COLONY AND PROTECTORATE OF KENYA

COMMISSION OF INQUIRY INTO THE PARTIAL FAILURE OF THE NGONG ROAD WEST OF DAGORETTI CORNER

1952

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THE SUPREME COURT OF KENYA,
NAIROBI,
KENYA.
25th January, 1952

YOUR EXCELLENCY,

On the 19th November, 1951, Your Excellency appointed me, under the Commissions of Inquiry Ordinance (Chapter 40 of the Revised Edition of the Laws of Kenya), to be a Commissioner with the following terms of reference—

"to inquire into and report on—

(*a*) the circumstances relating to the partial failure of the Ngong Road west of Dagoretti Corner, with special reference to the responsibility for such failure; and

(*b*) the manner in which funds allocated to the construction of the Ngong Road west of Dagoretti Corner were expended;

and to make such recommendations as appear to be necessary."

2. This appointment was published in the Official Gazette of the 20th November, 1951, under Government Notice No. 1268.

3. I took the prescribed oath on the 21st November.

4. In a notice which was published in the *East African Standard* on the 23rd November, members of the public who were in a position to give material evidence before the Commission were asked to submit memoranda of the substance of the evidence. There was, however, no response to this Notice.

5. The public sittings of the Commission were held in Room No. 18 in the Law Courts, the first being held on the 14th December. The public were notified of this sitting in the *East African Standard* and also of the second sitting, which took place on the 17th December. Apart from a Press representative, only one member of the public attended the first sitting and none attended the second or subsequent sittings.

6. I have now completed the inquiry and submit my Report.

I have the honour to be,
Sir,
Your Excellency's Obedient Servant,

G. B. RUDD,
Commissioner.

COMMISSION OF INQUIRY INTO THE PARTIAL FAILURE OF THE NGONG ROAD WEST OF DAGORETTI CORNER

The Ngong Road West of Dagoretti Corner

The road which is the subject of this Commission of Inquiry is that part of the Ngong Road which runs from Dagoretti Corner for a distance of 4·3 miles to the Karen Duka. It is a district road under the control of the Nairobi District Council. The first two miles approximately from Dagoretti Corner were constructed to a light bitumen standard in the early 1930's, and the remainder was murram surfaced. During the post-war years traffic increased greatly, with the result that neither the murram surface nor the bituminized surface could stand up to the wear, and satisfactory repair became uneconomic and indeed impossible to maintain; so that reconstruction to a heavier bitumen standard became necessary.

Appointment of Consultant

2. In 1948, the Nairobi District Council was given a special grant by Government for the purpose of employing a firm of consultants, the Independent Construction Company (East Africa) Ltd. (hereinafter called the Consultants), to carry out a soil analysis along the road, to prepare a report and to recommend a suitable specification for reconstruction. By January, 1949, the Consultants' report, specification, bill of quantities and an estimate for the reconstruction of the road were received and submitted to the Public Works Department for comment. The estimate was an approximate estimate only and was £45,000 provided sufficient rock for the base-course was available from the Railway Cutting, and that water for compaction was provided free of charge.

Consultants' Opinion and Specification

3. The Consultants' opinion and specification were on the basis of a 24-foot bituminized carriageway capable of carrying a 10,000 lb. wheel load. They estimated that a total pavement thickness of 13 inches was required over a red clay sub-grade, and 23 inches over a black-cotton soil sub-grade; and they recommended a 4½-inch base of crushed rock, properly compacted, over a sub-base of selected murram, and covered by a dense pre-mix bituminized surfacing 1½ inches thick. They further reported that the existing pavement thickness of the old road was 6½ inches where it had a bituminized surface, and 7 inches over the rest of the road.

4. The Consultants also recommended that, where there was already a bituminized surface, it should be left in place and the remainder of the road surfacing super-imposed; that the shoulders of the road should be surfaced with base-course material 2 feet either side of the carriageway and sprayed with bitumen; and that there should be an application of bitumen over the black-cotton section prior to the addition of sub-base material.

Public Works Department Amendments to Consultants' Specification

5. The Public Works Department amended the Consultants' specification so as to simplify it and reduce expense. The wheel load of 10,000 lb. was higher than any main road design in Kenya and was reduced to 7,000 lb., which was considered adequate. The width of the carriageway was reduced to 21 feet, and un-bituminized murram shoulders were substituted for bitumen-spread stone shoulders on the ground of economy. The Consultants' recommendation to seal the black-cotton soil sub-grade with bitumen was considered of doubtful value and an unnecessary expense, and the Public Works Department recommended a 1-inch armour coat instead of a 1½-inch pre-mix surface, as being satisfactory and cheaper.

Original Public Works Department Specification

6. The amendments resulted in a specification on red soil of 9 inches of murram sub-base, 4 inches of water-bound macadam stone base-course, and 1 inch of wearing surface, giving a total pavement thickness of 14 inches over red soil. The specification on black-cotton soil was 13½ inches of murram sub-base, 4 inches of waterbound macadam stone base-course, and 1 inch of wearing surface, giving a total pavement thickness of 18½ inches over black-cotton soil.

Tenders

7. Contract documents in accordance with this original Public Works Department specification were prepared and tenders invited. The lowest acceptable tender was £42,012, which greatly exceeded the amount of £28,000 which the Central Roads and Traffic Board had recommended should be allocated to the District Council for this work, and the District Council had no means of making up the shortfall of £14,012. It was, therefore, suggested that the Council should estimate the price of the work if undertaken by its own labour. The Council's Engineer submitted an estimate of £27,100 provided the specification of the base-course was amended to 4 inches loose depth of hard black-trap stone, semi-grouted with ¾ gal. bitumen per square yard and sealed with ¼ gal. bitumen per square yard, instead of a 4 inches waterbound macadam base-course plus 1 inch armour coat. The Council's Engineer's suggestion would have resulted in a similar base and surface to that on the Kabete road; but it was not approved by the Public Works Department because—

(1) it would not have provided as great a depth of base-course and surface as the Public Works Department specification;

(2) ¾ gal. bitumen per square yard would not have filled all the voids in the stone of the base-course, which would consequently not be well bonded; and

(3) the Public Works Department specification provided for approximately the same quantity of bitumen per square yard, but in a depth of 1 inch of stone as opposed to the Council's Engineer's 3 inches of stone, which would mean that the quantity of bitumen used would be three times as much per inch of depth and would result in a more impervious and better bonded structure.

