NOTES ON THE MEASUREMENT OF ROADS FOR ATHLETIC EVENTS

by
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INTRODUCTION

This investigation into the methods used for the measurement of road distances arose from doubts occasioned by unusually fast times in some recent road races. It will be unnecessary to remind those concerned with running and walking races on the road that the distances of events are periodically incorrect. Considerable errors have occurred not only in Club promotions but in Championship events and even in International competition.

In addition to the controversies which arise from time to time as to the correct distance of a number of road races, queries are received by the RRC as to how courses can be measured by the promoters of new races. We have in fact been asked from places as far apart as the USA and New Zealand as to how road courses are measured in England.

Rule 107 of the Amateur Athletic Association states that the course for a road race shall be measured 3ft 3 ins (1 metre) from the left hand verge of the road in the running direction. This is in accordance with the IAAF Rule. Nothing is said however as to how this is to be done. It has of course been the practice for generations to use the surveyor's wheel. Inquiry showed however that nothing was known about the accuracy of these instruments.

A.J.C. Kendall, Hon. Secretary of the Southern AAA recently made a survey of the methods being used to measure road courses in the South of England. It revealed that the organisers of road races, left to their own devices and without any guidance, were using an amazing assortment of methods which included the Surveyor's Wheel, Car Speedometer (Mileage Indicator), Cyclometer, 6 inch Ordnance Map, the method used by cyclists for their Time Trials, to which may even be added the Pedometer. Other measurements had been made by the County Roads Department or the Borough Surveyor. While the local authorities have often been most helpful in this work, it must be pointed out that they possess no magic way of arriving at the result. Unfortunately several courses, certified by Local Authorities in recent years have proved wrong, in particular a 20-mile event was 3/4 mile short and a 10-mile course was found to be 250-yards short. It must be stressed however that the subject matter of this report is valid irrespective of who carries out the measurement; it is concerned purely with what is a technical problem.

The case for the accurate measurement of road courses may now be briefly stated. This may appear axiomatic but the view is sometimes expressed that all road races are different because the courses are different. Nevertheless of far greater importance than differences between courses is that the distance should be correct in the first place. If an event is a 20-mile championship it should be 20-miles and not 19 3/4 or 20 1/4 miles. The magical marathon figures of 26-miles 385-yards, printed in the programme, imply that this is in fact the distance of the race.

Road runners who perform month after month in these events, year after year soon realise if the distance of a road race is not as stated, and will derive no satisfaction from a performance if the course is short. There should be no illusion amongst promoters on this point. Two other reasons for the accurate measurement of road courses may be stated. Road running standards such as the AAA 20-miles or the AAA Marathon are quite meaningless unless the distance is correct. What would be said at the AAA Track Championships if the White City track were incorrect and the Milers were running either 10-yards over or less than the Mile? Secondly it is now common practice to rank marathon runners according to their times in different races and althouhh factors such as the gradients of courses and weather conditions play an important part it has become absolutely essential that the distance is above suspicion. An athlete is labelled as a 2-20 or a 2-21 man and this may be of importance for International selection. The British 1960 Olympic team consisted of the three winners of three different marathons. It is clear that a wrong picture would have been obtained if any of those three marathons had been much off the correct distance.

When an outstanding performance is achieved on the road, the first question which comes to mind is, How was the course measured? Such a critical attitude is in fact the logical one to adopt, until the proof is forthcoming as to the accuracy of the course measurement. Ultimately the measurement of the course will fall on the shoulders of the busy promoter wherever he may be. His responsibility to his competitors in this matter is clear. Some organisers do in fact go to great trouble to ensure the correct measurement of their courses as far as they are able, that arch disciple of exactness, Flt.Lt. >Monty≅ Mountford comes immediately to mind. He claims the best measured road course in the country, after trundling his wheel up and down a steel tape inside the giant Airship Hanger at Cardington to determine the accuracy of the wheel.

The detailed report of the work which follows may appear academic and somewhat removed from the problem facing the busy promoter. This is not so, it is all directed to a practical end. The task has been to establish facts by precise measurement. It is hoped that the following notes will be of value to the organisers of road races and will in time result in a higher all round standard of accuracy.

A C C U R A C Y.

Every physical measurement involves an experimental error. This may be extremely small, for instance weight may be measured to one part in a Hundred Million. When a marathon course is stated to be 26-miles 385-yards this is the reading taken from the instrument used to measure the distance. It will not be the exact distance owing to the experimental error of the instrument.

This has been expressed very clearly by John Sterner of Bronx, New York. "Since the measurement of road courses is nothing more or less than a form of surveying, we should start by asking whether it is possible to survey any distance with complete accuracy. The answer is no, in any measurement even by the most scientific methods a certain percentage of error exists".

