PAPER No. 115.

CHEAP FEEDER RAILWAYS OF 5 ft. 6 in. GAUGE AND THE BAHAWALNAGAR-CHOLISTAN RAILWAY.

By T. N. Kunzru.

Brief History.

The question of building light feeder railways on the standard gauge has engaged the attention of railway engineers from time to time since the beginning of the present century. Over twenty years ago a beginning was made in this direction when the Amritsar-Patti Line was built to a standard somewhat lower than that which was in vogue at that time. Then followed other branch railways, built to a still lower standard which, however, was higher than could be justified by traffic prospects. In those days undue stress was laid on future requirements and the railways were consequently designed on a liberal scale.

It was not until 1925 that the Government of India took up the question of light feeder railways seriously. The decisions then arrived at gave a great impetus to railway construction. They are of such a momentous nature that no apology is needed for quoting the following long extract from the *Railway Board's Circular No. 598-P., dated 18th June* 1926, addressed to the agents of the Indian railways :—

2. "The Railway Board wish to bring prominently to your notice that for a considerable period there has been no definite move forward in railway construction on a large scale in India. The reasons for this are various, but speaking generally, the hesitation to undertake extensive new construction has been caused by a lack of confidence in the ability of railway properties to pay consistently the required return on borrowed capital. With the separation of railway finances from the general finances of the country and the success of the efforts of the railway administrations in the last few years to produce an adequate return, the outlook is now changed and it is possible to arrange with confidence for a definite programme of construction over a period of years. In many cases in the past the cost of construction as a whole has been unduly increased owing to the impossibility of carrying out a pre-arranged programme on a continuous basis, for it is obvious that a regular supply of funds and a continuously employed construction staff, both of which factors are ensured by preparing and working to a programme, give the best guarantee of economy in construction. The Railway Board therefore desire that each railway administration should work out a carefully arranged programme of construction for the next five years designed with due regard to practical considerations and subject to revision where necessary from year to year, of a nature which enables the demand for funds and the size of the staff required to be accurately foreseen and arranged for.

3. "The preparation of this programme will demand the most careful attention on the part of railway administrations to the following points :—

(i) *The standard to be adopted for the construction of each individual project.*— Except where the new line is to be interpolated between parts of an existing line (when conformity with existing standards may be essential), the standard should be determined primarily by the traffic to be carried, and should generally be that which will enable the expected traffic to pay a reasonable return on the capital expended.

"The Railway Board have discussed with agents of class I railways the desirability of adopting certain categories for standards of construction, and I am now to inform you that the standards to be adopted in future are those shown n the annexure to this letter. It will be seen that very considerable latitude has been allowed in the standard to be adopted for branch and feeder lines, and that with the relaxation in regard to axle loads on certain sections of rails now to be permitted, the field of activity in regard to branch and feeder line construction is very definitely widened. Practically any form of rail transport, from the highest standard of main line construction on the one hand to railways of the standard generally known as tramways on the other, must now come within the purview of your construction programme, and there is in fact no form of rail transport which should be rejected if it can be shown that its construction will give needed transport facilities and at the same time produce an increase in the business of the main line to an extent which justifies the expenditure of the required capital. As an example of one of the lowest forms of rail transport may be mentioned a 2′ 6″ gauge railway, built on the surface with causeways for the waterways, speed of 8 to 10 miles per hour, daylight traffic only, the minimum of accommodation at stations, booking of tickets in transit, and, if necessary, halts for picking up passengers and parcels at intermediate villages or at cross roads. In cases where no other form of transport would be remunerative, there would be no objection to considering the road-rail system or other simple form of transport suitable to the locality.

"In settling the standard to be adopted in individual cases railway administrations will have to take into consideration the co-ordinance of the improvement programme of the main lines with the construction programme, so that second-hand material from the main line may be made available for construction purposes. In some cases the choice may be between expediting renewals on the main line or purchasing new materials for constructions. Speaking generally, it will be more satisfactory to expedite renewals on the main line, but the problem can generally be solved by the correct application of financial considerations.

(ii) "*The return which it is reasonable to expect on the capital expended on each individual project.*

The Railway Board considered that in order to secure the railway development which is so desirable, agents should not hesitate to investigate by survey and the preparation of project estimates, schemes which there is *prima facie* reason to expect may give a return (including the net earnings from increased through-traffic on all existing systems) of 4½ percent. on the capital expended ; and they will have no objection to an agent investigating the prospects of schemes which seem likely to yield the even lower return of 4 per cent. though they are not as yet able to state positively that they can finance in all instances projects from which only a 4½ per cent. or even lower return is expected. The lower rate at which the Government of India can now borrow and the general improvement in the financial position of railways makes it, in their opinion, well worth while to have all such schemes investigated.

(iii) "*The arrangement of programme—*

(*a*) It is clearly desirable that the programme should be arranged so as to equalize as far as possible the work in hand in regard to survey and to construction in each of the 5 years, and your attention is again invited to the method of presentation by means of a diagram or graph which was suggested in paragraph 5 of the note which accompanied *Railway Board's letter No. 598-P., dated 10th March 1925*. Your attention is also invited to paragraph 4 of that note regarding the order in which projects should be taken up. Subject to the wishes of the Local Government being given full consideration, the order in which projects should be arranged in the programme should give precedence to those projects which are likely to be most remunerative which will presumably generally be those which are most needed to serve prospective traffic.

(*b*) The programme should also provide for the most expeditious construction possible of each project undertaken. Once the construction of a project has been decided on, it should be pushed through as rapidly as possible in order that a return on the capital may be obtained at the earliest possible date, and that interest charges during construction may be reduced to a minimum. The programme should not, therefore, show more projects under construction at any one tme than can be expeditiously constructed with the organization (of staff and plant) available.

4. "The Railway Board trust that these remarks will lead to the definite undertaking by railway administrations of the responsibility of developing the country-side, particularly in agricultural districts, as they are satisfied that there is not only room for, but an urgent need of, a rapid expansion of transport facilities in the interests of the country generally, and indirectly in the interests of the main lines of railway themselves. The Railway Board regard it as one of the first and most important duties of a railway administration to extend by any means in its power the service which it can give to the public, and they desire to see this duty carried out through the medium of the new construction programme as well as in all other railway activities."

As a result of this new policy, projects, which under the old conditions had been considered as not worth a thought, are quite feasible now. Construction programmes have been drawn up and on the North Western Railway, at any rate, actual construction is in full swing.

Brief History of the Bahawalnagar-Cholistan Railway.*

The principal object of a feeder railway is the development of the country through which it passes. Ordinarily an expected return of 4 per cent. on the capital cost of such a Railway is considered as a sufficient justification for its construction. In the case of the Bahawalnagar-Cholistan Railway, with which this paper deals, the underlying principle of feeder railways is carried a step further, in that the construction of this line has been undertaken with the full knowledge that it will not pay more than 2 per cent. even when the country it serves has attained a population density of 200 per square mile and that it will be many years before it becomes self-supporting.

The Bahawalpur State, which is paying for the railway, is content that, for the present, it should help only in developing the country, as the increased revenues from land will more than repay any losses it will incur on working the railway.

It is being built by the North Western Railway at the cost of the Bahawalpur Durbar, is of broad gauge and is 63½ miles long. Its object is to serve a tract of country to be irrigated by the Malakwah and Hakra branches of the Eastern Sadiquia Canal of the Sutlej Valley Irrigation Project.

In May 1923 the Bahawalpur State asked for a Railway through the country which was to be brought under cultivation by Sutlej Valley canals. In 1924 a detailed survey was carried out. Early in 1926, the State pressed for an immediate commencement with its construction with the object of realizing better values from the sale of

*In Bahawalpur State south of the Punjab.

land in the new colony. Final location was taken in hand in September 1926 and the construction was sanctioned by the Railway Board in December 1926.

Description of Country.

The country through which the line passes is very sparsely populated up to mile 24. Apart from canals some of which have now been built, water on the whole is scarce. Wells are few and far between, deep and usually brackish. Hitherto patches of land used to be cultivated, some depending upon inundation canals and others upon rain.

From mile 24 to the end, is one expanse of wilderness with neither roads, population, wells nor trees. Dotted about the country are a number of small ponds which hold rain-water till about the end of February. A few families take their cattle and sheep to graze on the shrubs which grow plentifully in this area during the cold weather and move off as soon as the ponds dry up.

The country, generally speaking, is flat with a few sand hills scattered at intervals. The soil is good cultivable loam, generally soft, occasionally stiff.

Climate.

The average annual rainfall is 2 or 3 inches. From April to July there are very severe, prolonged and frequent dust storms. The day temperature is high, but the nights are cool.

Equipment.

As this railway is intended to be a very light feeder line, its equipment and working staff have been reduced to the minimum necessary for immediate requirements.

Stations.

Between miles 0 and 24, four stations have been provided and from 24 to 63½, *i.e.*, in a length of 40 miles, only three.

Land.

Land has been acquired according to the tables given with Fig. 2, allowance is made for burrow pits and a berm 10 feet wide on each side of the toe of the slope. The berm on the side away from the burrow pits is intended to act as a service road during construction. Up to mile 27 the land acquired is all proprietary, averages 12 acres per mile and costs about Rs. 150 per acre. From mile 27 to the end it is waste land belonging to the State.

Earthwork.