Work Undertaken by Nairobi District Council on Public Works Department's First Revised Specification

8. The Council's Engineer was doubtful of the ability of his staff and plant to make a good job of water-bound macadam, using soft stone; but eventually he agreed to undertake it, provided that help in the form of technical advice was given by the Public Works Department, and that, on grounds of cost, the base-course was 3 inches thick instead of 4 inches, the difference of 1 inch being made good in the murram sub-base. This was approved, and the working specification of the road became 1 inch of armour coat wearing surface, over 3 inches of waterbound soft stone macadamized base-course over, in the case of red soil, 10 inches of murram sub-base and, in the case of black-cotton soil, 14½ inches of murram sub-base.

Public Works Department's Second Revised Specification

9. The work was put in hand in November, 1949, on this specification; but, as it progressed, the quality of the murram in the sub-base deteriorated to such an extent that it became no longer suitable, and the specification for the construction of approximately the last 1½ miles of the road to Dagoretti Corner was amended to provide that the top 4 inches of the sub-base should be 4 inches of crushed stone from the Railway quarry instead of murram.

Proposal to Seal the Road

10. The work was completed, ostensibly to these specifications, early in October, 1950. In January, 1951, the District Council asked the Government to pay the cost of sealing the whole road before the long rains started. This request was submitted to the Public Works Department, which recommended that about ¾ of a mile of the stretch between Dagoretti Corner and the Duke of York School turn should be sealed immediately, but that the balance of the road did not require sealing until 1952. This opinion was conveyed to the Government and to the Council; but, since the requisite funds could not be provided, no seal was applied to any part of the road before the long rains.

Failure of the Road in April, 1951

11. The 1951 rains were unusually heavy, and it became clear that the effect of the Railway embankment and bridge had not been fully realized. Large pools of water formed along the road and were confined by the embankment. Water flowed on to, over and along the road, which broke up badly in so many places, with such extensive failures, as to make it appear to be almost a complete failure for most of the 2 miles from Dagoretti Corner to the Duke of York School turn. Not all of this was due to the Railway embankment; but the failures around the Railway bridge, and from it to

Dagoretti Corner, where the water flowed along the road, were particularly bad. Other failures occurred in the dip in the forest and about the first Karen turn-off from the Dagoretti end (hereinafter referred to as the Karen turn-off); but the area of extensive failure was the first 1½ miles from Dagoretti Corner. These failures were undoubtedly due to the fact that water penetrated to the sub-base murram, which was of poor quality and too near the surface to bear the strain which was put on it. The specifications were designed to allow of the materials becoming wet, but I do not believe that it was envisaged that the sub-base would have to stand up to the wetting it got near the Railway bridge or from there to Dagoretti Corner.

Test Holes Reveal that the Base-Course is Not up to Specification

12. There were so many failures on the road which pointed to base or sub-base failure that, in May, 9 test holes were dug in the road between Dagoretti Corner and the Duke of York School turn, from which it was discovered that the base-course was not up to specification. Where there should have been 7 inches of stone base and sub-base there were only some 4 inches or less; and where there should have been 3 inches of base there were only 2 inches. A further 12 holes were dug in the rest of the road and disclosed a similar position: that is to say 2 inches or less of base instead of 3 inches. The greatest depth of stone base and/or stone sub-base found anywhere on the road was 4¾ inches at the Duke of York School turn.

13. The stone used in the base at the Karen end was very good quality hard stone, and the Materials Branch of the Public Works Department, which made the test, believed at that time that the whole base was constructed of such stone. The Materials Branch did not know that from the Karen turn-off to Dagoretti Corner a much softer stone was used. In some parts stone very similar to the Railway stone layer of sub-base which was specified for the last 1½ miles to Dagoretti Corner was used and, consequently, it appeared to the Materials Branch that in some places there was no depth of specified stone base at all—only sub-base masquerading as base.

Amount of Stone Ordered for the Base-Course: 232,000 cubic feet

14. One of the main reasons for the appointment of this Commission was the shortage of base disclosed by these test holes, and the explanation of this shortage is the most difficult task before this Commission. The original quantity of stone ordered for the base-course was 190,000 cubic feet, which should have been more than adequate to build the base to the specified compacted depth of 3 inches if it was all put into the base-course; but, notwithstanding this, a further 42,000 cubic feet of stone had to be ordered before the base-course was completed, and even then the finished base-course was under specification and only about 2 inches thick instead of 3 inches.

Possibility of Defalcation Discarded

15. The Commission has carefully considered the possibility that there was some deliberate defalcation in regard to this stone, but has discarded that as a possibility for the following reasons:—

(*a*) Too many people were involved. In addition to the Council's Engineer and staff, the work on the road was consistently inspected by a succession of different Public Works Department Engineers and other personnel experienced in road building. None of these noticed that insufficient stone was used in the base, and all of them were completely surprised at the results disclosed by the test holes. If there had been a conspiracy to defraud, a large number of people must have been involved or else a tremendous risk was taken.

(*b*) There was as marked a shortfall in the case of the Railway stone sub-base at the Dagoretti Corner end of the road. This stone was paid for in a lump sum at a cheap rate and obtained from the Railway and not from a contractor; so that there was no incentive to fraudulent conspiracy.

(*c*) The witnesses examined all impressed the Commission as being honest.

(*d*) Although the shortfall is large and difficult to explain, reasons can be found to account for a large proportion of it; and it seems possible to the Commission that they could account for the whole of it. There is admittedly a measure of uncertainty as to exactly how all the shortfall occurred, but this is mainly due to the fact that it was caused by a number of factors, and it is not possible in many instances to assess exactly the effect of each of the individual factors.

Quality of Stone

16. The Contractor who supplied the stone got the contract by tender. He submitted two samples of stone and two different quotations, depending upon which sample was selected. One sample was soft stone and the other was a hard building stone. The soft stone was selected. It so happened, however, that the first deliveries were of hard stone though subsequently soft stone was supplied. The softness of the stone was reported by the Council Foreman and Supervisor, but they were told that it was according to sample. This stone varied in quality and softness, some of it being extremely soft, crushing to dust, and some being clayey and likely to disintegrate on being saturated with water. The contract was for 2¼ inch crusher-run stone; so that anything which would pass through a 2¼ inch mesh was acceptable under the contract. There was a large proportion of fines and chips. The Contractor put it at 20 per cent to 22 per cent. They were not used in the base-course, though they were used in the shoulders. When the stone was ordered it was believed that the dust and chips would be valuable for binding the material into macadam and would help to procure a good consolidation. This would have been the case in regard to the soft stone, as a subsequent test by the Public Works Department's Materials Branch on the Duke of York School road showed; but the first stone delivered was hard stone and was laid and macadamized under the supervision and direction of Public Works Department road superintendents, who found that, when the fines were included, the material crept under the roller and would not bind. So they ordered the material to be relaid eliminating the fines, and thence-forward the fines and chips were eliminated from the base-course with the soft stone as well as with the hard stone, pronged forks being used for the purpose.

