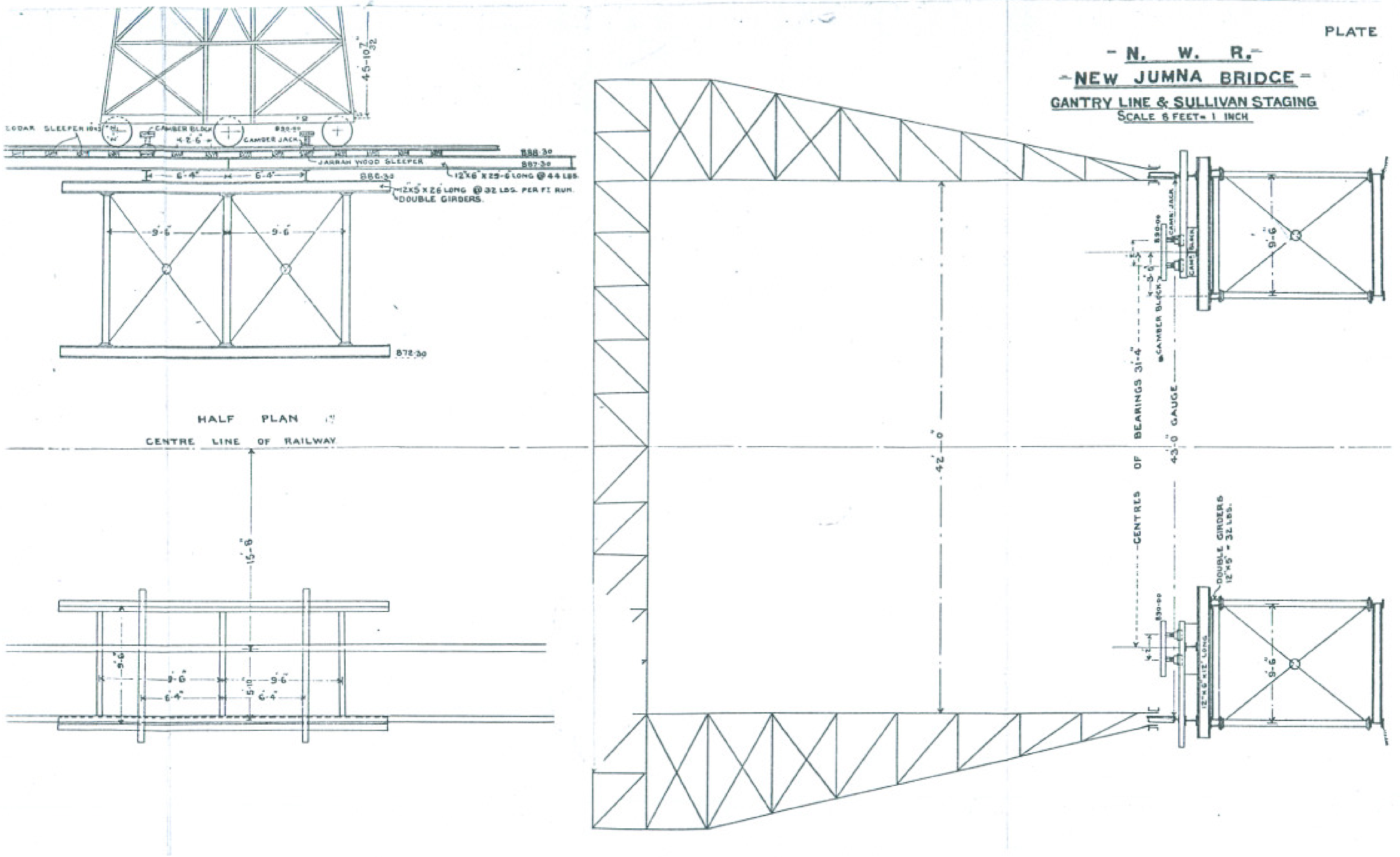
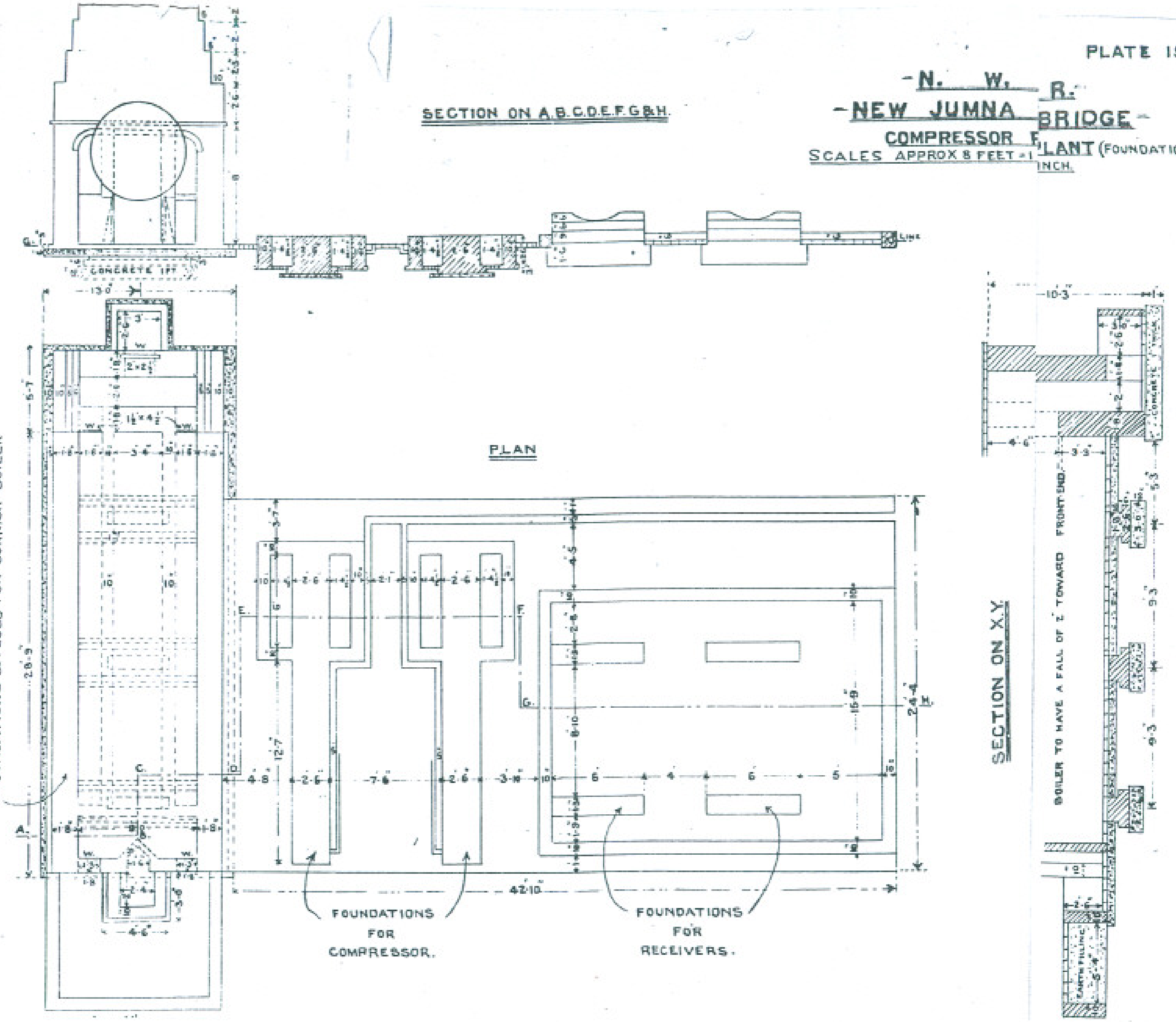