The width of bank at formation level is 16′ 6″ which is the minimum permissible. The height is kept as low as possible, generally 1½ feet above ground but, as a large number of canals and watercourses have to be crossed, the average height is 2·6 feet. The ruling grade is 1 in 300 and has been freely made use of in order to keep down the

height of bank. The average quantity of earthwork per mile is 3 lacs cubic feet.* The maximum height of bank is 9·2 feet at the Malakwah Branch Canal.

Bridges.

The minimum waterway has been provided. All openings are for irrigation channels. There are four classes of bridges, *viz.* :—

(*a*) 1′ 6″ diam. corrugated iron pipe drains with a 9″ shell of lime concrete all round. These are for watercourses where the height of bank is more than 5 feet. (Fig. 3).

(*b*) 2-foot open top culverts ; for watercourses where the bank is less than 5 feet high. (Fig. 4).

(*c*) Through girders have been adopted for spans of 8 feet and 7 feet for crossing minor distributaries. (Fig. 5).

(*d*) Girder bridges of 10, 12, 20 and 30 feet spans ; for branch canals and distributaries. (Fig. 6).

Eleven bridges are on the skew. To provide a smooth approach to these, part of the abutment has been built back and one girder extended so as to bring the ends of the two in a line perpendicular to the track. This is a departure from the usual practice on unimportant lines. (Fig. 7.)

Fencing.

No fencing is provided except for passenger platforms. Road crossings are all of the 4th class type. (Fig. 8). No gatemen will be employed.

There will be twelve telegraph posts to the mile, each with a number plate. Mile and gradient posts are of standard types.

Permanent-way.

The track consists of 75-lb. second-hand rails, second-hand fish-plates and bolts, new bearing plates and dog spikes and new creosoted fir or *chir* sleepers. Joint sleepers have four spikes and intermediate sleepers 2 spikes per rail per sleeper.

Stone or brick ballast has been omitted and in its place good sandy loam supplemented by cinder screenings in sandy stretches is used.

For speeds not exceeding 25 miles per hour this will give as good a road as desired.

The rails are of three lengths, 24 ft., 27 ft. and 30 ft. and the number of sleepers per rail is as follows, according to the formula (N+1) :—

24-ft. rail	..	..	9 sleepers.
27 „ „	..	..	10 „
30 „ „	..	..	11 „

Stations and Buildings.

The facilities provided at various stations are shown in Appendix A.

* 1 lac=1,00,000.

Staff Quarters.

No accommodation is available locally for superior staff. A few gangmen can find accommodation in villages, but this will affect only three gangs, and therefore practically the whole staff has to be provided with quarters.

Water Supply.

It having been decided that watering stations for this type of line can be placed at a maximum of 42 miles apart, the first watering station is at mile 40. The terminal station at mile 63 is the next. As suitable drinking water is not available anywhere on the line, 800-gallon storage tanks have been provided at stations and gang huts.

Junction Arrangements.

Junction arrangements at Bahawalnagar are of the simplest character as shown on Fig. 9. Abbas Fort, the terminus, has been provided with a triangle instead of a turntable, for reversing engines.

Operating Staff.

The extent to which the operating staff has been reduced will be apparent from the following table :—

Name of Station.	Station Master.	Clerks B class.	Pointsmen.	Water-men.	Sweepers.
Dhab Sanithika ..	..	1	1	..	1
Sawaiwala ..	..	1	1	..	1
Dunga Bunga ..	1	1	2	1	1
Khatan ..	..	1	1	..	1
Fakirwali ..	1	1	2	1	1
Khichchiwala ..	..	1	1	..	1
Abbas Fort ..	1	1	2	1	1
Total ..	3	7	10	3	7

Maintenance Staff.

Permanent-way Inspector	.. 1
Time-keeper	.. 1
Trolleymen	.. 4
Blacksmith	.. 1
Fitter and Carpenter	.. 2
Hammerman	.. 1
Bellowman	.. 1
Coolies	.. 3
Store Chowkidar	.. 1
Mates	.. 14
Gangmen	.. 128

Construction.

For reasons given in para. 4 the Bahawalpur Durbar were very anxious to have the railway opened as early as possible. Final location was commenced on 25th September 1926. Before this work was half finished the surveyors were withdrawn and on 24th November the construction staff took the field. The latter, therefore, had to complete the realignments, and longitudinal sections, prepare land plans and demarcate and acquire land in addition to construction work proper.

The chief difficulty was the absence of water and building materials along the line. It was therefore decided at the commencement to lay the rails as quickly as possible to allow of these being transported economically.

The following notes describe under separate heads how the work was carried out.

Land.

As the land plans were not ready when construction was started, the following system was adopted to enable possession to be taken quickly:—

The Bahawalpur Durbar were requested to depute a special land acquisition officer for the railway and to authorize him to transfer land to the Executive Engineer immediately where required in anticipation of formal sanction. They very kindly sent a man on 1st December.

Land plans were prepared for the first 5 miles and the land demarcated at site. One copy of each was given to the Land Acquisition Officer with a request to hand over the land. On receipt of these plans he noted down the nature of the ground, crops, etc., and immediately afterwards transferred possession of the land. Earthwork was started on this length and meanwhile the next 5 miles were being prepared and taken over and another contractor started.

Notifications and schedules were submitted some little time after the land was taken over.

This arrangement enabled the writer to commence earthwork in the third week of December 1926, otherwise it would not have been possible to do anything before March 1927.

Service Road.

It was of the greatest importance to make a service road first. A strip of land, 10 feet wide measuring from the toe of bank on one side of the line was cleared of jungle and roughly graded and dressed. Where the ground surface was of loose sand a layer of *sarkanda* grass was spread over it. This made quite a useful road for motor cars, but camels and bullocks, particularly the camels, did not like it and usually kept clear of it.

In the first 20 miles over 50 canals and watercourses were crossed. The types of bridge adopted for the service road are illustrated in Figs. 10 and 11. This was perhaps the cheapest form of bridging as the rails used were taken out undamaged when the bridges were dismantled, and the timber was all unserviceable sleepers otherwise only fit for fuel. Incidently, this road was very much used by farmers for transporting their crops to market during the harvest season. It was a great boon to them as hitherto the irrigation system in the Cholistan was conspicuous for the non-existence (practically speaking) of road bridges.

Earthwork.

Earthwork was started on 21st December 1926 soon after the land on the first 5 miles had been taken over. It was well known that it was impossible to work for two months after May. Therefore it was desirable to finish the earthwork, if possible, by the end of May. 2,000 men were required for this purpose and an attempt was made to import this number as early as possible. By February about 1,500 had been collected, but soon afterwards they began to desert and by the end of May only 200 were left, who, however, were not working in the Cholistan proper.

Due to the failure of the rains, the *tobas* or ponds had all dried up by the end of January and water had to be carried from canals or wells. The last canal along the Railway is opposite mile 26. 600 men working in the length from mile 24 to mile 35 depended for their water supply on this canal. 4 gallons per head were supplied by camels and bullock carts and the contractor was given an allowance of 12 annas to Rs. 1/4/- per 1,000 cubic feet of earthwork. It was very heavy work for the carts as there were no roads. In the hot days which followed, this allowance was found inadequate, no more conveyance could be obtained and the supply was at best precarious as it was very trying to move about in the severe dust storms which soon became a common feature of the Cholistan day.

For these reasons one contractor ceased work at the end of April 1927 and other contractors in the beginning of May. The result was that when track-laying commenced in the middle of April there was no bank on a length of 10 miles, and the track had to be laid on the ground. At the end of July, the ponds filled up, labour drifted back and by the end of August work was in full swing again.

Iron tanks of capacity varying from 60 to 400 gallons were supplied by Government to contractors for the use of labourers. One day's supply was stored in these. The smaller tanks were more appreciated as they were easier to carry about.

At those places where the track was laid on the ground sufficient earth was collected on both sides and a strong gang of 500 men employed to put this under the track. In this way a fairly long length was dealt with each day without interrupting the movement of trains.

Bridges.

The decision to lay the track before the bridges were built necessarily involved a certain amount of difficulty in crossing existing running canals. The first 22 miles of the railway goes through an area in which the canal system is nearing completion. There were one branch canal, four distributaries and about 50 watercourses running at the time construction was started. Two of the distributaries and a majority of the watercourses were not in their final positions and had to be kept open until replaced by permanent channels.

The arrangements for crossing the various classes of channels were as follows :—

(a) Temporary watercourses.

An armco culvert 18 inches diam. was placed in the bed of the channel and covered with earth. Where the bank was low care was taken to see that no sleeper was placed directly above the culvert. When the watercourse was no longer required the culvert was removed and the gap filled up.

(b) Permanent watercourses.

Temporary crib bridges of 8-foot span illustrated in Fig. 12 were erected at the sites of permanent watercourses. This span provided sufficient room for building the permanent culvert.

(c) Temporary Distributaries.

Crib bridges with sufficient waterway were built over temporary distributaries.

(d) Permanent canals.

For bridging permanent canals sleeper cribs were located so as not to interfere with the subsequent construction of abutments and piers.

It was ascertained at an early stage that three large canals, namely, the Gajjiani Distributary, the Malakwah Branch and the 3 R Distributary of the Hakra Branch could not be closed for a sufficiently long period to allow of the permanent bridges being constructed. Therefore these three canals were diverted temporarily while the bridges were under construction.

Fig. 13 shows the temporary bridge and the diversion of the Gajjiani bridge. Ordinary 24-foot track rails were used for making girders for these temporary bridges, the number for each girder depending on the span. For the Malakwah and Gajjiani Bridges with spans of 14 feet clear, 13 rails were used for each girder. On the 3 R for the same span the number was reduced to 9 without any appreciable difference in deflection.