Percy Cerutty has some pertinent remarks about road courses, "The time has come for standardisation of all courses, accurate measurements, and some forethought and planning. We must give up the old happy-go-lucky methods, the picnic goodtime days. Be exact and business

like and the public will support us."

Let us first distinguish between 'Repeatability' and 'Absolute Accuracy'. The former is the extent to which a measurement may be repeated. An instrument might be run between two points a number of times and a series of readings for the distance between them obtained. The reading thus obtained would not in general be the same but the repeatability of the measurement could be assessed, from them. Even if two values for the distance which were the same, were obtained it would not necessarily be the correct distance owing to the error of the measuring instrument concerned. The error of the instrument would limit the absolute accuracy.

Errors may in general be due to two causes, the inherent errors of the instrument or of the method of measurement, and accidental error occasioned, for instance, by taking a wrong reading or mistaking the actual course. The importance of making repeat or check measurements to avoid accidental errors must be emphazised, it is the only way of being dead certain. The check might be by an alternative method of measurement, i.e., after the course has been wheeled it can be checked by map. This later method of measuring road courses is described in the appropriate section. The inherent error in each method of measurement is described in the appropriate section. Obviously to get satisfactory results, the method must be of sufficient accuracy.

It may be necessary to split up the course for measurement as on a course consisting of different laps. It would be wise to put all measurements into a notebook as they are taken and to keep the record. Intermediate readings may prove valuable in case of road alterations. The date of measurements should be noted. After many hours of careful work, perhaps in inclement weather with traffic roaring past, the notebook may be taken home and the arithmetic can be worked out, unless it has been necessary to do some of this on the spot to see how the checks have gone.

As has already been stated very little information was available in the world of athletics on the accuracy of road course measurement and neither was very much obtained from a number of scientific bodies who were approached. The task was in the first place to determine the accuracy of the different methods of measurement to a high degree of accuracy by precise measurement. It might be thought that some of the work was in fact too pedantic. However it was soon apparent that it was no more tedious or difficult to work to a high degree of accuracy than to use the accepted method of pushing the wheel, taking the reading and the rest for granted.

Some understanding of the principles is however essential. The next consideration is 'How accurate should a road course be measured?' or >What is the greatest permissible error?'. Here we must think of the promoter, who even with the best of intention finds that the measurement of the course, however essential, to be only one of his tasks. A highly accurate method of measurement, which was tedious and time consuming would not be suitable and would be little used. However as will be shown later it is possible to measure to a very high degree of accuracy by a simple and rapid method.

Standard Times, such as the RRC Standards, are given to a minute, and therefor the distance of a road course should at least be correct so as to ensure that the athlete's time to the nearest minute

is the correct time to the minute at the particular distance in question, i.e., if his marathon time is 2-20, the error on the course distance should not be such that his real marathon time is not less than 2-19 1/2 or more than 2-20 1/2. This means that the error on the course should be less than the distance the athlete covers in half a minute.

A much higher degree of accuracy can easily be attained and would be highly desirable at the shorter distances, i. e. 10-miles but in general this is the minimum accuracy which can be considered satisfactory and will be taken as an initial yardstick. The greatest error which is permissible for courses of difference distances are.

	m	s	Running			Walking
10-miles	47	47	184-yards			124-yards
	h	m				
20-miles	1	42	173 "			120 "
Marathon	2	15	171 "			-
50 kms.			-			108
London to				h	m	
Brighton.	5	26	143	7	35	103

If a satisfactory measurement is to be obtained for a marathon course the error of our measurement must not therefore exceed 6.5-yds. per mile. When this is expressed as a percentage error, 0.37 per cent, it will be appreciated the method used has to be quite good. For a AAA Grade III standard the error on the course must not exceed 118-yards (4.5-yds/m). We now have some idea of the accuracy required and can now examine the principal methods used in measuring long distances in order to assess their relative merits.

Direct measurement by Tape or Chain.

It is not considered that direct measurement by steel tape or surveyor's chain is a practical means of measuring road courses at any rate in Great Britain, owing to the traffic apart from considerations of time. Direct measurement by tape would be the method used however in a civil engineering project, such as the construction of the new motorways.

The only course in England which has been chained, as far as we know, is the Ipswich 10 but Billy Morten has reported an ingenious method of direct measurement in Ireland. A quarter mile of Fishing twine was measured off round a running track and laid along the road to be measured, marking the ends with chalk on the road before measuring the next quarter mile.

Direct measurement has however been used elsewhere and we are indebted to Ted Corbitt for the following information.