PLATE 19

N. W. R.
NEW JUMNA BRIDGE
COMPRESSOR PLANT (FOUNDATIONS)

SCALES APPROX 8 FEET = 1 INCH.



-N. W. R.-

-NEW JUMNA BRIDGE-

SAND BLAST

SCALE 2 IN: = 1 FT.

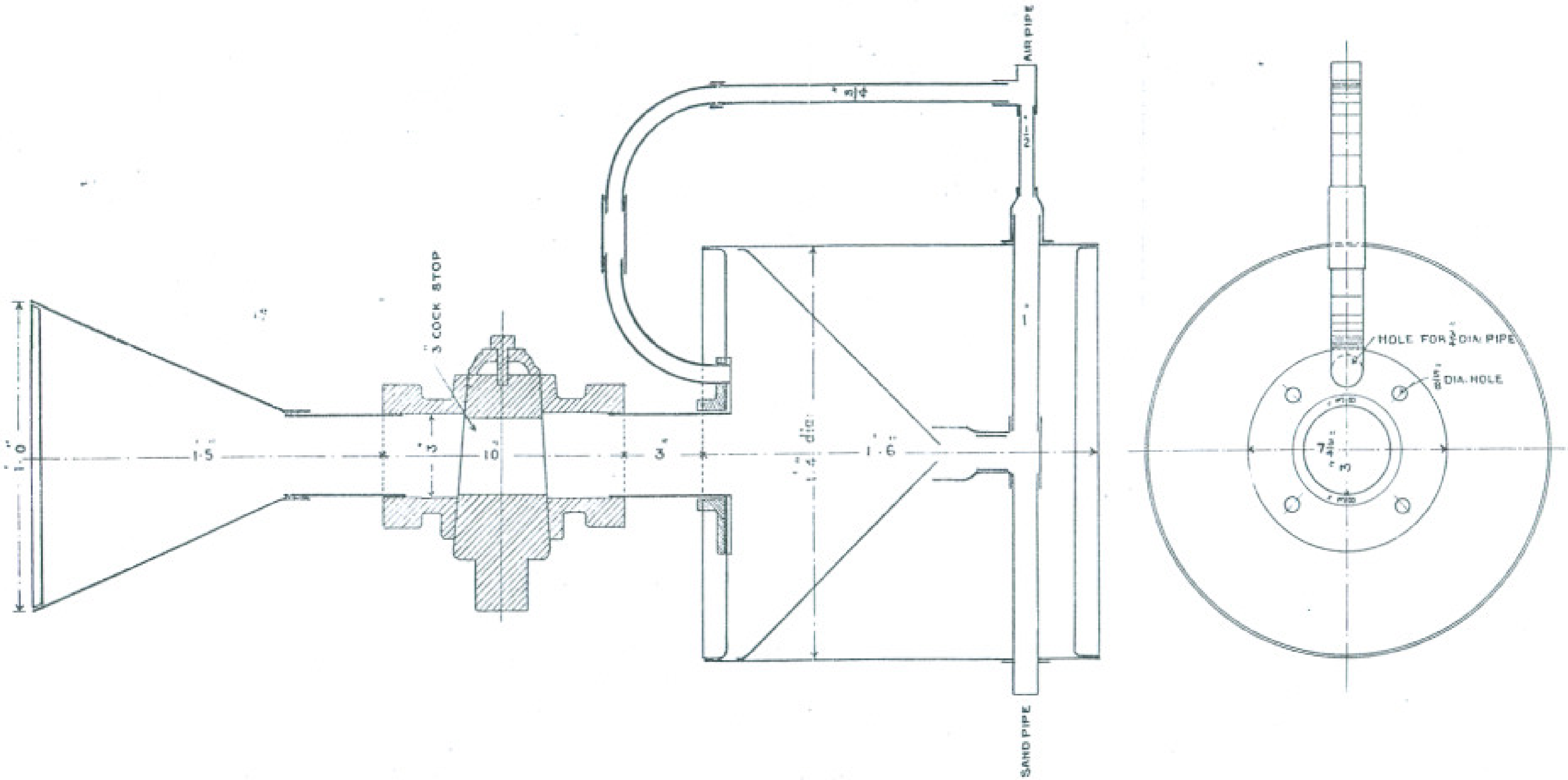


PLATE 21

N. W. R.

NEW JUMNA BRIDGE

CAMBER DIAGRAM

SCALES APPROX {HOR. 30 FT = 1 INCH. / VER. HALF FULL SIZE.

REFERENCES.

BEFORE RIVETING ....

AFTER DISMATLING STAGING { —— A / ------ B

AFTER TESTING WITH S. G. ENGINES ON 18-2-1913 { —— A / ------ B

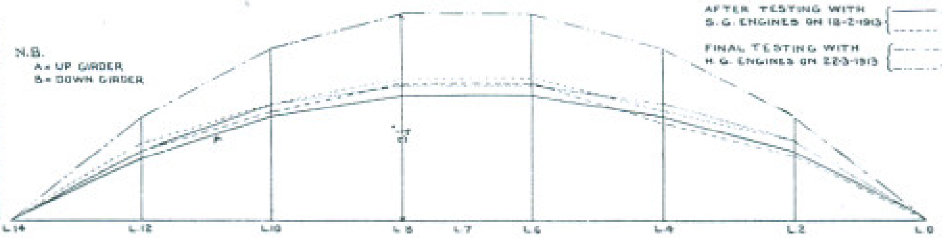
FINAL TESTING WITH H. G. ENGINES ON 22-3-1913 { -·-·- A / ------ B

N.B.
A = UP GIRDER
B = DOWN GIRDER

TABLE OF CAMBER ORDINATES.

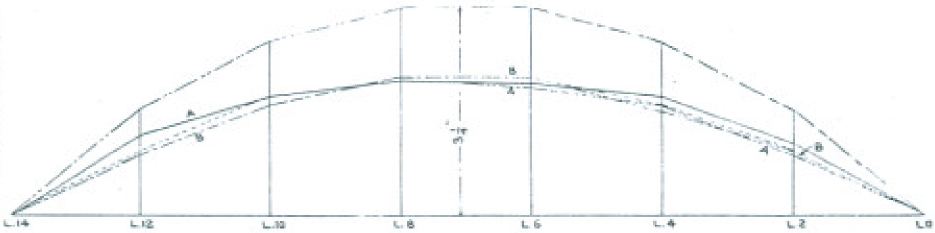
SPAN No. 7

JOINTS	AFTER S.G. ENGINE PASSED		AFTER TEST TRAIN PASSED	
	A.	B.	A.	B.