Temporary bridges, except those over the larger canals, were built as the linking proceeded. Material was sent out a day before required and was led out to site by the bridge gang who erected the bridge and completed the earthwork before arrival of rail-head. For larger bridges as for example that over the Malakwah Branch with

11 spans of 14 feet the bridge material was sent out the day rail-head reached the canal, so as to avoid unnecessary lead. Linking had to stop for 4 or 5 days while the bridge was being built. Gajjiani Bridge, 9 spans of 14 feet, took 3 days, Malakwah Bridge, 11 spans of 14 feet, took 6 days and 3 R Bridge, 9 spans of 14 feet, took 4 days to build.

In running canals cribs were founded a foot below the bed. No trouble was experienced at the Gajjiani and Malakwah, but at 3 R the bed being very light sand the cribs were undermined and had ultimately to be put 5 ft. below bed level. There was no scour noticed at this depth. Where cribs are used they should in the first instance be taken down to a sufficient depth.

After the line was laid, building material, *viz.*, bricks, ballast, lime, surkhi, cement, sand, etc., were trained out to the bridges. At sites where water was not available locally—and this applied to a very large number of works—it was sent out from Bahawalnagar. For storing this water, water-tight ground tanks were made at site, supplemented by 40-gallon empty tar drums. For small works about 3,500 gallons of water were used per day.

Permanent-way.

Track laying is usually the most important work on railway construction and is usually held over until the earthwork and bridges are complete but in this case as building material was not available along the line and transportation by carts was very expensive, it was essential to lay the track as early as possible so as to facilitate transportation. The supply of water was throughout a very important problem as it was required not only by the labour but also for works.

Of the 65 miles of track required 42 miles of rails and fittings were to be supplied by the end of June 1927 and the balance towards the end of the year. The store yard was therefore designed for material for 30 miles of track. The first consignment was received on 1st February; the supply of material, however, was not fast enough and by 15th April only 21 miles had been received. Rails and fish plates came from Karachi, Quetta, Tando Adam and Bostan—average lead 600 miles. Sleepers came from Dhilwan, bearing plates and dog spikes from Sukkur.

Linking was commenced on 16th April. For the first 22 miles progress was rather slow as numerous bridges had to be built. Fakirwali in mile 41 was reached on 25th August. Linking was carried on right through the summer without a break. In May, June and the first half of July when the temperature in the sun was in the neighbourhood of 140° to 150°, when the sand blew almost incessantly from morning till night and when dust storms were severe and prolonged, linking gangs with the Permanent-way Inspector at the head could be seen any day laying rail after rail in the trackless, treeless and waterless desert. Almost the whole of this labour force was composed of Bagris. Several gangs of Punjabis were recruited from time to time, but they did not

371

stay long, some deserting within a few hours of their arrival at rail-head. The credit of laying the track therefore goes entirely to the Rajputana Bagris.

The ordinary labourer was paid 12 annas a day. A grocer who was specially appointed and subsidized opened a shop in the labourers' camp and sold all food-stuffs and other necessaries at Bahawalnagar rates. A covered wagon with wooden floor and sides was fitted up with 50 large earthenware jars. They were filled with drinking water at Bahawalnagar and sent out with the linking train for supplying cold water to the men while at work. After the day's work the travelling water-tanks attached to the train delivered water to small portable storage tanks placed at the labourers' camp.

Two third class carriages were attached to each train for providing the men with shelter from the scorching rays of the midday sun.

The following is an extract from instructions issued for track laying.

.....

II.—Marshalling of material train.

.....

This work will normally be done by the engine of the material train on its return from work and must be completed over night.

The order of the marshalling will be as follows :—

1. Rails.
2. Sleepers.
3. Fittings.
4. Drinking water.
5. 3rd class carriages.
6. Brakevan.
7. Engine.
8. Water-tanks.
9. Other trucks.

2. The train will leave the depot so as to arrive at rail-head at daybreak. *En route,* the building material trucks, and water-tanks, if any, will be detached at the places ordered and the guard will not leave them until they have been adequately braked and secured.

III.—Unloading material.

After the material has been checked by the P. W. I., it should be laid out.

IV.—Carriage and spreading of material.

1. Sleepers will be carried on the head and spread on the bank. A set of 5 men will roughly space and correctly centre them with the centring board, and cotton string stretched between centre pegs.

2. A gang of boys, men and women will carry and distribute fastenings, and bearing plates. They will be laid out in their proper positions alongside the sleepers.

3. Rails will be carried by men on rail slings.

Each gang which consist of :—

Rail carriers	..	.. 8
Hooking on slings	..	.. 2
Unloading for trucks	..	.. 1
		11

Note.—22 men will be sufficient for carrying rails for half a mile of linking.

.....

VI.—Linking.

.....

Each rail as it is brought in by the carriers will be picked up by the linking-in men with rail tongs—4 men at each end—and placed on sleepers previously fitted with bearing plates. The liner-man will place the liner of correct thickness which will be intimated to him by the P. W. I., in the joint and the rail will be fished and half-bolted at once.

2. The rail is now to be chalk-marked to indicate the sleeper spacings and sleepers spaced under the rails to correspond with the chalk-marks. The joint can now be fully bolted and one rail spiked.

3. Spiking should not be done until fish-bolts have been bolted for three rail-lengths ahead. One rail should be spiked through first and then the other rail gauged and spiked.

On the straight, the gauge should be 1/8 inch slack and on curves $\frac{1}{4}$ inch slack.

.....

4. The liner should be removed when 20 rail-lengths ahead have been linked in. The newly laid track should be straightened and roughly packed as the rail-head progresses, just enough to allow the material train to move up.

5. A strong gang working about half a mile behind will pack, straighten and level the road thoroughly.

.....

Statements showing the labour employed in linking a quarter mile and a half mile per day are given as Appendix B.

With a rate of linking of a quarter mile per day the cost per yard was 2½ annas. With a rate of half a mile per day, the cost increased to 3½ annas per yard. The increase was due chiefly to the greater lead in the carriage of materials. Appendix C is a sample of a daily progress report.

Up to a distance of 20 miles the linking train returned to the depot within 24 hours. The running staff, although duplicated, were put to severe strain when they had to work more than 16 hours at a stretch. To avoid this a crossing loop was laid at Dunga Bunga 19 miles from Bahawalnagar, and the running of trains so arranged that the outgoing and the incoming trains would cross there at nightfall, the former stabling there for the night and proceeding to railhead early next morning and the latter proceeding straight to the depot and arriving at about 9 p.m. This arrangement worked satisfactorily, up to 30 miles. Beyond 30 miles the outgoing train did not stable at Dunga Bunga, but went straight to rail-head, travelling all night. It should be remembered that these trains also carried water and building material trucks which they detached and picked up *en route*.

When about 30 miles of track had been laid a strong gang of 450 men was sent out to raise it to the proper level. Light loom was used for packing.

Ballast Train.—

The following is an extract of instructions issued for the working of ballast trains :—

.....

2. Until block instruments are installed, the construction ballast train employed on linking or other purposes will be worked without *line-clear* on the "one-engine-only" system, not more than one train being allowed to occupy the section at any time.

3. No train will leave the store depot yard at Bahawalnagar without a written permit from the S. S. K. P. B. C., Railway Construction authorizing the guard to proceed on the line and giving instruction for the day's work.

4. As a rule trains will not run at night. But when it is necessary to do so, the front vehicle will be a brakevan fitted with head lights and the rear vehicles will be fitted with two tail lights.

5. Engines pushing trains will not exceed a speed of 10 miles per hour. The maximum speed permissible on difficult lengths will be notified to all concerned from time to time and speed boards will be erected on the line. Guards and drivers will strictly observe these instructions.

6. The Guard of the Ballast train will be responsible for securing the vehicles of his train, if it is divided, or the engine detached for any reason. Vehicles disconnected from the engine must be first secured, brakes being screwed on or pinned down. At least half the number of each group of vehicles on a divided train must have their brakes pinned down, and one wheel of each group spragged.

Store Yard.—

Fig. 14 shows the layout of the store yard and water arrangements. At times the accommodation was found inadequate and the need for one more long siding was badly felt. This happened chiefly when 40 to 50 wagons loaded with material were received.

Water Supply.—

The daily consumption of water was estimated as 40,000 gallons made up as follows :—

For two locomotives	12,000	gals.
,, 1,000 men	8,000	,,
,, works	20,000	,,
Total ..	40,000	gallons.

A high service tank measuring 23′×23′ × 6′, capacity about 20,000 gallons, cost Rs. 2,600/- was erected on a sleeper staging. An existing 10-ft. diam. well was acquired and a pumping set consisting of a 3½ b. h. p. Campbell cold-starting crude oil engine and pump, cost Rs. 3,100 was used to supply the water required.

Two 6-wheeled Morris lorries of 1½-ton capacity, costing Rs. 9,000/- each have been ordered but have not yet arrived. They will be used for supplying water to labourers.

Telegraph.—

The telegraph line was laid by the Telegraph Department by March 1927 and telephone connections established soon after in the offices of the Executive Engineer, sub-divisional officers and of the sub-storekeeper.

Appendices D and E show the staff, work-charged establishment and plant used.

APPENDIX A.

Facilities at Stations.