Bob Prentice, Australian Olympic Marathon runner and President of the Victorian Marathon Club has used a 100-yd. tape, later 50-yds. was found to be more convenient, owing in part to the traffic. A team of 7 or 8 with two cars was used, one man being in the centre of the tape on corners and bends. The method was abandoned for a wheel owing to the amount of work involved.

Cerutty has experimented with several methods and found all the courses were out. He then used a 66-yard Chain and measured distances up to 5-miles with it, maintaining that all marathons should be held on lap courses carefully chained. Choichiro Takenada, coach and Olympic marathon runner, reports that a steel tape is used in Japan where there are no measuring wheels.

Dr. Michael, Santa Barbara, California says that the only way to measure a course is by hand using a 100 foot tape, its hard and it takes time.

Referring again to John Sterner who says that the steel surveying tape is the most accurate method, but requires care round bends, preferably using short tape lengths. If the distance is to be considered accurate it would be preferable if one member of the party had some surveying experience. The big disadvantage is the time required since 2-miles only can be covered per hour. It might be added that the Surveyor's chain has in fact been replaced by the Steel tape for accurate surveying work. Direct methods are not likely to be much used except perhaps on short lap courses: for longer races other accurate methods of measuring courses exist which have many advantages over direct methods.

The measurement of a Standard Distance.

Before the accuracy of the various measuring instruments and devices could be assessed, it was necessary to carefully measure out a definite distance on a convenient road and to mark its ends so that it could be continually referred to. This known distance was also required in order that the method of measurement by calibrated cycle wheel which is the standard method of road measurement used by the Road Time Trials Council of the British Federation of Cyclists could be used. All tests and measurement of courses used this standard distance and how it was measured is described in some detail so that anyone in any country can set up a standard distance for the accurate measurement of road courses. Distance is measured by steel tape, the ultimate standard of length being the standard Imperial Yard, kept by the Standards Office of the Board of Trade in the Vaults of the Palace of Westminster, or the International Prototype Metre at the International Bureau of Weights and Measures near Paris.

It may be mentioned as a matter of interest that these standards have been measured in terms of the wavelength of light so that if all the standard Yards or Metres in the world were destroyed, the standard of length could be reproduced.

It was considered essential in order to obtain the highest accuracy to measure the standard distance on a dead straight stretch of road. The straight stretch of road provided a definite distance to test the wheels against without any ambiguity due to bends. The Road Time Trials Council use a standard Mile, and a distance of not much less is required, as otherwise an error, correspondingly greater on a shorter distance, would be multiplied to a sizeable amount when

one came to measure a marathon course. It is not easy to find such a straight stretch of secondary road in the London area, carrying light traffic, but finally Priory Lane, Roehampton, which runs from the Upper Richmond Road to the Priory Lane Gate of Richmond Park, was chosen. This provided a level dead straight stretch of road with a good surface and enabled a distance of 1100 yards to be accurately measured and marked for repeated use.

A 100-ft. Rathbone Steel Surveying tape was used. It was not possible to obtain the use of one checked by the Board of Trade but our tape was tested against another Rathbone tape and no difference was discernible. Two independent checks, described later, were in any case made on our distance of 1100-yards after it had been marked out. As a matter of note the tolerance allowed on a new tape is 0.3-ins. per 100-feet.

Rather than mark the 100-feet lengths off on the road with chalk as they were measured out, the marking was done in the following way. Two flat steel plates 6-inch square and about one eighth inch thick, kindly lent by the cyclists, were used to mark each 100-feet as it was measured out. Each plate was ruled with a pair of fine lines at right angles to one another and crossing in the centre of the plate. The Plates were placed flat on the road, one at either end of the tape and with one edge touching the side of the kerb. The tape was layed along the line on each plate parallel to the kerb and was thus kept at the same distance from the kerb throughout. Two men are of course necessary, one at either end of the tape. The zero mark of the tape was then brought exactly opposite the commencement of the stretch to be measured as it would in the ordinary way and the first plate was then slid under the tape and along the side of the kerb stone until the second line on the plate (at right angles to the kerb) lay exactly under the zero mark on the tape. While one man kept the tape exactly in this position, the second man at the other end of the tape pulled the tape straight and positioned the second plate until the line on it lay exactly under the 100-feet mark. The two lines on either plate lying flat on the road were now exactly 100-feet apart. The tape and the first plate were then removed by the first man who then proceeded to mark off the second 100-feet length. The lines on the plates were simply used to mark off 100-foot lengths instead of chalk marks which can have appreciable width. A spring balance was used to stretch the tape to a pull of 10-lbs. the tension at which the tape was originally calibrated. This was hooked on to the 100-foot end and the man there pulled the balance and the tape taut until the balance indicated this tension and then with the other hand positioned the plate to mark the 100-foot calibration. A 10-lb pull is quite appreciable. The standard distance was thus measured out in 100-foot lengths and checked.