17. The elimination of fines and chips would be a direct explanation of a substantial part of the shortage—up to 15 per cent at least in my opinion, and possibly up to 20 per cent, of the stone ordered. Apart from this direct result, the elimination of chips and fines would have a result on compaction, because 4 inches of large stone with no dust or fines in it would have more voids than the same thickness of stone which included a high percentage of chips and fines; so that the layer with greater voids would compact to less than the other, and the softer the stone the greater would be the compactive effect. In the Public Works Department compaction test on the Duke of York School road dust and chips were not eliminated; so that the result of that test, which showed that 5½ inches loose, including fines, compacted to 4 inches, is not exactly applicable to the base-course in the Ngong Road.

18. Another point in connexion with this compaction test was made by Mr. Fleming of the Public Works Department during my inspection of the road. He believed that the effect of a roller on a thin layer of stone would be greater as regards compaction than it would be on a thicker layer and that, as the test was on a loose layer 5½ inches thick, the compaction loss on a layer 4 inches thick or less would be in greater proportion. I think there is some support for this contention in page 3 of the Consultants' report on the soft Railway stone, where it was said: "It was felt that the effect of standard compaction on this material did not reflect the effect of a heavy roller on a thin layer".

19. Although the measurements of the thickness of the base in the test holes made in the road by the Public Works Department were taken as carefully as possible, it was pointed out in the evidence given by the representative of the Materials Branch who took the measurements that they were necessarily inaccurate to some extent, and that he could not guarantee them to within less than about ¼ inch either way. Although ¼ inch seems a small margin, it amounts to 12½ per cent on 2 inches, or 8⅓ per cent on 3 inches. The same witness also pointed out that most of the stone used was very soft, and that where it crushed to dust it would be very difficult indeed to distinguish from the underlying murram: in this he was supported by Mr. Strongman, the Materials Engineer, who said that the stone was so soft and clayey that, if it got wet, it would be liable to disintegrate.

20. Another effect of the softness of the stone was that, when it was slurried and brushed in the process of macadamizing, some of it which had crushed to dust would be carried away with the water and brushing. The test holes disclosed that a considerable quantity of water permeated through the armour coat to the base and sub-base.

21. When all these facts are taken into consideration, it is considered that they probably afford, in the aggregate effect, a sufficient explanation as to why a loose layer of stone (say from 3½ to 4 inches thick) should have compacted to a visible layer of about 2 inches-plus thick, instead of 3 inches-minus.

Shortfall between the Amount of Base-Course Stone Ordered and the Amount Found in the Road

22. There remains, however, the question as to what happened to all the 232,000 cubic feet of base stone ordered and paid for, which seems ample to provide a greater loose depth than a layer of 4 inches, since 4 inches multiplied by 4·3 miles multiplied by 21 feet comes to only 158,928 cubic feet.

23. In the first place, although the specified width of the base-course was 21 feet, it appears to have spread wider under pressure. Three cross sections of the road were measured and found to vary in width from 21 feet 3 inches to 22 feet 2 inches, the average being 21 feet 7 inches. These cross sections were all made towards the Dagoretti Corner end of the road. For the first three quarters of a mile at the Karen end hard stone was used, which would be inclined to spread more. At the bends the road was made wider; and more stone would be used for banking to get the correct camber. This was agreed by Mr. Fleming and Mr. Hugo. From all this it appears that the carriageway was made wider than 21 feet, and therefore more stone than 158,938 net cubic feet would have been required to give a 4 inches loose depth of stone base.

24. The stone was delivered at various places: at first it was stacked at the side of the road in a triangular windrow, but, as this obstructed operations and caused loss of stone in the drains, the stone was subsequently dumped in the middle of the road. However, since the delivery rate of stone far exceeded the progress of the road, this method also had to be given up, and the stone was then stacked in several stock piles off the road. This must have increased the handling and caused some added waste. The stone was delivered some considerable time before it was used: it was soft and porous, and I think this too must have added to the loss, particularly if it was heavily rained on. This stone was also used to make temporary repairs in the old road by filling up holes in the old surface, and to make deviations passable in bad weather. It is usual to allow a minimum of 10 per cent for waste. In this case I think a larger allowance should be made, and I do not consider that 20 per cent would be too much. If to that is added only 15 per cent for the elimination of fines and chips, we would have left 150,800 cubic feet, which is enough to provide a loose layer of 3¾ inches over the road, taking the width of 21 feet 7 inches, which is the average of the three cross sections. 20 per cent may seem a large amount to allow for waste, but it is surprising how small amounts can mount up. When the road was finished, up to 50 loads were taken to the Mbagathi road, and 1½ were used for the compaction test. These amounts, though small in relation to the total amount of stone ordered, came to about 2 per cent of it. Half a mile of base ravelled under traffic and had to be relaid, with a loss of approximately 10 per cent of the stone in that half mile, which is upwards of 1 per cent of the amount for the whole road. So these two factors alone would mean an increase in loss of approximately 3 per cent over the usual 10 per cent allowance.

25. There is a possibility that there was some measure of short delivery of the 190,000 cubic feet of loose stone originally ordered. Where this was delivered to stock piles, the piles were not levelled off before measurement but were measured in the uneven state. There is a possibility of a shortfall of up to 5 per cent on the measurements. Some of the witnesses put the possibility of error at considerably more than 5 per cent but, owing to the absence of records, it is not possible to make a definite finding that there was a short delivery, and it has not been established as a fact that there was any serious short delivery. It is a possibility, and, if it existed in fact, it would help to explain some of the shortage of stone disclosed by the test holes.