Name of station.	Station Buildings.	Platforms.		Lamps.	Name Boards.	Latrine.	6 ft. diam. wells.	Sidings.
		Passenger.	Goods.					
	Sq. ft.	Ft.	Ft.	No.	No.	Seats.		
Dhab Sanithika	450	400	..	4	2	2	..	159 ft. (*a*).
Sawaiwala ..	450	400	..	4	2	2	..	,, ,,
Dunga Bunga	830	600	100	6	2	2	1	1,720 ft. (*b*). 285 ft. (*c*). 2 (*d*).
Khatan ..	450	400	..	4	2	2	..	159 ft. (*a*).
Fakirwali ..	830	600	100	6	2	2	..	1,720 ft. (*b*). 825 ft. (*c*). 2 (*d*).
Khichchiwala	450	400	..	4	2	2	..	..
Abbas Fort ..	1,500	600	100	6	2	2	..	285 ft. (*c*). 1,720 ft. (*b*). 2,058 ft. (*e*). 2 (*d*), 1 (*f*). 1 (*g*).

(*a*) dead end sidings.

(*b*) crossing loop.

(*c*) goods loop.

(*d*) dead ends.

(*e*) platform sidings.

(*f*) spare dead-end.

(*g*) dead-end for stabling vehicles.

APPENDIX B.

Labour employed in linking a half mile per day.

		Mates.	Coolies.
1.	Unloading and carrying rails to site ..	On contract at 2 annas per yard.	
2.	Unloading and carrying sleepers to site ..		
3.	Unloading and carrying fastenings ..		
4.	Rough spacing and aligning sleepers ..	..	8
5.	Chalk-marking rails	..	2
6.	Placing rails in position and half-fishing ..	..	8
7.	Oiling fish-plates	..	2
8.	Spacing and squaring sleepers	..	6
9.	Spiking rails	5	30
10.	Straightening and full-bolting	1	11
11.	Line-men	..	1
12.	Chowkidars	..	6
13.	Watermen	..	6
	Total ..	6	80

Labour employed in linking a quarter mile per day.

		H. mates.	Mates.	Coolies.	Women	Boys.
1.	Unloading and carrying rails	..	1	12	..	..
2.	Unloading and carrying sleepers ..	1	..	16	..	..
3.	Rough spacing and aligning sleepers ..	..	..	3	..	..
4.	Chalk-marking rails ..	..	..	2	..	..
5.	Unloading and carrying fastenings ..	..	..	..	3	3
6.	Placing rails in position ..	..	..	4	..	..
7.	Spacing and squaring sleepers ..	..	..	3	..	..
8.	Spiking rails ..	1	2	16	..	..
9.	Straightening and full-bolting	..	..	3	..	..
10.	Line-men	..	..	1	..	..
11.	Watermen ..	..	..	2	4	..
12.	Chowkidars ..	..	..	8	..	..
	Total ..	2	3	70	7	3

APPENDIX C.

Daily Report for the 29th day of July 1927.

Work done, 88 rails 30 feet, track 2,640 feet.

Laid in and straightened between ch. 152,950 and 155,590.

Particulars.	Head Mates at	Mates at Rs. 1-8.	Mates at Rs. 1-4.	Mates at Rs. 1-2.	Coolies at Rs. 0-14.	Coolies at Rs. 0-12.	Women at Rs. 0-8.	Boys at Rs. 0-8.	Carpenter at Rs. 1-0.	Blacksmiths at Rs. 20.	Boys at Rs. 0-4.	Boys at Rs. 0-6.	Total.	Amount.	Remarks.
1. Unloading and carrying rails to site.	By	con	tract											Rs. a.	
2. Unloading and carrying sleepers to site.	By	con	tract												
3. Rough spacing and aligning sleepers.					6	2							8	6-12	Linking Rs. 75-5-0
4. Chalk-marking rails.					2								2	1-12	Earthwork ,, 14-2-0
5. Unloading and carrying fastenings.	By	con	tract												
6. Oiling fish-plates					2								2	1-12	Major Bridges 45-14-0
7 Placing rails in position and half fishing.					8								8	7-0	
8. Spacing and squaring sleepers					6								6	5-4	Total Rs. 135-5-0
9. Spiking rails		1	2	2	22	8							35	31-8	
10. Straightening and full bolting				1	4	7							12	9-14	
11. Liner men						1							1	0-12	
12. Carpenter									2				2	2-0	
13. Rough packing						4							4	3-0	
14. Earthwork				1		14		3					18	13-2	
15. Trollyman										1			1	0-11	
16.							8	1					9	4-8	
17.							9						9	4-8	
18. Major Bridges			1	2		45	1	9			1	1	60	42-14	
Total ..		1	3	6	50	81	18	13	2	1	1	1	177	135-5	

APPENDIX D.

Regular staff and work-charged establishment.

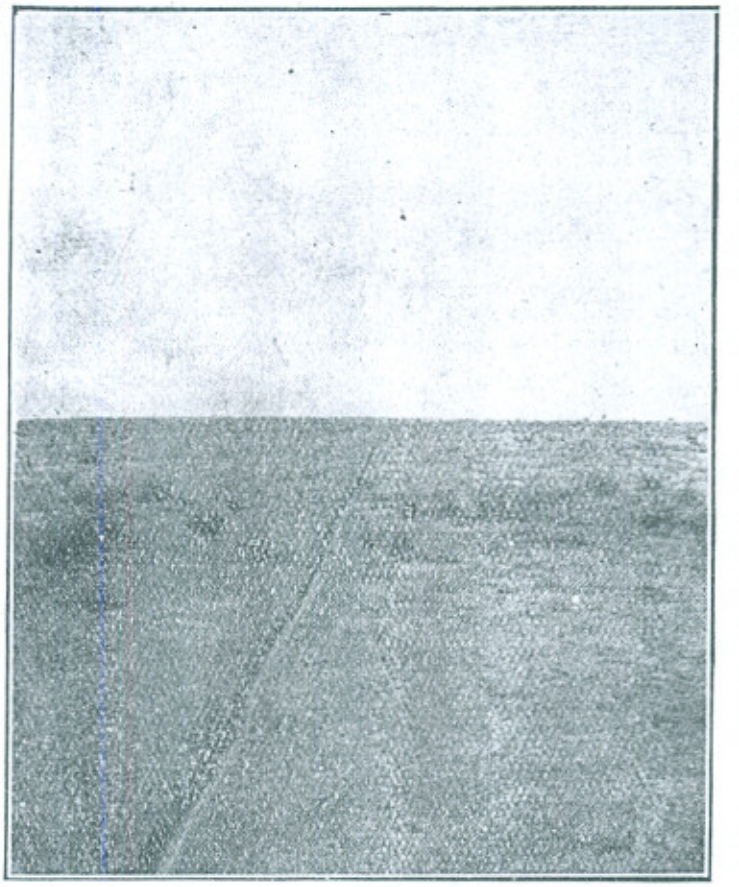
Executive engineer	1
Sub-divisional officers	2
Temporary upper subordinates	2
,, lower ,, ...	4
P. W. I.	1
S. W. I.'s	2
Accountant	1
Account clerk	1
Cashier	1
Store accounts clerk	1
General and establishment clerk	1
Assistant accounts clerk	1
Typist	1
Record clerk	1
Assistant store accounts clerk	1
Despatch clerk	1
Head draftsman	1
Draftsman	1
Estimator	1
Tracers	2
Sub-storekeeper	1
Depot store clerk	1
Asstt. ,, clerks	2
Sub-divisional clerks	2
Sub-assistant surgeon	1
Dispenser	1
Ward boys	2
Bhisty	1
Chowkidars	4
Sweepers	4
Daftry	1
Jamadar peon	1
Peons	7
Barkandaz	2
Mistries	5
Mates	37
Timekeepers	3
Carpenters	13
Mason mistries	3
Bridge work mistry	1
Camel-men	6

Khalasis	61
Chowkidars	16
Masons	4
Banias	2
Dak runners	3
Coolies	682
Trollymen	20
Challandars	5
Shunting jamadar	1
Brakesmen	2
Shunting porter	1
Pointsmen	3
Firemen	6
Shunter	1
Cleaner	1
Drivers	3
Guards	2
Blacksmiths	4
Hammermen	3
Fitters	4
Assistant fitter	1
Jamadar	1
Smith-boy	1
Repacker	1
Carriage fitter	1
Sawyers	4

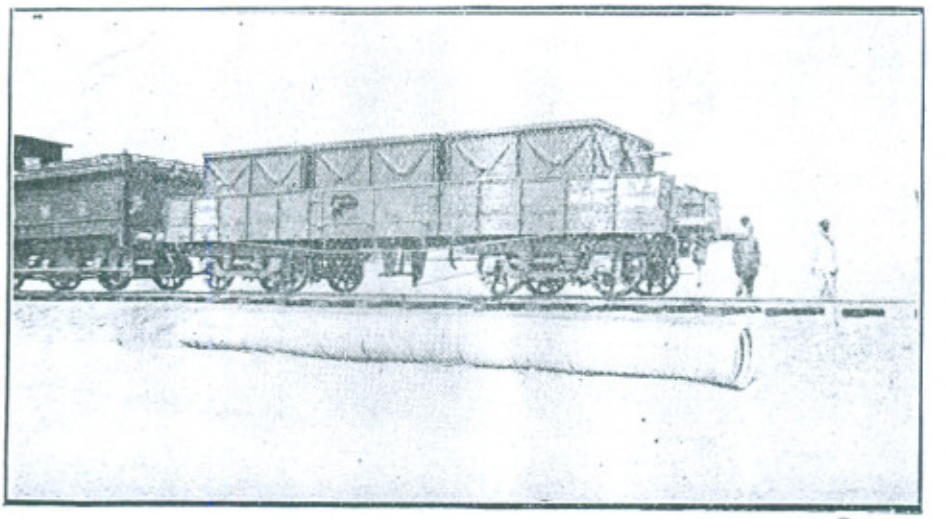
APPENDIX E.