L 12	·08	·09		
L 10	·136	·14	[illegible]	[illegible]
L 8	·16	·173	[illegible]	[illegible]
L 7	·16	·174		
L 6	·16	·175	[illegible]	[illegible]
L 4	·13	·125	[illegible]	[illegible]
L 2	·085	·08		



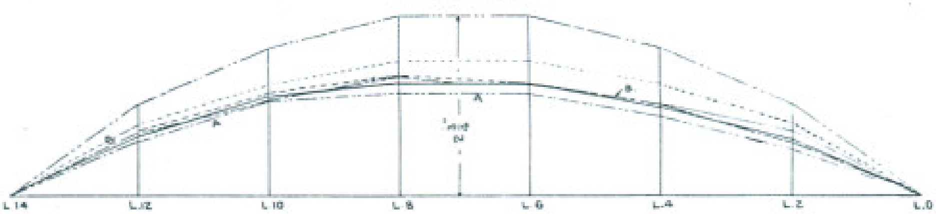
SPAN No. 6

JOINTS	AFTER S.G. ENGINE PASSED		AFTER TEST TRAIN PASSED	
	A.	B.	A.	B.
L 12	·09	·075	·08	·075
L 10	·15	·147	·15	·148
L 8	·17	·175	·17	·175
L 7	·17	·175	·17	·175
L 6	·17	·175	·165	·175
L 4	·15	·14	·137	·14
L 2	·09	·08	·075	·08



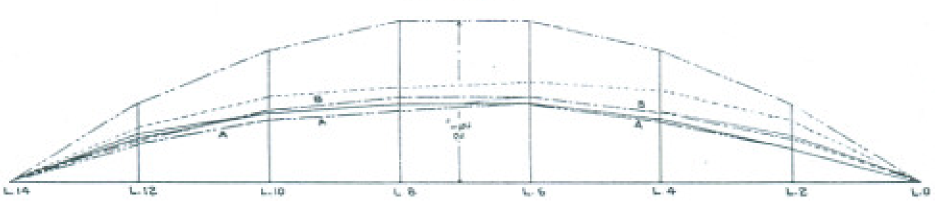
SPAN No. 5

JOINTS	AFTER S.G. ENGINE PASSED		AFTER TEST TRAIN PASSED	
	A.	B.	A.	B.
L 12	·073	·08	·065	·08
L 10	·125	·13	·12	·12
L 8	·14	·15	·127	·15
L 7	·14	·14	·13	·14
L 6	·14	·14	·128	·14
L 4	·108	·11	·10	·11
L 2	·063	·06	·055	·06