The tape calibrations are correct at a temperature of 62F and therefore the air temperature was taken periodically throughout the measurement and the distance measured, corrected to a temperature of 62F by the following formula. Correction in ins. length in feet (T-62) x 0.00000633-ins. Where T is the observed temperature. If T is greater than 62F this correction will be subtracted from the tape measurement to obtain the correct distance and if less it will be added.

The measurement was made in the evening in the absence of direct sunshine and the biggest temperature correction on either of the two measurements made amounted only to 1 inch.

The refinements of steel plates, spring balance and thermometer need not in fact be used except by the most fastidious but it was of some importance to us that the most accurate measurement possible of the standard distance with the simple equipment used, should be made so that all our subsequent work might be on a sound basis. The distance of 1100-yards was taken by us simply because it was the longest distance which could be conveniently covered on the road concerned. If it is possible to measure a straight mile or longer so much the better. The job was not a difficult one, it took two men three hours, the distance being measured and then checked. The measurements were:- 1100-yds. 0-ft. 0 3/4-ins. - 1099-yds. 2-ft. 11-ins. The measurements show excellent agreement and the figure of 1100-yards was taken for all subsequent work in testing the different measuring wheels and in measuring courses.

Two cross checks were then made on the 1100-yards as follows. Both were performed by a calibrated cycle wheel which is described in full later.

Firstly the standard 1100-yards in Priory Lane was checked against the Metropolitan Police Mile on the Kingston-by-Pass, a couple of miles away. The latter was set out by the National Physical Laboratory to be exactly One Mile +/- 6-ins. This Mile is not on a perfectly straight stretch of road but the curves are gradual and the road clear of obstructions. The difference between our standard and the N.P.L. standard was in fact found to be 6-ins. on the mile which is naturally a greater accuracy than required for the measurement of road courses.

A second completely independent check on the Priory Lane Standard was made by S.G. Oliver of the South West Road Club who compared our 1100-yards with the Standard Mile on the Great West Road at Heston used by the Road Time Trials Council. This had been checked in 1955 by an accurately calibrated and tensioned steel tape using the steel plates already mentioned. He reported our standard as being 1100.005-yds. Hence our standard and the cyclists tied up to One Inch per mile taking the mean of our two measurements, an exceedingly satisfactory result. These two checks were in fact not only checks on our Priory Lane standard but also checks on the accuracy of the Road Time Trials Council method of measurement.

It is advantageous to mark the ends of the standard distance by 'Monuments', i.e. Permanent landmarks such as the edge of a lamp-post, edge of a drain or crack between kerbstones, which can be related to more conspicuous landmarks such as a lamp-post, houses, gate etc., rather than to simply mark the spot with paint which will wear off in the course of time. Our Priory Lane standard was in fact delineated by cracks between kerbstones at either end and noted in relation to a lamp-post and drain at one end and at the other to a gate leading to a house. Discrete white marks have in addition been painted at either end on both sides of the road. The important thing is that the distance between the marks should be accurately known and this need not be a whole number of yards or a simple integral of a Mile. 'Monuments' on the road itself are recommended and not permanent features standing back from the road such as the edge of a building as these cannot be lined up so accurately. The author will be glad to give the exact location of the Priory Lane Standard to anyone wishing to use it.

<u>Secondary Standards</u>.
The standard in Priory Lane can be used to set up other standard distances elsewhere using the

cycle method already mentioned. The number of revolutions of the front wheel are recorded by counter when the machine is ridden over the 1100-yards. The machine can then be ridden away to wherever the secondary standard is required and the number of revolutions counted when the machine is ridden between the two marks delineating the new standard distance. The length of the latter is then worked out by simple proportion. This is exactly what was done in checking with the Police Mile or for that matter what is done in the measurement of a road course. The exact details are described in the section dealing with measurement by calibrated cycle. There is no reason why the cycle, after calibration on the Priory Lane standard in order to determine the number of revolutions per mile, should not be transported a considerable distance by car or rail and a secondary standard set up in another part of the country or a road course measured, although to be quite certain a check back again to Priory Lane would be necessary.

A secondary standard has in fact been set up on Western Avenue, west of Hanger Lane on the South side of the road. It is marked by two 'Monuments', in this case Lamp-posts. This is closer to the author's residence, and for him it may be more convenient to use this standard than to cycle some 6-miles to Priory Lane for calibration before proceeding to a road course being measured. This stretch of road is not quite straight but four measurements have shown its length to be 1354.7-yds. With a standard deviation of 0.6-yds. i.e., 0.8-yds. per mile.