Plant used.

Locomotives	No. 2
Brakevans	3
Open rail trucks	24
Low-sided trucks	39
Bogie open rail trucks	4
Wagons covered	7
Third-class bogies	4
Water-tank	1
Trucks loaded with 9 tanks	3
Tanks 23′× 23′× 10½′	1
Tanks 8′× 8′× 4′	5
,, 8′× 4′× 4′	4
,, 4 Cub. feet	6
,, miscellaneous	7
,, cylindrical	7
Hand pumps A-frame	2
Large drums, 40 gallons	100
Crude oil engines	1
Engines steam portable	2
Disintegrators	2
Winches crab	1
Rail-sawing machines	1
Rail lifters	12
Motor-trollies	1
Light riding-trollies	5
Material trollies	2
Kabul tents	8
Shouldaries	79
Tarpaulins	3



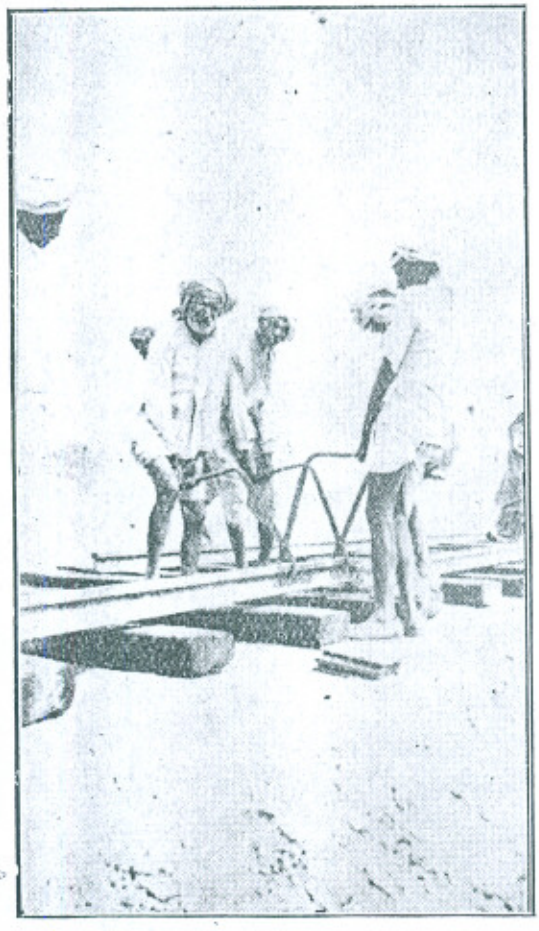
"The country is flat with a few sand hills scattered at intervals".
The centre line.



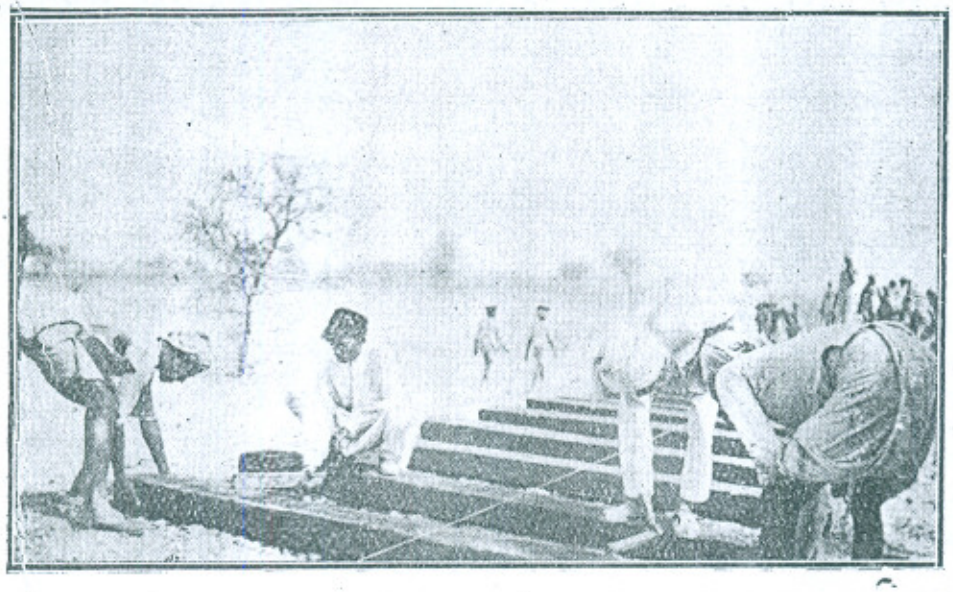
An 18" dia. Armco culvert and a travelling water tank.
Tankage on wheels totalled over 40,000 gallons.



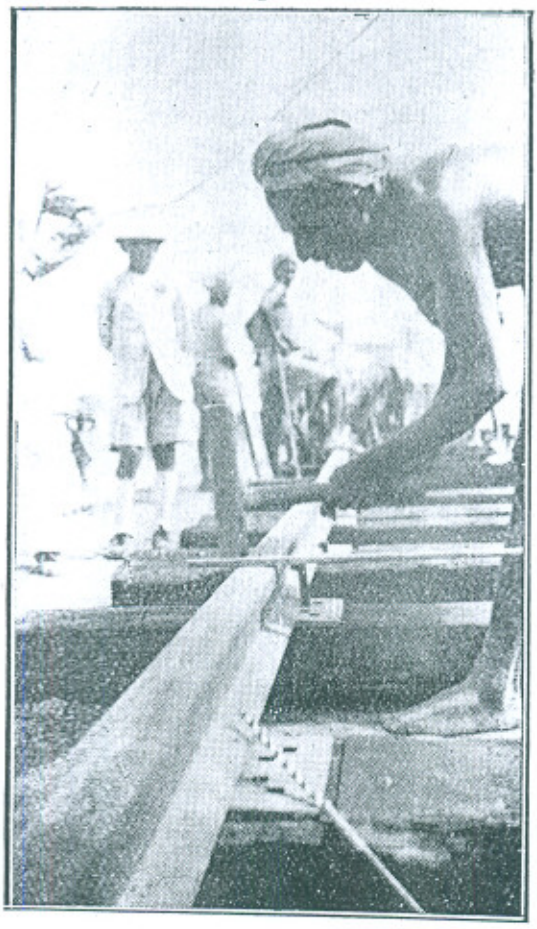
Rail being carried from the trucks to the head for linking.



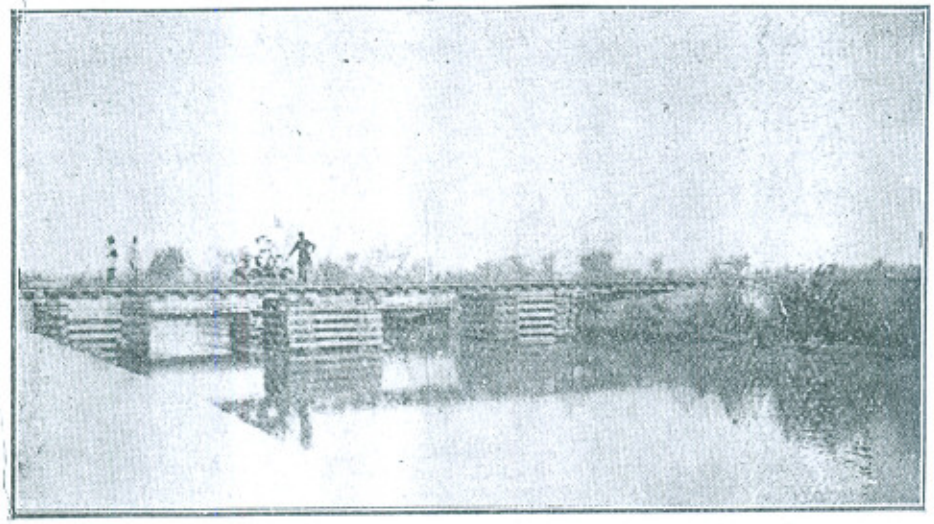
Placing in position. Women and boys were employed for carrying small fastenings.



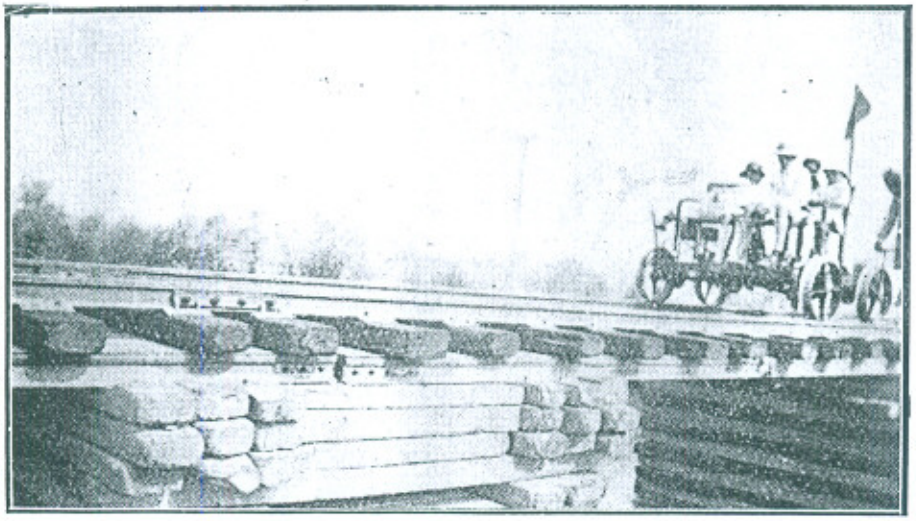
Centering and rough spacing.