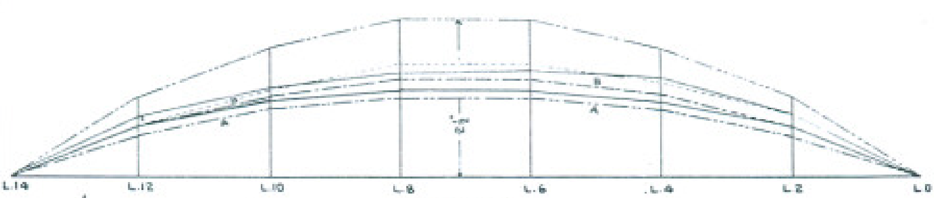
SPAN No. 4

JOINTS	AFTER S.G. ENGINE PASSED		AFTER TEST TRAIN PASSED	
	A.	B.	A.	B.
L 12	·055	·07	·05	·052
L 10	·09	·10	·08	·092
L 8	·10	·115	·09	·112
L 7	·10	·11	·09	·11
L 6	·10	·11	·10	·11
L 4	·08	·09	·078	·09
L 2	·04	·055	·04	·055



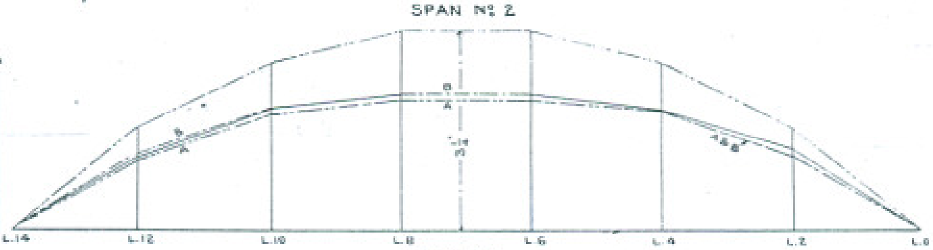
SPAN No. 3

JOINTS	AFTER S.G. ENGINE PASSED		AFTER TEST TRAIN PASSED	
	B.	B.	A.	B.
L 12	·065	·065	·05	·065
L 10	·10	·105	·085	·102
L 8	·11	·125	·10	·125
L 7	·11	·125	·10	·125
L 6	·11	·125	·10	·125
L 4	·09	·112	·084	·112
L 2	·065	·065	·047	·065



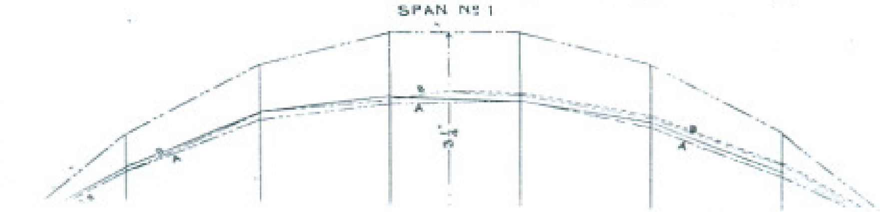
SPAN No. 2

JOINTS	AFTER S.G. ENGINE PASSED		AFTER TEST TRAIN PASSED	
	A.	B.	A.	B.
[illegible]	[illegible]	·10	·092	·10
[illegible]	[illegible]	[illegible]	·12	·18
L 7	·18	·18	·175	·18
L 6	·18	·18	·172	·18
L 4	·16	·16	·16	·16
L 2	·108	·10	·10	·10



SPAN No. 1

JOINTS	AFTER S.G. ENGINE PASSED		AFTER TEST TRAIN PASSED	
	A.	B.	A.	B.
L 12	·09	·085	·085	·085
L 10	·16	·16	·15	·16
L 8	·18	·185	·18	·18
L 6	·18	·185	·185	·18