Railway Stone

26. As regards the Railway stone, the test holes showed an even greater shortage. There should have been 4 inches compacted thickness under the base, but in fact there is only about 4 inches including the base. Part of this shortage can be explained by the fact that the calculations were worked out on the basis of a loose depth of 4 inches, instead of a compacted depth of 4 inches, which immediately points to a

shortfall of three-elevenths of the specification. Further, insufficient allowance was made for voids. This stone was brought to the road in large boulders and there crushed to a smaller size. The heaps of boulders would contain many voids and, as a result of crushing, the amount of stone which was available for the road would be much less than the cubic capacity of the heaps of uncrushed stone. It is estimated that the shortfall on this account would be 30 per cent, and that about 2¼ inches compacted is the most that could be expected on the calculation for this stone. In fact only just over 1½ inches was found; so there appears to be a definite shortfall in results as regards this stone just as there was as regards the other base stone. The Railway stone was put on the part of the road which failed most, and the murram under it was of very poor quality and became plastic when it got wet. There must have been considerable disturbance of the murram layer, which also affected the stone layer, and this fact would make it difficult to find out exactly what happened to the soft stone sub-base and difficult to distinguish it and measure it exactly. Further, the sub-base was not blinded and macadamized with water, and so it would have been liable to more disturbance and penetration, and possibly to a greater degree of compaction.

27. There was no incentive to fraud in regard to this stone, as it was not obtained through a contractor and it appears to have been paid for in a lump sum rather than by the load. The only inducement to use less of this stone than was necessary was the need to hurry through the work on the road in order to complete it before the season of the short rains, and also to keep the cost of the road within the amount allocated for it. I am, however, satisfied that there was no deliberate attempt to skimp this stone. The necessity for it was realized and the laying of it was watched frequently by the Public Works Department Inspecting Engineer, who would have no incentive to connive at a shortfall.

Relations between the Public Works Department and Nairobi District Council Staffs

28. Throughout the reconstruction of the road, relations between the District Council staff and the Public Works Department Inspectors and advisory staff were amicable. It is agreed by everyone that the Public Works Department staff had no executive responsibility for the building of this road, which remained at all times the responsibility of the District Council staff. The Public Works Department promised technical advice and assistance and gave it generously; but the responsibility for adherence to the specifications was always with the Council. It is true that the calculation of the amount of Railway stone required was done by a Public Works Department official, and he frankly takes responsibility for that; but it was not his duty to see that the specified depth was put into the road. He did measure the loose depth of the base-course on one occasion and found it approximately correct. Both the Council staff and the Public Works Department staff are agreed that executive responsibility rested with the Council throughout.

Quality of Murram Sub-Base

29. The murram sub-base was of adequate depth according to the specification up to the time the specification was altered to provide for a 4 inch layer of stone sub-base; that is to say, on all but the last 1½ miles of the road.

30. As regards quality, the murram was of good quality from the Karen dukas to about the Karen turn-off, when it began to decline in quality and got progressively worse. The Materials Branch of the Public Works Department made constant tests and began to be worried about the quality as from the Karen turn-off; but, so long as the quality was on the borderline of satisfaction, no action was taken in the interests of economy. Eventually, however, the quality became definitely unsuitable, and so for the last 1½ miles a sub-base layer of Railway stone was specified.

31. By the time this decision was taken a considerable quantity of the inferior murram had been placed on the road right up to Dagoretti Corner. It was not ordered to be removed because of the cost and the delay which its removal would involve, and also because it was thought that it would be satisfactory enough if topped by a 4 inch layer of Railway stone sub-base. For the last 1½ miles the quantity of murram sub-base was not quite sufficient to comply with the specifications. The District Council cannot be blamed for this, however, as their supervisor had been told not to use any more of the murram.

32. It was the intention of the District Council's Engineer to scarify the old bitumen surface before putting on the murram sub-base. This was not done on grounds of expense and also because the Public Works Department's adviser did not consider it necessary or advisable. Opinions differ as to whether or not it should have been scarified. Test holes showed that scarification was not necessary to provide a key. It would, of course, have enabled the water which penetrated from above into the sub-base to go down into the sub-grade, thereby weakening the sub-grade; but as against this, it would possibly have made the sub-base stronger by allowing it to get rid of some of its water. I think that scarification would probably have made the sub-base stronger; but it appears to be a moot point as to whether it would have had a very marked effect, and certainly no blame can be attached to the Council's staff for failure to scarify the old pre-mix, since they acted on the best advice obtainable by them when they left it as it was. Nor do I think that any blame lies on the Public Works Department for recommending against scarification, as this is a matter upon which experts differ and it is not certain that scarification would have made any big difference to the result. The Consultants' report advised that the old pre-mix be left intact.

Quality of Armour Coat

33. The armour coat was laid by the Public Works Department and was fully up to specification as regards depth and showed very good penetration of bitumen. It turned out, however, to be very porous and allowed a great deal of water to penetrate to the lower layers. This was partly due to exceptionally heavy rain in 1951 and bad drainage on parts of the road; it was also due to the fact that it had not been laid long enough before it got wet for traffic to have kneaded it sufficiently to make it more waterproof. In these circumstances, it was unfortunate that a seal was not put on the Dagoretti Corner end at least, as advised by the District Council and the Public Works Department; but, even if such a seal had been put on, it is by no means certain that it would have prevented a failure at the Railway bridge owing to the lack of drainage there. If the inferior murram sub-base got wet failure was bound to occur. A seal might, however, have minimized the failures which occured there and have prevented others from occurring.

Causes of Failure

34. The main cause of failure was not due to the sub-grade even where this was black-cotton soil. The test borings showed that the sub-grade, even when it was black-cotton soil, was relatively dry and sound. The cause of the failures at the Dagoretti Corner end of the road was the saturation of the inferior murram of the sub-base which became plastic, and the weakness of the base. The main area of failure was the portion of the road which contained a sub-base layer of Railway stone and which was most subjected to flooding. Failure to consolidate the Railway stone into proper macadam rendered it liable to penetration by the clayey murram sub-base when it became plastic on saturation with water, and this penetration would lubricate the stone and cause disturbance of the stone and thus lead to failure. The thinness of the stone layers had a threefold effect: in the first place, it had the direct result that the layers themselves were weaker than they should have been; in the second place, being thin, they were more liable to penetration by inferior material from below; and, in the third place, it increased the load which the inferior murram had to bear, because the intensity of pressure or weight per square foot on a road foundation varies with the depth at which it is measured, the weight of a vehicle being distributed over a wider and wider area of the foundation according to the depth. For example, the intensity of pressure at 2 inches from the surface would be considerably greater than at 3 inches from the surface, and it would be very much greater at 4 inches from the surface than it would be at 7 inches.

35. The softness of the base stone, as well as its lack of depth, predisposed it to failure; and the fact that some of it was clayey would lead to failure where such stone was included in the base-course. The stone used for the base was in general too soft for this purpose.