Driving spikes. Note the striker's position.

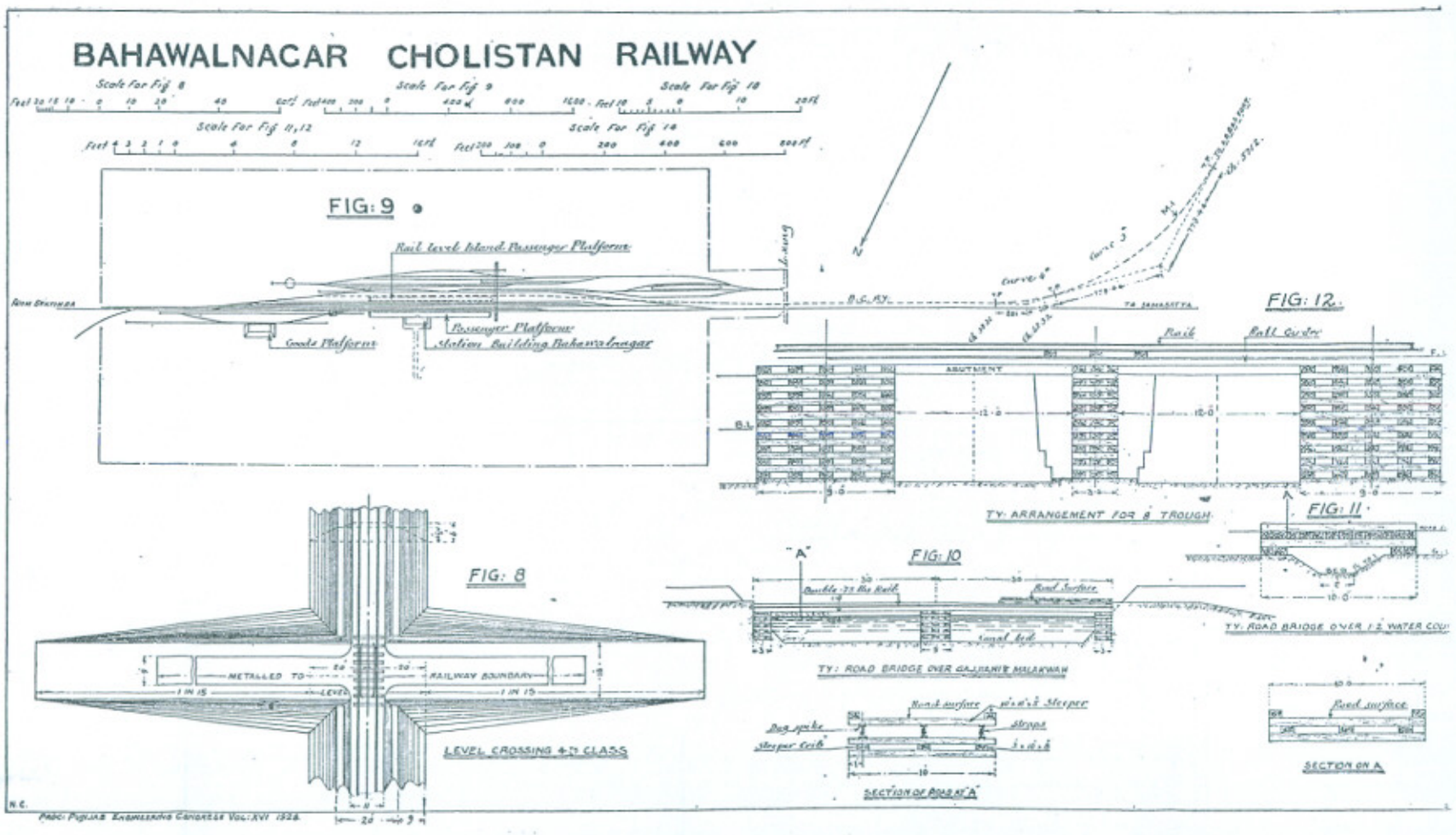


Temporary bridge over existing canal.
The Service Road bridge is also visible.



Girders and cribs. 13 rails 75 lb. FF were used for one girder of 14 ft. clear span.

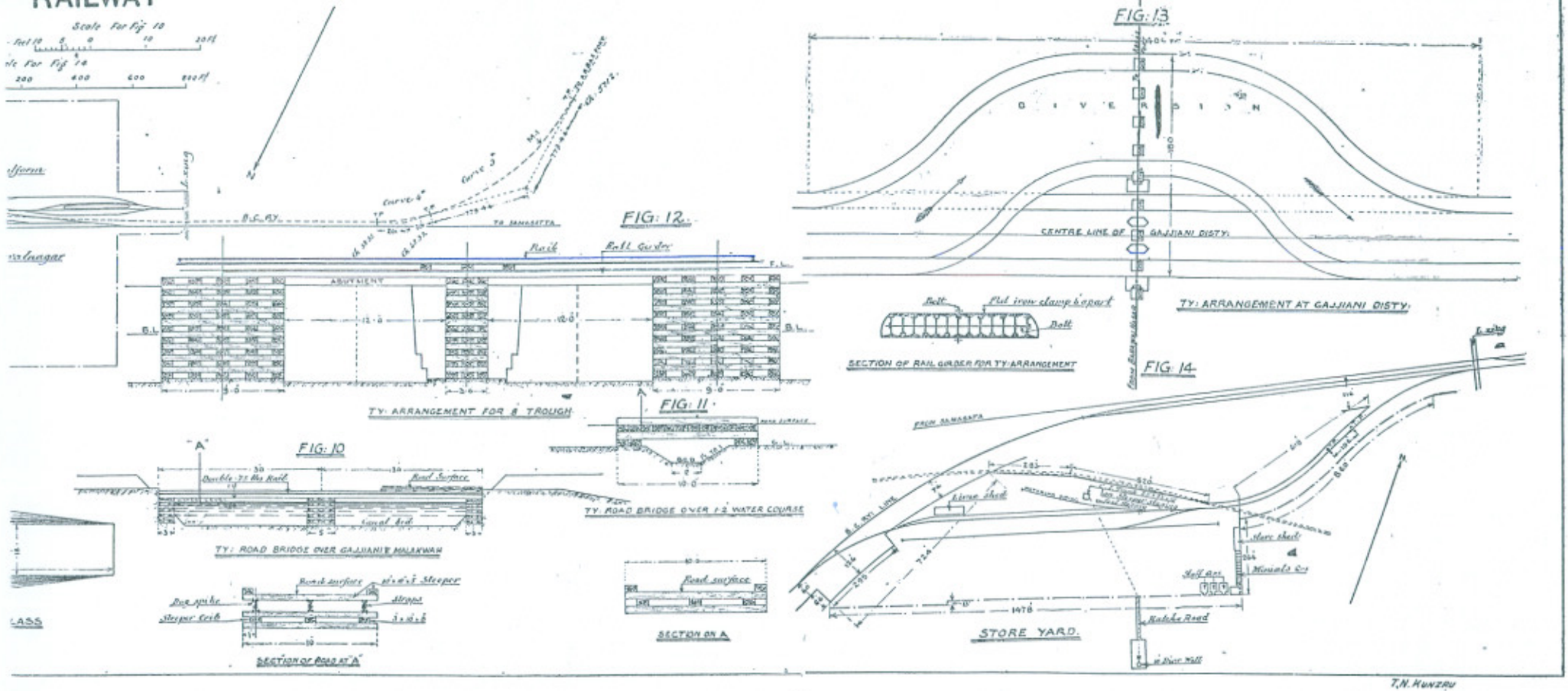
BAHAWALNACAR CHOLISTAN RAILWAY



Proc: Punjab Engineering Congress Vol: XVI 1928.

RAILWAY

PLATE No 2



T.N. KUNZRU

BAHAWALNACAR CHOLISTAN RAILWAY

Scale For Fig 1

Miles 0 4 8 16 24 Miles

Scale For Fig 3, 4.

Feet 4 2 0 8 12 ft

Scale For Fig 5

Feet 0 4 8 16 24 ft

Scale For Fig 6, 7

Feet 10 5 0 10 20 30 ft

FIG: 1

INDEX PLAN

SHOWING ALIGNMENT & WATER WAYS

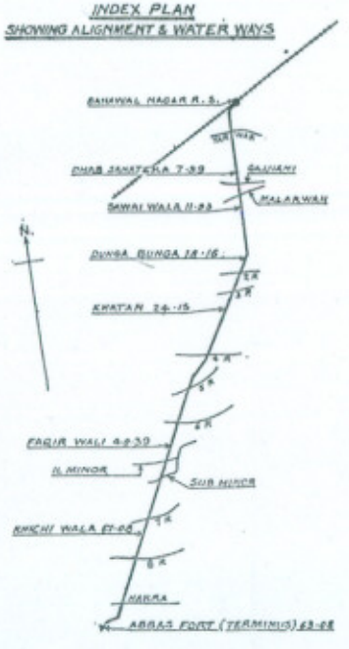
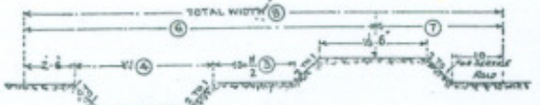


FIG: 2.