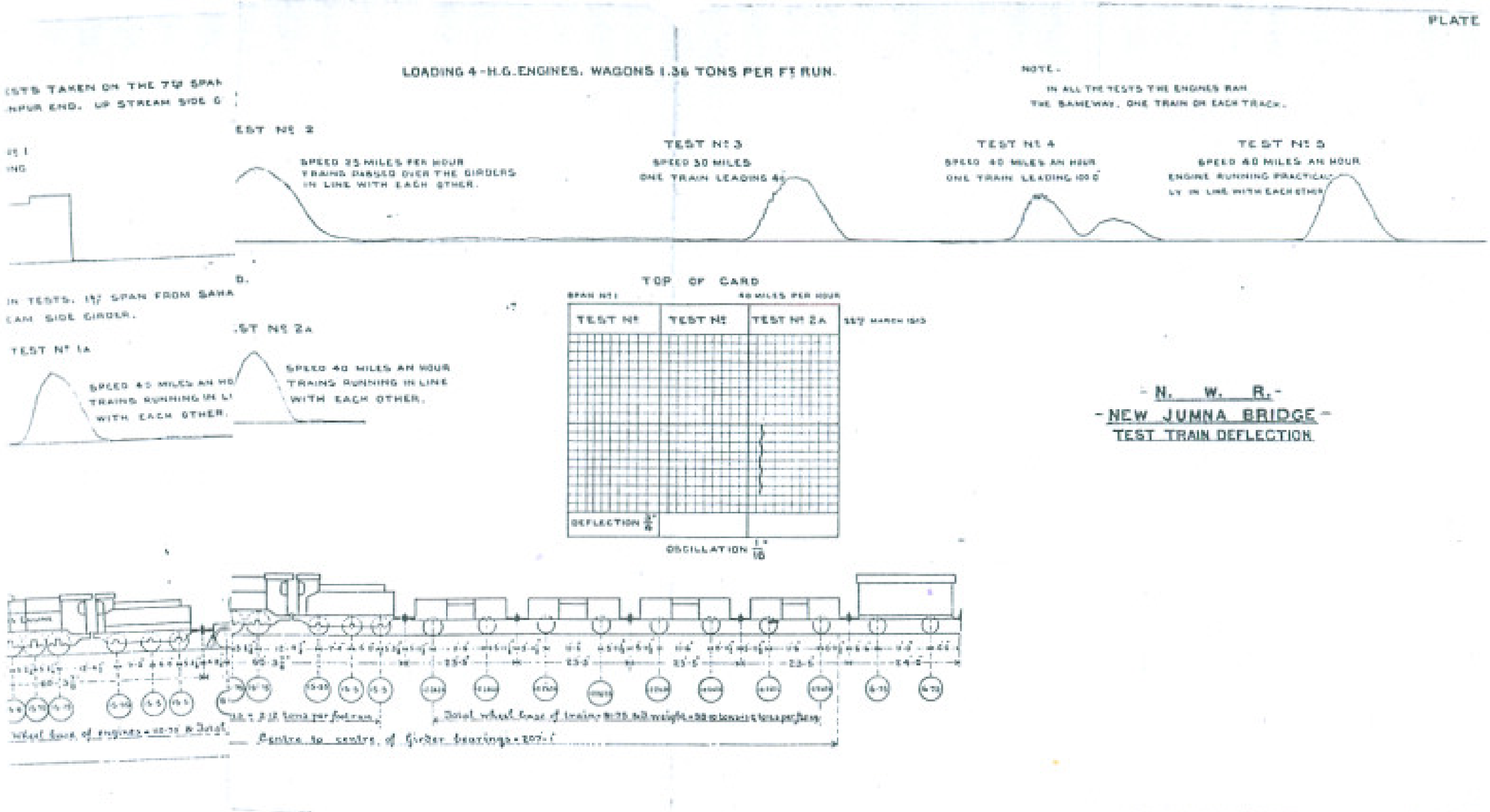
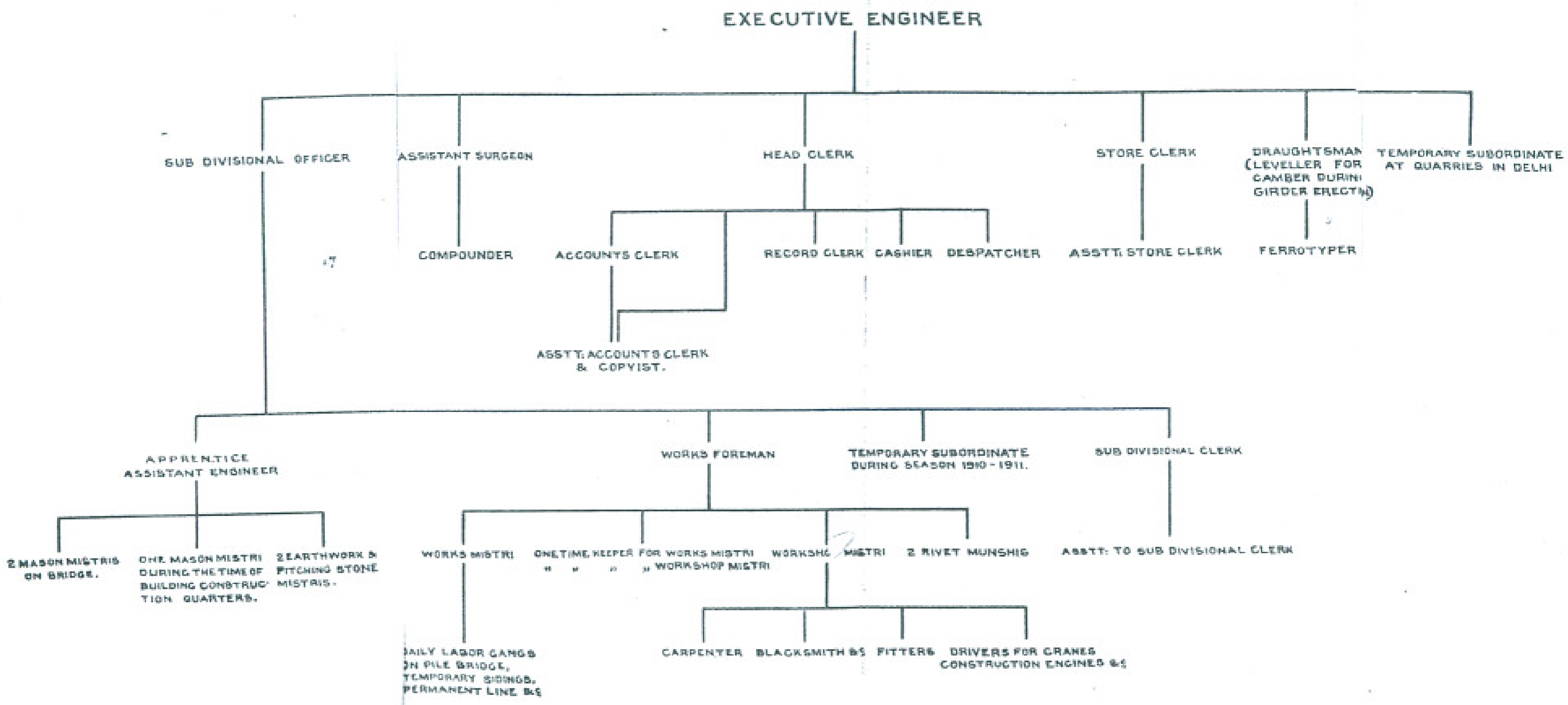