36. Near the Karen turn-off failure was chiefly due to insufficient drainage and the raising of the water table there by a hard bank of murram which hindered water from percolating and draining away from the road foundation.

37. The whole road is technically sub-standard. Apart from those places where failure occurred to the extent of disintegration of the surface, there is evidence of technical failure not amounting to breakdown. This is shown by the existence of depressions, somewhat similar to corrugations, which have occurred.

Recommendations

38. No experienced engineer would guarantee this road to stand up to traffic unless it is strengthened by the addition of a carpet of hard stone. There is, however, a chance that the road will continue to be servicable for some years if it is carefully maintained.

39. The bad stretch consisting of the last 1½ miles to Dagoretti Corner has been improved by additional drainage and culverts installed after the first breakdown and has stood up fairly well to the 1951 short rains, which were unusually heavy and prolonged. But there is a noticeable tendency for cracks to appear now that these rains are over and the road is drying out in warmer weather. These cracks will cause trouble if they are not attended to. The best, and in the long run the most economical, step would be to add to the existing structure of this stretch sufficient hard stone and bitumen, or other suitable material, to raise the standard of the road to a condition where future failures would not occur. The cost of this work might be in the region of £3,000 a mile; but no accurate estimate could be made until the work came to be properly planned. This is the part of the road which failed most and which carries most traffic. If the necessary money can be made available, I strongly recommend that at least this 1½ miles be strengthened. If, however, the money for that is not obtainable, then there is a chance that even this stretch will be servicable if it is very well maintained and constantly sealed and patched whenever it shows signs of deteriorating. The cost of such heavy maintenance is, in my opinion, likely to increase progressively as time goes on and to exceed the interest on the capital cost of the more satisfactory course of strengthening the road now.

40. The other danger area at present is near the Karen turn-off, where signs of failure occurred during the last short rains. Here the primary necessity is to improve the drainage if that be possible, and steps to that end should be taken immediately. I consider that the strengthening of the existing surface on this stretch of the road is also desirable as it is a difficult drainage area. I would apply the same recommendation and comments as in the case of the Dagoretti Corner end, with the reservation that, if the present drainage position can be substantially improved, the addition of extra material would be less urgently required as this part of the road does not carry quite so much traffic. The stretch is comparatively short, however, and, if the Dagoretti Corner end is strengthened, similar strengthening near the Karen turn-off is desirable.

41. The rest of the road, though sub-standard, has not given much trouble and should remain serviceable for some considerable time if it is properly serviced and maintained.

42. Although it is not strictly within the terms of reference of this Commission, I cannot resist mentioning that the present traffic island at Dagoretti Corner is not well designed for the convenience of the road-users and, if the major recommendation to strengthen the Dagoretti Corner end of the road is carried out, it might be possible to improve the design of the traffic island at the same time without large additional expense.

Cost of the Road

43. The cost of building the road came to £28,045 19s. 14 cts., which is made up of the following main net items:—

	Sh.	*cts.*
Stone, ballast, sand, etc.	171,250	00
Direct labour and plant	243,435	00
Bitumen	46,243	40
Hire of sprayer	20,380	00
Administration charge	40,249	12
Sundries (e.g., culverts, timber, Railway stone, cement, water, etc.)	39,361	62
	*Sh.*560,919	14

(£28,045 19s. 14 cts.)

The amount of £28,045 19s. 14 cts. is the net amount after certain credit items have been allowed for. Details of monthly expenditure and of the credit items are given in Appendix 5. The credit items do not include anything for the soft stone used on the Mbagathi Road (*see* paragraph 24 above) or for a small proportion of blacktrap stone used on the Langata road. The administration charge was assessed on the basis of 8 per cent of the other expenditure.

When the estimate for the cost of constructing the road was prepared no allowance was made for the devaluation of the pound sterling, which may reasonably be assumed to have increased the cost of operations somewhat.

The amendment to the specification requiring a 4 inch-layer of Railway stone sub-base was estimated to have increased the cost by some £800.

44. The ultimate cost of the road before it failed and had to be repaired was practically within the allocation of £28,000 and was much cheaper than the lowest acceptable tender (£42,012).

45. The result was not as satisfactory as it ought to have been, but the expenditure has not been wasted by any means. Even including the cost of subsequent repairs, which up to the 30th December, 1951, came to £4,255 5s. 18 cts., and the cost of strengthening the road towards the Dagoretti Corner and near the Karen turn-off as recommended in this report, the total cost should be well below the lowest acceptable tender. It may be pointed out that, had the construction been done by a private contractor, the cost might quite well have exceeded the lowest acceptable tender, and there would have been the additional expense of checking and measuring the work.

46. On the whole it can be said that the Public have received fairly good value, though not quite as good value as was expected.

Responsibility for the Failure of the Road

47. Although the unusually wet weather and the lack of sufficient drainage on parts of the road contributed largely to the failures, some of the responsibility for the failures in the road must lie with the District Council, who failed to check that the specification was complied with. There should have been much more supervision, and a check should have been made from time to time to see that the compacted depth of the base-course was up to specification. Similarly, the compacted depth of the layer of Railway stone should have been checked. Generally it can be said that the District Council did not provide enough staff for the proper amount of supervision which should have been given to the operations. For most of the work there was only one European Foreman and one Chief Works Supervisor for the whole job, and the latter had to supervise work on other roads at the same time.

48. The soft stone used in most of the base-course was not a satisfactory material for the purpose. In view of the fact that soft stone varies in quality from quarry to quarry, and from place to place in the same quarry, and also in view of the lack of trained personnel, the Council's Engineer's initial doubts as to the advisability of water-bound soft stone macadam seem to have been only too well founded. If soft stone is used for such a purpose, there must be a constant check on deliveries to see that the quality is maintained and that it does not deteriorate to the extent it did in this road. Hard stone, though more expensive, is much more satisfactory, and, where it is specified, there is less likelihood of the deliveries falling below the danger point as happened in this case.

49. Similarly with murram, there should be a constant check at the quarry to see that only suitable material is excavated and used. The use of doubtful clayey material instead of murram should be rigorously excluded, particularly where efficient drainage is difficult to arrange.

50. Unfortunately, finance was necessarily a governing factor in this matter; and, if there had been all the supervision that was desirable and only hard stone had been used, the cost would undoubtedly have greatly exceeded the allocation.