Standard Distance from a Map.

Although the organiser of a road race may wish to use the method used by the Cyclists, he may not always want to lay out a standard distance as already described. The following method of measuring a standard distance has been used by Norman Dudley, Hon. Secretary of Blackheath Harriers. The distance between two 'Monuments' marking the standard is measured on either the 50 inch or 25 inch Ordnance Map, preferably on a straight stretch of road. These maps are of such a large scale that it is possible to measure to 2-yards with the former. Dudley measured a standard across Hayes Common in Kent of some 1 1/4-miles in order to measure the Kent '20'. The accuracy of this method is really the same as the accuracy with which a road distance can be measured on the map itself and this interesting topic is fully dealt with in a separate section later in these notes.

SURVEYOR'S WHEELS.

These instruments have at various times been called Hodometers, Odometers, Perambulators and Waywisers. Their principle is very sample, they consist essentially of a wheel of known circumference, either connected by a train of gears to a counting mechanism or the counter is actuated by a striker on the wheel as with an ordinary cyclometer. The wheel may be mounted in a frame and some types resemble the front fork and handlebar of a cycle. The circumference is generally either 1 or 2-yards exactly and the counter will give directly the number of yards the instrument has covered when it is pushed along the road.

The principle has not in fact changed since Roman times and the use of such a distance measuring device by the ancients has in fact been described by Hero of Alexandria and Vitruvius. The Romans used a type of wheelbarrow with a mechanism which dropped a pebble into a box after so many turns of the road wheels. Leonardo de Vinci (1452-1519) was familiar with such a

measurer and they were being made by several instrument makers in England in the 18th century, notably by James Knight of Ipswich and John Smeaton who in 1750 made a Waywiser with a wheel of 1-yard circumference. The wheel and axle were of wood but the bearing was metal.

When enquiries as to the accuracy of the surveying wheels at present in use was made in athletic circles, it was soon apparent that for the most part this question had never been considered. A search of the technical literature and questions asked of a number of scientific bodies produced little information. It was evident that the way to tackle the problem was to start from scratch and conduct tests on the wheels. Hence the standard distance was measured out in Priory Lane as already described. Meanwhile information was gathered from a few people who had realised that the problem existed and had tackled it in a logical way.

A.D. McSweeney, Championship Hon. Secretary of the Race Walking Association reported in 1958 that the Surrey Walking Club Wheel gave different readings on the road and on the Track. He also tested a RWA wheel, which had been made in Coventry, and had been stated to cover One Mile in 785 revolutions on the road, McSweeney found the figure was 782 revs per mile on the road and 786 on Parliament Hill Track. Harold Whitlock's figure was 780 on the Alperton Track and Tom Misson's 790. Everyone in fact who had used the wheel, disagreed, in McSweeney's words, 'On the road all these wheels slip and bounce however careful you are'. These figures also show that a wheel cannot be tested on a track and this has been confirmed by the author.

McSweeney further reported that he disagreed with practically all measurements on the road made with the old Surrey Walking Club wheel and he appreciated that people who had spent many hours measuring a course are not very pleased to hear their results described as inaccurate. The fault lies of course not with the people as we will show from our own work, but in the inherent errors in the method of measurement. He also refers to one 50 km walk course, measured by the same wheel which was found to be 600-yards short when checked by the Mobile Distance Recorder described later.

McSweeney has in fact abandoned the use of surveyor's wheels except for comparative measurement of short lengths, such as when choosing an alternative road or for altering the start or finish of a course. He uses either Maps or a calibrated car mileage indicator, both of which are described later in this report. Finally McSweeney says that 'varying road surfaces make a lot of difference in road measurements with a light wheel. I pushed one recently for a measured mile on an average surface concrete road at a speed of 3 1/2 m.p.h. and the amount of bounce was very noticeable and I'd much rather rely on my own methods'.

Flt. Lt. Monty Mountford says that in all drives depending upon friction it can no doubt be shown scientifically that there is always a degree of slip, infinitesimal though it may be in many cases; in the case of a perambulating wheel the degree of slip is determined by the nature of the ground surface. Measurements taken over grass or uneven surfaces would be unreliable.

John Sterner, already quoted has realised the necessity of checking the accuracy of a surveyor's wheel. He says 'Probably the most practical method, is by surveyor's wheel. This can be used by

an inexperienced person, although an effort should be made to calibrate it by walking it over a previously measured distance to check its accuracy'.