PLATE
LOADING 4-H.G. ENGINES. WAGONS 1.36 TONS PER FT RUN.
NOTE.-
IN ALL THE TESTS THE ENGINES RAN THE SAMEWAY, ONE TRAIN ON EACH TRACK.
ESTS TAKEN ON THE 7th SPAN
NPUR END. UP STREAM SIDE G
EST Nº 2
SPEED 25 MILES PER HOUR
TRAINS PASSED OVER THE GIRDERS
IN LINE WITH EACH OTHER.
TEST Nº 3
SPEED 30 MILES
ONE TRAIN LEADING 4
TEST Nº 4
SPEED 40 MILES AN HOUR
ONE TRAIN LEADING 100'
TEST Nº 5
SPEED 40 MILES AN HOUR
ENGINE RUNNING PRACTICAL
LY IN LINE WITH EACH OTHER
IN TESTS. 1st SPAN FROM SAHA
EAM SIDE GIRDER.
TEST Nº 1A
SPEED 45 MILES AN HO
TRAINS RUNNING IN LI
WITH EACH OTHER.
ST Nº 2A
SPEED 40 MILES AN HOUR
TRAINS RUNNING IN LINE
WITH EACH OTHER.
TOP OF CARD
SPAN Nº 1
40 MILES PER HOUR
TEST Nº
TEST Nº
TEST Nº 2A
22nd MARCH 1913
DEFLECTION 3/8"
OSCILLATION 1"/16
- N. W. R. -
- NEW JUMNA BRIDGE -
TEST TRAIN DEFLECTION
Centre to centre of Girder bearings = 207·1

— N. W. R. —
— NEW JUMNA BRIDGE —
— STAFF DIAGRAM —



DISCUSSION.

MR. SLEIGH, in briefly introducing his paper, said that, as time was short, he did not consider it necessary to say much, but brought to the notice of the Congress that he considered, from the experience gained during the construction of the Jumna bridge, that a bridge designed on the lines suggested in his discussion of Mr. Harvey's paper, which was read before the Congress in 1914, would have been more economical and equally efficient.

MR. HADOW, in opening the discussion, remarked that the author had assumed a depth of sixteen feet for scour at the piers,* why had sixteen feet been provided for ? why not twenty-six or only six feet. It would be interesting if Mr. Sleigh told them how he had arrived at sixteen feet for the depth of scour.

RAI BAHADUR GANGA RAM enquired by what formula or rule the thickness of the steining of wells had been arrived at. His experience as an engineer in the Buildings and Roads Branch of the P. W. D. was that the steining was never made as thick as that indicated in the paper. He would also like to know more about the method adopted for sinking wells as described on page 17 of the paper, more especially as to the use of dynamite. He explained a method of well sinking practised by himself in which he employed a dredger of about twenty cubic feet capacity, and a bucket or *dol* of sheet iron of capacity sufficient to bring up thirty-three cubic feet of water. After working the dredger by means of a winding engine from twenty to thirty times, the unwatering bucket was attached to the winding rope and worked. By this method he had always been able to sink wells quite easily about three feet per day.

MR. BAGLEY here drew attention to the fact that in certain kinds of sand, the method adopted would almost certainly result in a " blow," which would, of course, cause great difficulty in sinking.

RAI BAHADUR GANGA RAM explained that he had never experienced any such difficulty, and that he thought the blowing of sand rather facilitated the sinking.

RAI SAHIB MAKKHAN LAL speaking in reference to the pressure of 3·5 tons per square foot at the bottom of the curb,

* *Vide* page 6.

referred to on page 6 of Mr. Sleigh's paper, asked what maximum intensity of pressure could be allowed in such cases.

MR. GIBB, referring to the paragraph in the middle of page 4, where it was stated that, since the slopes of the approach banks had to be protected against wave action it was unnecessary to make the guide banks sufficiently long to prevent any flow along the face of the approaches, and that a velocity of five feet per second could therefore be allowed along these banks, pointed out that protection against wave action was required only at water surface level, whereas the attack of flowing water was all below the surface. For wave action no apron was necessary, but for protection against face scour by a stream an apron of some kind was always required. Protection suited to withstand only wave action would be useless against the attack of a stream ; the course followed was therefore not justified.

MR. DUTHY remarked that he knew very good kankar could be obtained almost anywhere in the Ludhiana District, and he presumed that the railway quarries were situated at Baddhowal for convenience of carriage. He had always found the kankar lime from this part good enough to set neat, but, in hydraulic works, it was the custom to use a mixture of white and kankar lime which was found to set better under water and to be cheaper than pure kankar lime.