Summary of Recommendations

51. (*a*) For 1½ miles from Dagoretti Corner there should be added to the existing structure sufficient hard stone and bitumen, or other suitable material, to raise the standard of the road to a condition where future failures would not occur (*see* paragraph 39 above).

(*b*) For the short stretch near the Karen turn-off, which exhibited signs of failure and deterioration during the recent short rains, similar steps should be taken to raise the standard of the road, and the drainage should be improved in this area (*see* paragraph 40 above).

(*c*) The remainder of the road should be carefully maintained and resealed and patched promptly as and when signs of deterioration occur (*see* paragraph 41 above).

(*d*) The design of the traffic island at Dagoretti Corner should be improved (*see* paragraph 42 above).

Acknowledgments

52. I wish to express my thanks to all the witnesses who gave evidence before the Commission (a list is contained in Appendix 2); to the Nairobi District Council for the ready manner in which it made available the requisite documents; and to the stenographers who made verbatim records of the evidence given.

I also wish to record my appreciation of the assistance given by Mr. Adie, the Secretary to the Commission, whose efficiency greatly facilitated the execution of the Commission.

G. B. RUDD,
Commissioner.

APPENDIX 1

NOTE ON THE DOCUMENTS USED BY THE COMMISSION

The documents used for this Commission of Inquiry are contained in the following files:—

P.W.D. File (Roads Branch) F.2/4.

Local Government Office File 336A.

Secretariat Files B.RDS.38/8/13/13.
B.RDS.38/8/13/13/1.
B.RDS.38/8/13/13/1A.
B.RDS.38/8/13/13/1B.
B.RDS.38/8/13/13/1C.

Nairobi District Files containing Foremen's returns and monthly progress sheets.

APPENDIX 2

PERSONS WHO GAVE ORAL EVIDENCE BEFORE THE COMMISSION

Mr. K. L. Hunter, O.B.E., Assistant Chief Secretary.

*Mr. G. B. Weale, O.B.E., B.Sc. (Civil Eng.), M.(S.A.)I.C.E., Road Engineer, Public Works Department.

Mr. F. S. Strongman, M.I.Str.E., M.I.Mun.E., M.R.S.I., Materials Engineer, Public Works Department.

*Mr. J. Fleming, Inspecting Engineer, District Council Roads, Public Works Department.

Mr. C. F. Krause, Materials Assistant, Public Works Department.

Mr. H. C. Rossouw, Road Superintendent, Public Works Department.

*Mr. W. J. Dyack, Computor, Hydraulic Branch, Public Works Department (formerly Engineer, Nairobi District Council).

*Mr. J. J. N. Hugo, Assistant Road Superintendent, Public Works Department (formerly Chief Works Supervisor, Nairobi District Council).

Mr. G. H. Farndell, Assistant Road Superintendent, Public Works Department.

*Mr. J. C. Trowsdale, Accountant, Nairobi District Council.

*Mr. J. W. Judd, Road Foreman, Nairobi District Council.

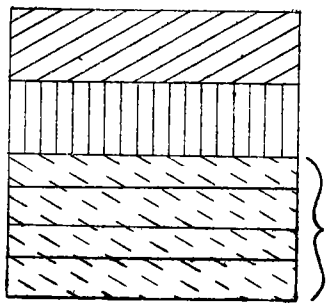
Mr. Oteng s/o Andal, Headman, Nairobi District Council.

*Mr. Ved Parkash Behal s/o Lachmandass, Partner in the firm of Lachmandass & Co. (General Contractors and Builders).

*These witnesses also submitted written Statements.

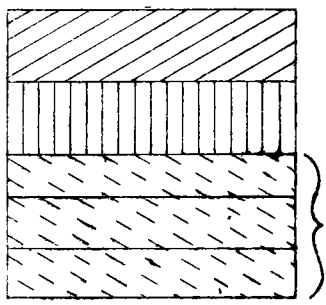
APPENDIX 3

DIAGRAMMATIC REPRESENTATION OF NGONG ROAD SPECIFICATIONS ON BLACK SOIL



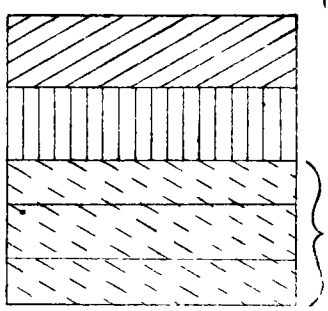
TOTAL 23″

CONSULTANTS' SPECIFICATION—(10,000 lb. WHEEL LOAD)

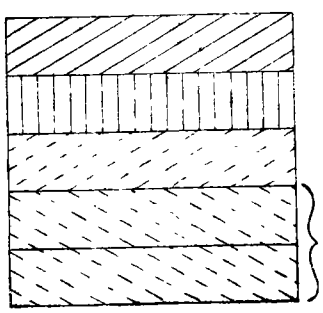


TOTAL 18½″

COUNCIL'S SPECIFICATION AMENDED BY P.W.D.—(7,000 lb. WHEEL LOAD)



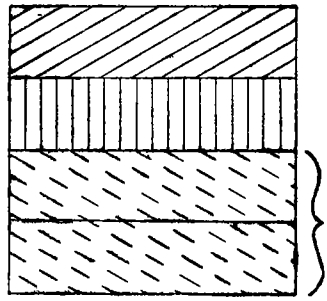
TOTAL 18½″—FIRST AMENDMENT



TOTAL 18½″—SECOND AMENDMENT

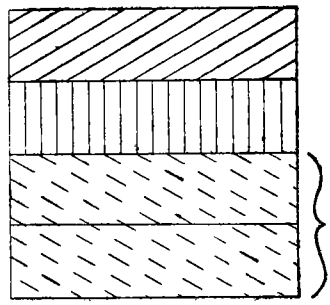
APPENDIX 4

DIAGRAMMATIC REPRESENTATION OF NGONG ROAD SPECIFICATIONS ON RED SOIL



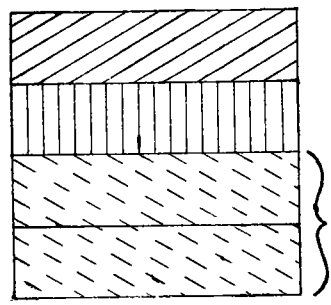
TOTAL 13″

CONSULTANTS' SPECIFICATION—(10,000 lb. WHEEL LOAD)



TOTAL 14″

COUNCIL'S SPECIFICATION AMENDED BY P.W.D.—(7,000 lb. WHEEL LOAD)



TOTAL 14″—FIRST AMENDMENT

NOTE:—In all specifications the existing material in the road above the natural soil was to be taken into account where this material was at least the equivalent of suitable murram, e.g. if there were 5″ of murram, stone or old bitumen over black cotton, the sub-base depth as far as new murram is concerned would be reduced from 17″ (Consultants) to 12″.