LAND WIDTHS FOR STANDARD "C" RAILWAY FOR BANKS UPTO 6 FT HIGH

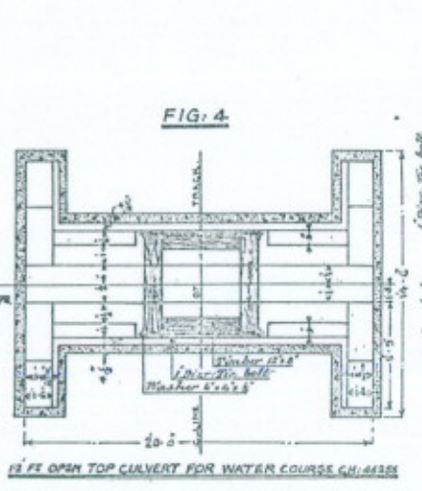
1	3	4	10	6	7	8
HEIGHT IN	SECTION	WIDTH AT TOP OF PUCKA	DEPTH OF PITS	WIDTH OF PITS OUTSIDE	WIDTH OF BANK AT BASE	TOTAL WIDTH
1	1:1	15	2	33	21	93
2	1:1	19	3	34	23	77
3	1:1	23	3	40	25	85
4	1:1	44	3	79	27	103
5	1:1	48	3	81	29	120
6	1:1	50	4	93	31	124



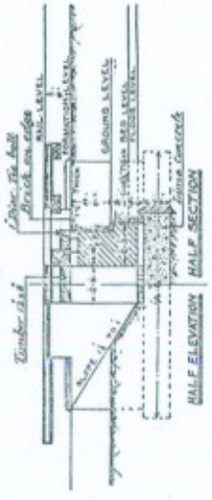
FOR BANKS ABOVE 6 FT HIGH

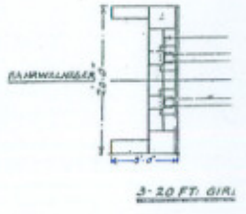
1	3	4	10	6	7	8
HEIGHT IN	SECTION	WIDTH AT TOP OF PUCKA	DEPTH OF PITS	WIDTH OF PITS OUTSIDE	WIDTH OF BANK AT BASE	TOTAL WIDTH
7	1:1	73	4	111	33	145
8	1:1	83	4	119	35	164
9	1:1	103	4	117	37	184
10	1:1	120	4	136	39	205
11	1:1	139	4	138	41	229
12	1:1	158	4	149	43	253

FIG: 4.



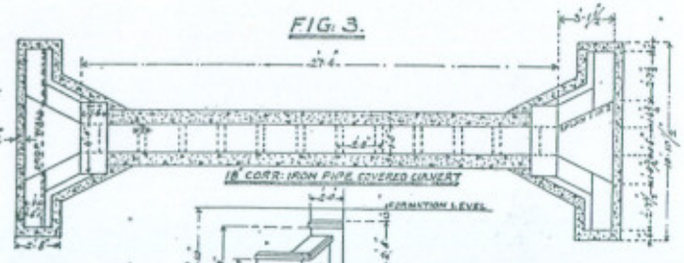
12 FT OPEN TOP CULVERT FOR WATER COURSE CH: 64526

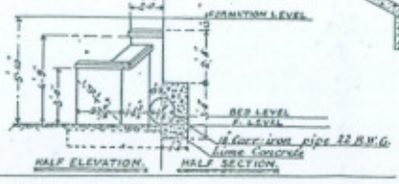




3-20 FT. GIR

FIG: 3.







OVER JA

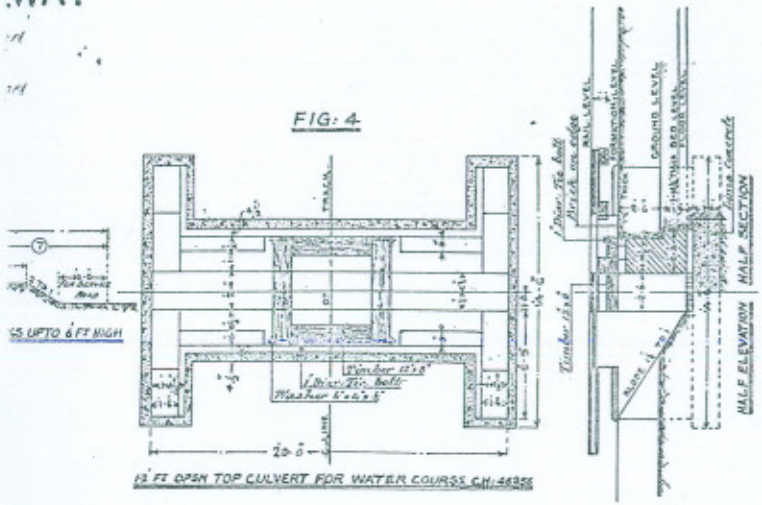
N.C.

PROC: PUNJAB ENGINEERING CONGRESS VOL: XVI 1928

.WAY

PLATE No. I

FIG: 4



13' FT OPEN TOP CULVERT FOR WATER COURSE CH: 4835

FIG: 3.

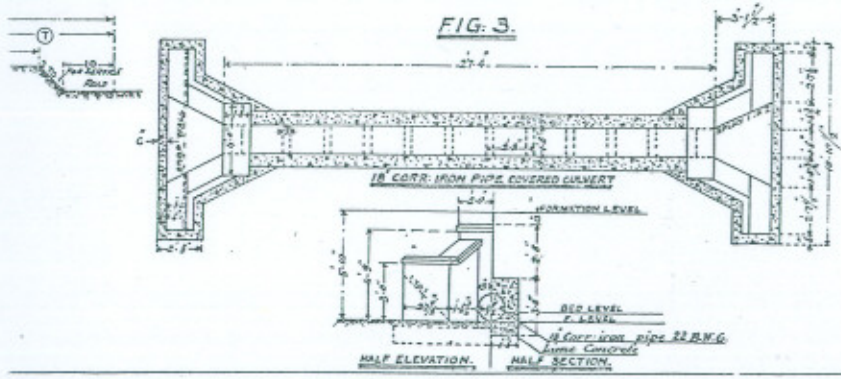
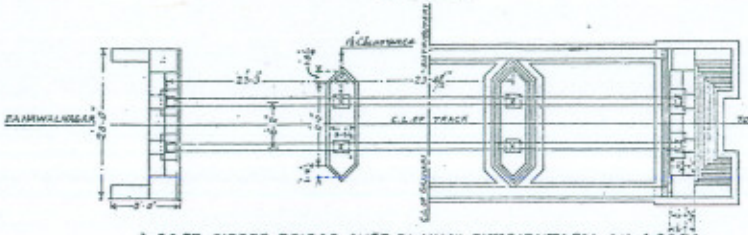
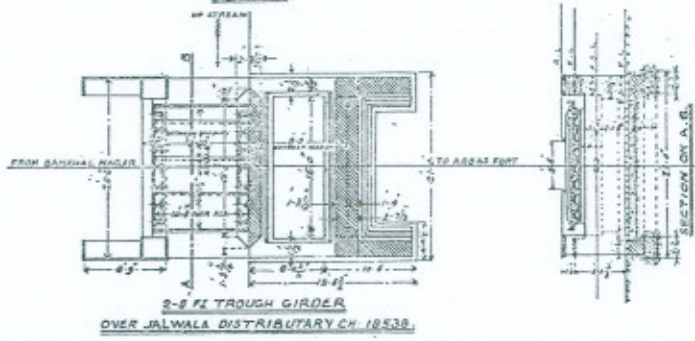


FIG: 6.



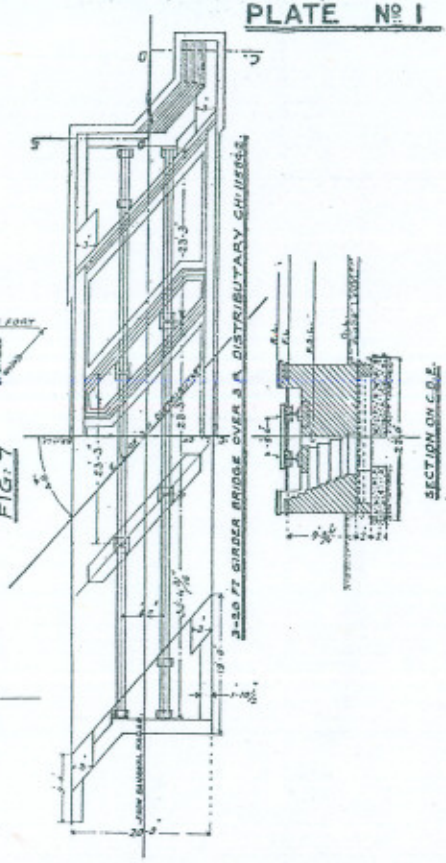
3-20 FT. GIRDER BRIDGE OVER GAJJIANI DISTRIBUTARY CH: 4-99 73

FIG: 5



2-8 FT TROUGH GIRDER
OVER JALWALA DISTRIBUTARY CH 18538.

FIG: 7



T.N. Rowzee.

DISCUSSIONS.

MR. KUNZRU, introducing his paper, drew attention to the economy effected in building the Bahawalnagar-Cholistan Railway. Land constituted a very important item of expenditure and therefore only sufficient land was acquired to accommodate the bank of the railway, or a cutting, as the case might be, with a 10 ft. wide berm on either side. This was the minimum under the regulations in force. This referred to the land permanently required. The area of the land only required temporarily did not matter much, as it was handed back on the completion of the railway.