MR. NICHOLSON enquired what was going to happen to the old bridge, as the new bridge was only a short distance upstream ; and practically halved the width of waterway through the old bridge. This old bridge had shallow well foundations which could not have been considered to be deep enough for the constricted width of waterway. He further enquired if, in sinking the wells, it was found that the material removed by the dredgers was greater than the water percolating into the well thereby resulting in a lowering of the water surface in the well which might cause bad blowing. Another point on which the author might give some useful information was the skin friction on the wells. What was the friction per square foot of the surface of the well ? Did it vary with the depth, or was it constant throughout ? Had any precautions been taken to give the outside face of the wells a fair surface to reduce friction as far as possible.

MR. F. J. HARVEY, referring to the last paragraph on page 3, in which the author advocated straight bunds, and implied that the idea of a curved bund was to coax the river from forming eddies, but said nothing of the effect of the curving of the nose of the bund in preventing the river from attacking the rear of the bund, said that he considered this was a very essential use of the curved head. It would be very instructive if the author would give the Congress the result of the 1914 floods on the protection works, and state whether those effects indicated any possible improvement in design. He enquired whether any protection stone was placed round the piers, and, if so, with what object ; and whether the floods of 1914 indicated that the object had been fulfilled. He considered that the stone put round the piers of the railway bridge over the Beas had at some piers a very harmful effect in constricting the waterway. Where the stone had been washed away no evil result, nor even an excessive scour at the piers, had occurred. As regards the second paragraph on page 4, he asked what length of a guide bank would ensure a cushion of still water against the approach bank and yet not be unnecessarily long.

As regards cement concrete bed blocks, he considered that the top three inches should be made a little richer in cement and a little wetter to assist in getting a good bearing surface. He deprecated the practice of putting on a thin skin of cement plaster, as he had noticed that this invariably powdered. He considered that a sheet of felt soaked in red lead and oil was the best thing to use under the bearings. He was not in favour of lead sheets, as they were invariably squeezed out, and in consequence broke up the surface of the concrete in doing so, besides destroying the level of the girder.

MR. SLEIGH, in reply, said that the depth of sixteen feet had been assumed with reference to the depth of scour holes formed close to the piers of the old bridge in the flood of September 1910, when the river rose to R. L. 877·3.

The object of the heavy section in the steining of the well was to provide a large sinking effort without recourse to loading the wells with pig iron, rails, &c. There was no fixed proportion between the diameter of well and the steining on which a calculation could be based. Experience obtained from the new Beas bridge wells proved that circular wells, eighteen feet diameter with 4′-3″ steining, did not sink easily, and required extra weight to drive them down eighty feet into the bed of the river. It had, therefore, been decided to increase the steining of the wells of the Jumna bridge, and the easy way in which these wells sank fully justified the extra expense of the greater section of steining.

No empirical formula could be given for the proportion of section of steining to depth of well, as so much depended on the strata through which wells had to be sunk.

(Here Mr. Bagley added that a certain section of well was also necessary to take the bed plates of the girders, and that it was now found more economical to use a heavier section in steining than had formerly been the practice.)

With regard to the use of dynamite in founding the wells, the author explained that a conical hole was first excavated (the apex of the cone being about six feet below the cutting edge of the curb), the wells had then been weighted with sixty tons of pig iron, and successive four ounce charges of dynamite were exploded until the well only sank one-eighth of an inch after each explosion.

The method of sinking wells explained by Rai Bahadur Ganga Ram had been tried, also steam-driven pumps had been used in place of the *dol* with success in cases where the wells had a tendency to stick, but this method was only used as a last resort on account of the heavy blows which took place with the accompanying risk of the wells getting out of plumb.

In reply to Rai Sahib Makkhan Lall, Mr. Sleigh said he considered $3\frac{1}{2}$ tons a very safe figure. This was practically the intensity of pressure recommended by Rankine, Trautwine, and other authorities.

The protection necessary for wave lap, to which reference had been made by Mr. Gibb, was sufficient to withstand a slight flow along the approach bank, but, when the velocity was high, an apron was necessary, as had been provided on the right guide bank at the Jumna.

Replying to Mr. Duthy the author stated that the kankar had been obtained from Baddhowal, and that, with the heavy section adopted, it had not been necessary to use mortar of high tensile quality—the addition of white lime would not have been economical.

Mr. Nicholson had enquired what was going to happen to the old bridge, as the new bridge was only a short distance upstream, with about half the width of waterway. He hoped, however, that, for the sake of the Buildings and Roads Branch, who were about to take over the old bridge, as they had already taken over the old Beas and Sutlej bridges, there would be no cause of anxiety now that the river had been properly constricted. As regards skin friction, he had not carried out any systematic observations, as it was found to vary under the same conditions, but he considered 3·3 cwt. per square foot to be about the average of the observations that had actually been made. No *special* precautions had been taken to give the brick-work of the wells a smooth surface.

He regretted to find that Mr. Harvey was still under the impression that some of the stone around the new Beas bridge had been washed away, instead of having sunk, as he had explained last year * and, in order to disillusion Mr. Harvey, and to represent the correct state of affairs on the new Beas bridge to the members of the Congress on this point, he would like to visit the bridge with Mr. Harvey and a third member of the Congress, and show them that the stone round the piers in question had not been washed away but that it had practically sunk *en masse*. Not a single stone was placed round the wells of the piers of the new Jumna bridge.