Finally, Bob Prentice in Australia recognised the limitations of the ordinary surveyor's wheels, and constructed a special wheel. He took the frame of an ordinary 28-inch cycle wheel and rivetted to it an outer circle of thick steel, welded into a circle 8-ft. and 1/4 inch circumference with a width of 2-ins, Works and a handle were constructed and an ordinary counter added. His wheel recorded 660 revs per mile when tested on a measured Mile and walking at 4 m.p.h. The readings were generally constant to 6-ins & never more than 1-ft out per mile.

It was necessary to concentrate on walking straight. Prentice who thus overcame the inaccuracies due to wobble by using a wheel of much greater width, also referred to a commercial rubber tyred wheel 1/4 inch wide which had no stability, wobbled and led to inaccuracies. Enough has now been said to show that some people had doubts as to the satisfactory performance of measuring wheels. It was our task to start from scratch and to establish facts and figures for ourselves by tests.

Priory Lane Tests.
Three wheels of different design were used. The old Surrey Walking Club Wheel was a home made wheel which has been used for many years. The other two were commercial instruments made respectively by Stanley & Co., of 79-80, High Holborn, London, the well known instrument makers and the other by Trumeter & Co. Ltd., Milltown Street, Redcliffe, Manchester. A check was made with the British Standards Institution that no B.S. Specification existed for a surveyor's wheel.

SWC Wheel.
This wheel had a narrow metal rim of 2-yds. circumference and was mounted in a fork with a handle. The counter registered single revolutions and was actuated by a short arm. The wheel had one striker mounted on a spoke and therefore registered units of 2-yards.

The following method was used to obtain more precise readings of distance than 2-yds. As the wheel completed the last full revolution before the end of the run, i.e., as the striker just passed the counter arm, a mark was made on the road at the point of contact with the wheel. The distance of this mark to the end of the standard stretch (less than 2-yds.) was measured by tape and this distance was added to that recorded by the counter. Hence distance readings were taken to 3-ins. (0.1-yds.) although the wheel measured units of 2-yds.

Although the counter worked satisfactorily in Priory Lane tests, it did not do so when it was used on one occasion for a course measurement.

Stanley Wheel. (AAA wheel).
This was similar in design to the SWC wheel, the rim being of brass, 2-yds. in circumference and again narrow. The counter was similar to a cyclometer fitted with a star wheel which was moved by two strikers mounted on the same diameter on opposite sides of the hub so that the counter registered in units of 1-yard. The fork and handle were of the usual type.

Trumeter.
This was of different design, the wheel being much smaller than the previous two and is pushed by a removable handle. It is about a foot in diameter and possesses the advantage of being easily transported as it packs into a carrying case. Unlike the other two wheels with metal rims, the Trumeter has a synthetic oil resisting rubber covering on the wheel, ground to the correct diameter. The counting mechanism is driven continuously as the wheel rotates by a gear drive. There are six models registering different units i.e., yard, metres, feet and various fractions. The model we tested showed yards and eighths of a yard. The Trumeter in case is sold at ,15-10.0d. about the same price as the Stanley Wheel.

Method of Tests. The counter was either set at zero, or the existing reading on the counter was taken, depending on the wheel being used. The wheel was then carefully placed exactly on the road so that the axle was opposite the mark on the kerb indicating the start of the 1100-yards. The striker with the first two wheels was so positioned as just to have left the counter so that when the counter first registered the wheel had made exactly one revolution. The wheel was then pushed over the standard 1100-yards keeping the same distance from the kerb, just sufficient in fact to miss the drains. Care was taken to walk as straight and at as uniform a speed as possible. The counter reading was taken when the axle of the wheel was exactly opposite the mark at the other end of the 1100-yds. The readings was taken to 3-ins: how this was done with the SWC and Stanley Wheel has already been described. All readings were rounded off to the nearest 0.1-yds. and the differences compared with the standard distance were calculated as yards and tenths of a yard per mile. The time taken to walk the 1100-yds. was taken by stopwatch and the average speed calculated in m.p.h. Tests were done by two operators but no differences due to this were discernable. The air temperatures were taken during the first series of tests, but it was soon apparent that the errors observed with the wheels, were many times greater than could be produced by any alterations in the circumferences of the wheels due to the largest possible temperature changes in England or for that matter elsewhere. Hence temperature measurements were discontinued.