There was no elaborate provision for fencing except where it was considered indispensible and even level crossings had been avoided as far as possible. These were ordinarily fourth class, *i.e.*, without any gates or a gateman, but in places where the traffic was heavy proper arrangements for a gate-lodge and a gateman were made. The number of stations had been reduced to a minimum and the water stations were forty miles apart. The operating staff had also been reduced to the very minimum required to work the railway.

To reduce the cost of these light feeder railways still further, he made two suggestions. The first was that steeper gradients might be permitted. The second was that where canals had to be crossed, these should be diverted so as to cross the railway at right angles. The problem of bridging also needed careful attention. On a small wayside station where there was no large traffic, fencing could be dispensed with without fear of trespass.

MR. HADOW remarked that he had seen the Bahawalnagar-Cholistan Railway under construction and appreciated the difficulties with which Mr. Kunzru was faced. This line ran through the same country as the Irrigation Department was tackling in the case of new canals in the Bahawalpur State. Mr. Kunzru, however, was fortunate to find canal water there before he came and consequently he had at least been able to give his staff something to drink. He had thus avoided some of the difficulties encountered by those who had to get canal water there. The country was now a barren waste, worse than any colony he had seen. In fact it corresponded more or less to what the tail of the Sirhind Canal was in its early days. As the canals had been under construction first Mr. Kunzru had naturally to face the problem of making a number of bridges across them. The case was the reverse when the Irrigation Department had to make hundreds of bridges in localities where a railway had been constructed first. It was, therefore, a matter which called for closer co-operation on the part of both the administrations in that they should keep each other closely acquainted with various proposals for new railway lines or canals.

As regards the construction of this line he considered that Mr. Kunzru had gone down to the absolute minimum expenditure. Personally he was against acquiring the full width of land necessary for borrow pits, as he considered that it would perhaps be economical to use a zamindar's land and pay him small compensation afterwards.

As the line ran mostly through the desert or sparsely populated country he was inclined to think that it would not be a very paying one in its earlier stages. In the early days of his service he remembered being told the history of the Lyallpur line which was then being taken down the Chenab Colony. The railway engineers were very doubtful about it, and Col. Ottley, who was then Chief Engineer of Irrigation, considered the necessity of floating a company to take up the line, but finally it was agreed that the railway administration should work the line. As far as he remembered, second hand rails were used on that line and within two years of its opening it took such an enormous amount of traffic that the track had very soon to be renewed. This would be the case in new canal colonies where traffic was bound to be heavy in the course of the next few years. He was, therefore, of the opinion that Mr. Kunzru had striven too much after economy in track as he would later have to undergo heavy expenditure in renewal, when the traffic developed, because feeder lines opened up the country and ultimately gave a very good return.

COLONEL WALTON said that he wished to touch on two points, firstly, in regard to the use of second-hand 75 lb. rails and secondly, on the financial justification for the construction of this branch line.

This construction was one of those in a large programme of construction that had been taken in hand by the North-Western Railway. One factor which had contributed largely to making many of the new constructions into economical propositions was the fact that as the main lines were being renewed with heavier rails considerable lengths of second-hand 75 lb. rails were made available for use in the new feeder lines. By this means the cost per mile was decreased by Rs. 10,000 as against the use of new 75 lb. rails. In the new broad gauge constructions the old policy of using 60 lb. rails had not been maintained because this entailed a restriction of speed on wagons with 16-ton axle loads and necessitated the use of engines with axle loads as low as 12 tons or so.

The new extensions gain by having 75 lb. rails and girders capable of taking 16-ton axle loads, both on locomotives and rolling stock, without restriction, not only were these generally obtained second-hand, at a reduced price, but they would not require renewal for at least a generation, while these low category lines were being built up into lines with increased capacity.

Secondly, this particular railway had been financed by the Bahawalpur Durbar and built by the North-Western Railway who would also be the working agency. It had been built at a minimum cost for a low category line and had been justified by the fact that it would serve an area which was about to be opened out by perennial irrigation and would thus attract immigration and lead to better values in the sale of land.

MR. COLYER referred to the temporary acquisition of land advocated by Mr. Hadow in preference to acquiring permanently wide strips for borrow pits for construction and for subsequent repairs. The permanent acquisition of land for borrow pits was fairer to the zamindar, who did not consider the rent he got in exchange as being much compensation for the use of this land especially when it was returned to him with the top soil removed, as this was very often the only portion of any value for growing crops.

LIEUT-COLONEL E. P. ANDERSON, R. E., wrote that the paper was of particular interest to him personally for two reasons. The original survey was carried out under his direction before any canals existed and he could verify from personal experience the correctness of the author's description of the country. With the coming of the canals he felt sure that the line would soon become remunerative. This was the first account given to the Congress of a line built to the cheaper standards advocated by him in a paper read at the Congress in 1924, though several other such lines had already been built. The value of the paper would be increased if the author would give the cost per mile under the usual heads. The use of second-hand rails had greatly reduced the total cost but the supply of them would not last for ever, and we would have to look in the future for cheaper steel or other economies. He was glad to see that the length of sidings had been kept even lower than he thought possible, but he still thought further reductions in the number of staff employed on such a line were possible, with a corresponding saving in quarters. Why was a design of culvert adopted with splayed wing-walls both up and down stream? Experiments made some years ago showed that square return walls on the up-stream side gave better results in passing floods. Was the line to be worked with tank or tender engines? For the former the watering station seemed rather far apart. He did not agree with the author about platform fencing. This was necessary to prevent passengers travelling without tickets.

MR. KUNZRU replying said it would be very many years before bank repairs on a large scale could be done away with on the Bahawalnagar-Cholistan Railway. The railway was unfortunate in that it had not the advantage of the canal water helping to consolidate the bank quickly. Till the earth packing was replaced by stone or brick ballast, earth from side pits would be constantly required for boxing and packing, in these circumstances, it was, in his opinion, necessary to take over land for borrow pits permanently.

As regards the points raised by Col. Anderson, he attached a statement giving the cost per mile under various heads. The figures were taken from the revised estimate, but they were expected to be very close to the actual expenditure.

All bridges on this railway were openings for irrigation channels. The line was to be worked by 'tender' engines. It was only decided after the paper had been submitted to make a loco watering place in mile 29 approximately in mid length.

Estimated cost of the Bahawalnagar-Cholistan Railway as per the revised detailed estimate.
(Length 63·08 miles).

Heads.	Sub-head.		Main Head.	
	Amount.	Rate per mile.	Amount.	Rate per mile.
	Rs.	Rs.	Rs.	Rs.
I. *Structural Engineering Works.*				
1. Preliminary expenses ..	..	..	46,249	733
a. Survey expenses ..	16,168	256	..	..
b. Plant	4,445	70	..	..
c. Establishment ..	25,636	407	..	..
2. Land	92,374	1,464	92,374	1,464
3. Formation	..	..	3,03,706	4,815
a. Earthwork ..	3,03,706	4,815	..	..
b. Side drains ..	..	..	..	..
4. Bridge work	..	..	1,92,820	3,057
a. Major bridges ..	21,551	342	..	..
b. Minor bridges ..	1,71,269	2,715	..	..
5. Fencing, etc. ..	..	..	41,517	658
a. Fencing ..	18,900	300	..	..
b. Road crossings ..	15,435	244	..	..
c. Mile and gradient posts	7,182	114	..	..
7. Ballast and permanent-way	..	..	24,09,633	38,200
a. Main Line—				
(*i*) Permanent-way ..	21,16,083	33,546	..	..
(*ii*) Ballast	1,11,909	1,774	..	..
b. Sidings—				
(*i*) Permanent-way ..	1,37,069	2,173	..	..
(*ii*) Ballast	6,559	104	..	..
c. Points and crossings ..	38,013	603	..	..
Total carried over ..	30,86,299	48,927	30,86,299	48,927

Estimated cost of the Bahawalnagar-Cholistan Railway as per the revised detailed estimate—concld.
(Length 63·08 miles).

Heads.	Sub-head.		Main Head.	
	Amount.	Rate per mile.	Amount.	Rate per mile.
	Rs.	Rs.	Rs.	Rs.
Brought forward ..	30,86,299	48,927	30,86,299	48,927
8. Stations and Buildings ..	..	..	3,94,597	6,256
a. Station and office ..	58,553	928	..	..
b. Workshop and store building ..	4,347	69	..	..
c. Staff quarters ..	1,83,666	2,912	..	..
d. Fixed station machinery	1,48,031	2,347	..	..
10. Plant Construction ..	1,44,453	2,290	1,44,453	2,290
II. Equipment	..	..	25,646	407
1. Plant—				
a. Engineering ..	9,273	147	..	..
b. Locos and carriages ..	10,598	168	..	..
2. Station and office furniture	5,775	92	..	..
IV. General Charges ..	..	..	3,43,990	5,453
1. Salaries and allowances ..	..	..	2,64,240	4,189
a. Direction ..	50,420	799	..	..
b. Engineering ..	1,67,402	2,654	..	..
c. Audit	20,168	320	..	..
d. Store	17,730	281	..	..
e. Medical	8,520	135	..	..
2. Office accommodation ..	..	..	40,500	642
a. Office accommodation	16,500	262	..	..
b. Contingencies ..	24,000	380	..	..
3. Residential quarters ..	33,750	535	33,750	535
4. Instruments	3,000	47	3,000	47
5. Indian freight ..	2,500	40	2,500	40
Grand Total ..	39,94,985	63,333	39,94,985	63,333