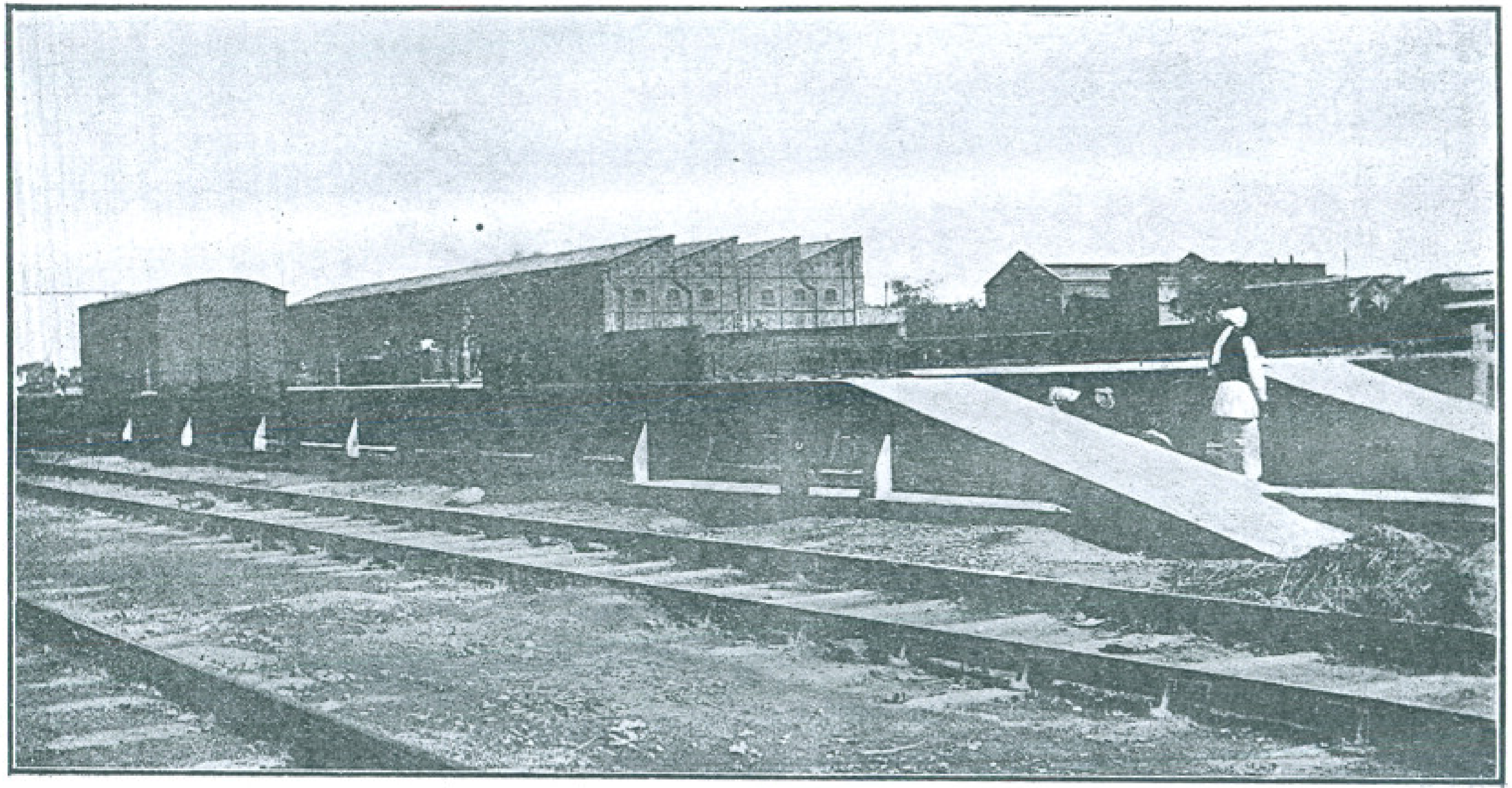
He would also like to pay a similar visit to the new Jumna bridge in order to convince Mr. Harvey that the design of straight guide banks was preferable to guide banks with curved mole heads. So far as the author had been able to find out from enquiries, the floods of 1914 had caused no specially noticeable erosion to the apron at the back of the guide banks, in spite of the section of stone having been reduced from what had in the past been considered necessary under similar conditions. As regards the correct length of guide bank, he would refer Mr. Harvey to page 154-*d* of the discussion on his own paper at the last Congress.

He agreed with Mr. Harvey regarding the use of cement plaster on the bed blocks, as this had been found to separate from the concrete bed blocks. He did not, however, understand Mr. Harvey's objection to the use of lead sheet. The author on a visit to the bridge a year after it had been opened, specially inspected the lead sheet with regard to its spreading, and found that the sheets had not been reduced in depth. Spreading may have been adverted by keeping the top of the bed blocks not more than one-eighth of an inch above the top of the pier, and enclosing them on all four sides with the brickwork forming the top of the pier. He did not consider that felt (a perishable article) would be better than lead sheet.

COLONEL CRA'STER, in closing the discussion said, that dynamite had been used by railway engineers with good effect for

* *Vide* Volume II, page 154 *c*.

well sinking. He cited the instance of a well at Malakwal, which refused to be coaxed in any other way, but dynamite had overcome the difficulty, and the well had gone down easily. Care, however, had to be taken to place the charge fairly well in the centre, and not too close to the curb. The only other point, he would like to touch upon, was the question of the old bridges. All these old bridges had had stone poured into them for thirty years, with the result that an enormous apron had formed right across the river from some sixty feet upstream of the bridge to a hundred and twenty feet downstream. The scour was from five to six feet above the bottom of the old wells, and these were still holding. After the completion of the new bridge over the Beas, he had taken a bet that the old bridge would not stand, but had lost it.



New Carriage Washing Platforms—Lahore Station.