The results are summarised on the next page:-

ERROR

WHEEL	SPEED OF WALKING	NO. OF RUNS	YARDS PER MILE MEAN ERROR	STANDARD DEVIATION
S.W.C	1.9 - 3.4-m.p.h	7	Plus 6.1-yds./mile	0.9-yds./mile
	3.8	1	8.2	
	4.0	1	7.7	
	5.0	1	11.7	
Stanley	2.1 - 2.8- m.p.h	4	plus 6.3-yds./mile	1.2-yds./mile
	3.8	2	15.4	
Trumeter	3.2 - 5.0	5	Plus 3.8-yds./mile	0.8-yds./mile

The results show that the S.W.C. and Stanley wheels will only just give the required precision if operated at speeds not much over 3-m.p.h. All three wheels over estimate the distance. Errors increased when the wheels were run at higher speeds. It appeared that the errors were due to the bouncing and wobbling which occurred with the metal rim wheels, i.e. the S.W.C. and Stanley wheels since these errors increased with speed.

The wheels were examined on a metal table and in particular, the circumference of the Stanley wheel i.e., 2-yds. was found to be within the manufacturer's tolerance of 1 part in 2000 so that the errors found in the road tests were not due to any inaccuracy in the circumference of the wheel. The manufacturers were, as a matter of fact, unable to say how accurate the measurements of the wheel on the road would be. The instability of this wheel even when pushed along a concrete floor was quite apparent, the wheel tending to topple over owing to the narrowness of the rim. The effect of the nature of the surface on the instrument which produces irregularities in the rotation of the wheel as had already been found, was confirmed by a direct experiment carried out on the Watford Track with the Trumeter.

The experiment was carried out on the 110-yds. straight. The wheel was pushed up and down the same lane line until 880-yds. had been covered when the reading was taken. This was done by locking the wheel carefully by hand at the end of each 110-yds. before turning it round and pushing it back along the line. The condition of the track varied in roughness from the inside towards the outside lanes. After a reading had been obtained on one line the wheel was moved to another lane line nearer the outside of the track.

As might be expected the errors increased with the roughness of the surface.

Least smooth.	Error.	Plus 8.0-yards per mile
Smoother.		5.5
Smoothest.		4.5
Grass.		4.4

A number of runs were also made on the Alperton track with the Stanley wheel which confirmed the irregular results which had been obtained by Harold Whitlock, etc. It appears to be useless to test the accuracy of a surveying wheel on a track partly owing to the nature of the surface and also owing to the difficulty in following any prescribed path accurately round the track. Errors due to this second cause were eliminated in the Watford tests by using the straight, as already explained.

The picture as regards the accuracy of the wheels and the causes of the observed errors was now clearly established. All the wheels over-estimated the distance owing to bouncing and wobbling due to their poor road holding qualities this was especially the case with the tall narrow rim wheels. All subsequent measurements with the wheels on actual courses showed that errors of a similar magnitude occurred. This is shown by the measurements made on the Inter County 20-mile course in Victoria Park, London, E, where it was possible to determine very accurately the distance by the R.T.T.C. method and, the Mobile Distance Recorder. The table gives the results and also shows corrected wheel measurements which have been calculated from the actual

wheel reading by applying the average error found in the Priory Lane tests. This is of course again variable so that such corrections will tend only to give a measurement nearer to but not precisely the most accurate measurement made by better methods. We would agree however with an official of the N.C.A.A.A. who says that a calibrated surveyor's wheel when pushed slowly will give measurements correct to 5-yds. per mile. The time would seen to be better spent, however, in calibrating a cycle wheel rather than a surveyor's wheel.

INTER-COUNTY 20-MILE CHAMPIONSHIP COURSE
in Victoria Park, London.
1960 Course

Surrey Walking Club Wheel	20-miles	69-yards	Corrected	19 miles	1709
Stanley	20	176		20	116
Trumeter	20	196	plus or minus 20-yds.		
Mobile Distance Recorder	20	0	plus or minus 20-yds.		
Ordnance Map 50-ins./mile	20	74			

Note that the course was as used in 1960, and had been lengthened slightly twice previously. The excellent agreement between results achieved with the Mobile Distance Recorder and those achieved with the cycle is apparent, notwithstanding the difficulty of wheeling the circular road the same distance from the inside kerb. Further the cycle on this occasion was calibrated on the secondary standard and not on Priory Lane. The tests were carried out on a distance 300- yards short of the full course, the distance from the road to the finish on the track. This 300-yds. was added to each of the above wheel measurements. The SWC wheel gave better results on this course than might be expected; both other wheels gave excessive errors.

One other test on the Stanley Wheel might be mentioned. This was run along the cyclist's mile on the Brighton road at around 2.4 m.p.h. and it overestimated by an average of 13.2-yds. per mile. Finally we must mention the indefatigable Monty Mountford, who on hearing of the errors which we had found, sent Flt.Lt. Ian Paul, Technical Instructor of the R.A.F. at Henlow, to Trafalgar Square with his Trumeter. Paul ran the Trumeter up and down the standard 100-feet set out on the north side of the square until 1000-ft. had been covered as we had done at Watford. The wheel was pushed as slowly as possible and duplicate measurements agreed to one eighth of an inch. The error was however 5.75-yds. per mile. Monty sent the wheel back to the Sports Board!