APPENDIX 5

NAIROBI DISTRICT COUNCIL

DETAILS OF EXPENDITURE INCURRED BY NAIROBI DISTRICT COUNCIL FOR THE CONSTRUCTION OF THE NGONG ROAD

Date	Firm	Order No.	Sh.	cts.
1949				
Nov.	N.D.C. direct labour, plant, etc.	—	6,502	90
	N.D.C. direct labour, plant, etc.	—	62	40
	Montague Dwen Jessop—camber board ..	C.5764	312	07
	Karen Provision Store—bamboo poles ..	C.5757	17	50
	Barker & Monnas—road sign boards ..	C.5754	360	00
Dec.	N.D.C. direct labour, plant, etc.	—	15,726	00
	Santa Singh—to hire of D.7 tractor	C.6264 C.6261 C.6259	3,300	00
1950				
Jan.	N.D.C. direct labour, plant, etc.	—	12,181	30
	N.D.C. direct labour, plant, etc.	—	80	00
	E. W. Barker—road sign boards	C.5792	157	50
	Gailey & Roberts—sign paint, etc.	C.6603	87	56
	Lachmandass & Co.—2,000 cu. ft. ballast ..	C.6801	1,200	00
	—1,000 cu. ft. ballast ..	C.6531	600	00
	—1,000 cu. ft. sand ..	C.6530	850	00
	Montague Dwen & Jessop—12 sign boards ..	C.6601	688	26
	Gailey & Roberts—2 semi rotary pumps ..	C.6805	216	00
	—brooms, handles, cutters and twine	C.6630	97	35
Feb.	Beales & Co.—concrete pipes	C.6513	1,462	50
	—concrete pipes	C.6512	337	00
	Fazal Din & Co.—piping	C.6636	3	50
	—2 gal. iron tanks	C.6505	873	50
	E.A. Timber Co-operative—timber	C.6629	29	25
	N.D.C. direct labour, plant, etc.	—	980	00
	N.D.C. direct labour, plant, etc.	—	14,927	85
	N.D.C. direct labour, plant, etc.	—	280	00
	Journal 232—28 bags cement	—	308	00
	Gailey & Roberts—water meter, etc.	C.6805	137	35
	—rakes and handles ..	C.6657	37	80
	—rakes and twine	C.6651	26	55
	—spirit level	C.6660	13	58
	—bass brooms	C.6826	69	00
	—solder for water supply pipes	C.6664	11	79
	Lachmandass & Co.—firewood	C.6640	625	00
	—firewood	C.6641	625	00
March	Sunder Singh—camber boards	C.6659	50	00
	Montague Dwen & Jessop—fitting pipes to pump ..	C.6450	36	33
	N.D.C. direct labour, plant, etc.	—	3,830	70
	N.D.C. direct labour, plant, etc.	—	17,120	20
April	E. W. Barker—2 road signs	C.6683	45	00
	Lachmandass & Co.—supply of ballast as per tender	Contract	60,750	00
	—supply of ballast as per tender	Contract	48,385	00
	N.D.C. direct labour, plant, etc.	—	1,733	90
	N.D.C. direct labour, plant, etc.	—	14,255	65
	N.D.C. direct labour, plant, etc.	—	295	00
	Journal 234—admin. charges	—	42,697	52

APPENDIX 5—*Contd.*

Date	Firm	Order No.	Sh.	cts.
May	J. G. Aronson—cateyes	C.6014	1,785	00
	Gailey & Roberts—bass brooms	C.6884	54	60
	Sunder Singh—boards, wooden	C.6628	57	50
	—boards, wooden	C.6604		
	Shell Co.—bitumen	Contract	7,562	96
	Lachmandass & Co.—ballast	Contract	24,750	00
	—ballast	Contract	10,175	00
	N.D.C. direct labour, plant, etc.	—	4,183	70
	N.D.C. direct labour, plant, etc.	—	1,663	90
	N.D.C. direct labour, plant, etc.	—	1,214	50
	N.D.C. direct labour, plant, etc.	—	23,900	40
	Petty Cash—fundis wages	—	412	50
June	Beales & Co.—concrete pipes	C.7419	1,012	50
	—concrete pipes	C.7081	427	50
	E. W. Barker—sign boards	C.7331	108	00
	Dalgety & Co.—rakes and brooms	C.7427	304	38
	Shell Co.—bitumen	Contract	6,105	04
	Gailey & Roberts—twine	C.7424	57	00
	Journal 238. V.4/50—labour, plant	—	3,620	00
	P.W.D.—cost of distribution of bitumen	Letter	20,000	00
	Petty Cash—fundis wages	—	550	00
	N.D.C. direct labour, plant, etc.	—	9,159	80
	N.D.C. direct labour, plant, etc.	—	8,274	30
	N.D.C. direct labour, plant, etc.	—	29,332	30
	N.D.C. direct labour, plant, etc.	—	1,718	50
	N.D.C. F. & O. Diesel for bitumen	—	2	75
	Journal 241. 102.—cement	—	1,224	00
	Beales & Co.—concrete pipes	C.7452	427	50
	—concrete pipes	C.7459	225	00
	—concrete pipes	C.7467	675	00
	—concrete pipes	C.7450	450	00
	Karen Estates—water	—	73	00
	Lachmandass & Co.—sand	C.7333	1,700	00
	—ballast	C.7367	960	00
	—ballast	C.7366	1,280	00
	—sand	C.7379	1,700	00
	Simpson & Whitelaw—mosquito oil pump	C.7385	264	00
	Shell Co.—bitumen	C.7375	13,668	00
July	N.D.C. direct labour, plant, etc.	—	5,730	60
	N.D.C. direct labour, plant, etc.	—	245	00
	N.D.C. direct labour, plant, etc.	—	15,149	95
	N.D.C. F. & O.	—	180	05
	Petty Cash—fundis wages	—	550	00
	Gailey & Roberts—twine	C.7399	57	00
	Kenya Marble Quarries—lime	C.7478	44	00
	Kassam & Karmali—hammers	C.7813	335	00
Aug.	Journal 243—tar drums	—	284	00
	N.D.C. direct labour, plant, etc.	—	6,569	70
	N.D.C. direct labour, plant, etc.	—	201	60
	N.D.C. direct labour, plant, etc.	—	6,477	40
	N.D.C. direct labour, plant, etc.	—	13,850	55
	N.D.C. F. & O. diesel for bitumen	—	373	15
	City Council of Nairobi—H.S. oil	C.7384	199	50

APPENDIX 5—*Contd.*

Date	Firm	Order No.	*Sh.*	*cts.*
Sept.	N.D.C. F. & O. diesel for bitumen	—	372	50
	Lachmandass & Co.—ballast	C.7451	704	00
	N.D.C. direct labour, plant, etc.	—	8,542	70
	N.D.C. direct labour, plant, etc.	—	123	20
	N.D.C. direct labour, plant, etc.	—	10,183	75
	N.D.C. direct labour, plant, etc.	—	14,480	35
	N.D.C. direct labour, plant, etc.	—	108	70
	N.D.C. direct labour, plant, etc.	—	486	50
	Journal 244.—9. cement	—	108	00
	Dalgety & Co.—twine	C.7495	66	20
	Lachmandass & Co.—ballast	Contract	18,900	00
	L. Meghji Kanji—cement	C.7691	249	00
	Shell Co.—bitumen	C.7842	13,668	00
	—bitumen	C.8107	4,556	00
Oct.	N.D.C. direct labour, plant, etc.	—	1,291	00
	N.D.C. direct labour, plant, etc.	—	1,680	60
	N.D.C. direct labour, plant, etc.	—	3,235	45
	Journal 248—labour	—	300	00
	Dalgety—sisal twine	C.8115	49	65
	P.W.D.—cost of bitumen boilers	—	380	00
Nov.	N.D.C. direct labour, plant, etc.	—	200	00
	N.D.C. direct labour, plant, etc.	—	2,641	40
	N.D.C. F. & O. diesel for bitumen	—	43	20
Dec.	Reliance Service—reflectors	C.8321	180	00
	Shell Co.—bitumen	C.8128	683	40
	E.A. Railways—stone from cutting	Letter	400	00
		Sh.	565,345	54

1950	Credit Items		*Sh.*	*cts.*
Apr. 30	Sale of old tar drums	Journal 234	284	00
June	Sale of old tar drums	Journal 240	270	00
	Sale of old tar drums	Journal 239	70	00
July	Karen Estates	Journal 242	450	00
Oct.	Sale of old tar drums	Journal 246	240	00
	Tfr. Journal 246—admin.		1,582	40
	Sale of old tar drums	Journal 247	140	00
Dec.	Journal by Auditor—admin.		866	00
	Allowance for water tankers (estimate) ..		524	00
		Sh.	4,426	40

APPENDIX 6

NAIROBI DISTRICT COUNCIL

NGONG ROAD CONSTRUCTION

SUMMARY OF MAIN ITEMS OF EXPENDITURE

TOTAL COST: £28,045 19s. 14 cts.

The following were the main items of expenditure:—

Date Paid	Firm	Order No.	Sh.	cts.
	LACHMANDASS & CO.			
25-7-50	4,000 cu. ft. sand	7333 7379	3,400	00
25-7-50	3,500 cu. ft. 2½ in. ballast	7367 7366	2,240	00
21-2-50	2,000 cu ft. ¾ in. ballast	6801	1,200	00
21-2-50	1,000 cu. ft. sand	6530	850	00
21-2-50	1,000 cu. ft. ¾ in. ballast	6531	600	00
26-5-50	55,500 cu. ft. 1¾—¾ in. hardstone	Contract	10,175	00
20-4-50	21,200 cu. ft. ¾—½ in. hardstone	Contract	48,385	00
20-4-50	14,800 cu. ft. ½—¼ in. hardstone			
20-4-50 26-5-50	190,000 cu. ft. 2¼ in. ballast	Contract	85,500	00
24-10-50	42,000 cu ft. 2¼ in. ballast	Contract	18,900	00
		Sh.	171,250	00
	Direct Labour		114,006	00
	Cost of Plant		129,429	00
		Sh.	243,435	00
	SHELL COMPANY			
19-12-50	510 gal. 180/200 bitumen	Contract	683	40
24-10-50	13,600 gal. 180/200 bitumen	Contract	18,224	00
25-7-50	10,200 gal. 180/200 bitumen	Contract	13,668	00
20-6-50	4,556 gal. 180/200 bitumen	Contract	6,105	04
23-5-50	5,644 gal. 180/200 bitumen	Contract	7,562	96
		Sh.	46,243	40
	PUBLIC WORKS DEPARTMENT			
10-6-50	Hire bitumen sprayer	Letter	20,000	00
	Hire bitumen sprayer	Letter	380	00
		Sh.	20,380	00
	ADMINISTRATION CHARGES			
	Journal	*Sh.*	40,249	12

The balance of Sh. 39,361 62 cts. approximate was expended on sundry items, i.e. culverts, cement, timber, stone from Railway Cutting, water supplies, signs, etc., etc.

APPENDIX 7

NAIROBI DISTRICT COUNCIL

EXPENDITURE TO 30th DECEMBER, 1951, INCURRED FOR THE REPAIR AND SEALING OF NGONG ROAD

Date		Order No.	Sh.	cts.
1951				
April	¼ in. blacktrap, 9,500 cu. ft.	8649–8474 8475–8477/8/9	6,080	00
	Wood fuel for boiler	8642	875	00
	Bitumen—Shell	8657	9,751	20
May	¼ in. blacktrap, 1,200 cu. ft.	8634	768	00
	¼ in. blacktrap, 6,000 cu. ft.	8458–8459	3,600	00
June	Woodfuel	605	168	00
July	Bitumen—Shell	608	5,372	00
Aug.	Direct labour, plant, etc.	—	15,208	80
Sept.	Direct labour, plant, etc.	—	9,520	95
	Diesel for bitumen	—	63	00
	Bitumen—Shell	8999	14,025	00
Oct.	Woodfuel	677	168	00
	¼ in. blacktrap 1,188 cu. ft.	684	297	00
	Diesel for bitumen	—	72	85
	Direct labour, plant, etc.	—	10,380	65
Dec.	Direct labour, plant, etc.	—	1,873	25
	Diesel for bitumen	—	248	00
	¼ in. and ½ in. blacktrap, 972 cu. ft... ..	930/951	329	40
			78,801	10
	Administration Charges at say 8 per cent		6,304	08
		Sh.	85,105	18

G.P.K. 333—250—3/52