The Road Research Laboratory of the Department of Scientific and Industrial Research have examined our figures and report they are remarkably good considering the method of

measurement the repeatability figure being +/- 0.05 per cent.

Adequate absolute accuracy however is required for course measurement. In the main, the surveyor's wheel does not provide it. Some wheels are more accurate, but all must be used at slow walking speed. The wheels we have examined are typical, although we are aware that other designs exist. In particular we have seen a solid rubber tyred wheel used by one city engineer; the accuracy of such a wheel should of course be periodically checked to compensate for wear. The wheels in general, however are too light and their runs too narrow to hold the road satisfactorily.

Surveyor's wheels have been given up by the Metropolitan Police many years ago in legal disputes involving such questions as taxi fares. The cyclists used them 30-years ago when the present method of road measuring superceded them.

CAR SPEEDOMETER MILEAGE INDICATOR.

Faced with the problem of measuring a road course, use of a car speedometer immediately comes to mind. It would be easy to take the car round the course and take the mileage reading on the speedometer. Firstly, however, it should be noted that these do not register less than a tenth of a mile. Car speedometers are also mass produced and not precision instruments. They are liable to considerable errors from various causes.

An interesting reference to the errors of a car speedometer was published in 'The Times of Natal' as long ago as 1925. 'To make sure that the distance between the two Town Halls was the 54-miles that is given on the Government maps it was resolved by a self appointed committee of the City sportsmen, to measure the distance.' (This refers to the measurement of the Comrades Marathon course by Arthur Newton). 'It has been found in experimenting with the measurement of distance by the speedometer of a motor car that the instrument always records a slightly greater distance than the car actually traverses, due to the fact that bad bumps on the road send the car up into the air and cause the wheels which operate the speedometer mechanism, to spin. The spin is very slight but continuous multiplication in this direction may cause a big error in the reading over a long distance'.

Although the roads have vastly improved since those days other potential sources of error still exist. One authority in England places the possible error on a car mileage recorder as +/- 5-10 per cent. The Motor Industry Research Association when asked to comment on these figures reported. 'Owing to the large number of makers, models, and years of manufacture it is not possible to give an average decree of accuracy to be expected f'rom the mileage recorder in a motor vehicle. It is true that errrors as large as 5-10 per cent have been noticed in different vehicles, although the mileage recorder is less prone to error than the speedometer. There are errors which come from the deformation of tyres under load, and from the fact that the tyres tend to expand at higher speeds'.

It is evident this method of direct reading from the instrument is unsuitable for course measurement.

McSweeney's Method.

McSweeney has realised the inherent errors of the car speedometer and has developed a modified method, based on calibrating a car mileage recorder on a standard mile before use. The method is the same in principle as that used by the Time Trials Council, namely the accurate calibration of a pneumatic tyre before use. He goes through the somewhat tedious procedure of adjusting the tyre pressure so that the readings of the mileage recorder are correct, whereas with the Cyclists' method it is only necessary to blow up the tyre hard and to determine the number of revolutions covered in a mile. The rest is simple arithmetic.

McSweeney's method is basically sound. Although the speedometer distance recorder indicates tenths of a mile it is moving continuously and McSweeney is able to estimate to 25-yards. Because he is also able to stop with care exactly on a tenth of a mile, the error is often less than this amount.

McSweeney recommends a maximum speed of 20-m.p.h. on a very smooth road, otherwise 10-m.p.h. 'I have measured road mile on a triangular lap at Parliament Hill area and on the way to measuring a course I go there first, check the pressure of my tyres to see that they are always the same as on the previous occasion, go round this lap five times, and if my instrument comes up to the mile exactly at the same spot every time round I know I am OK and proceed on my way to do the job'.

He then refers to how when he changed the tyres it was necessary to experiment with the pressure until he got the one mile lap accurate again. McSweeney has used this method for a number of years on RWA courses in preference to surveyor's wheels. His 10-mile Inter-County Walk. course in Victoria Park was measured with the following results.

McSweeney. Calibrated Car Speedometer Recorder.	10-miles +/- 25-Yards.
Calibrated Cycle.	10-miles +/- 10-yards.
Trumeter.	10-miles 220-yards.

These results are also of interest on account again of the overestimation by the surveyor's wheel.

Dr. Rutherauff of California has come to the same conclusions regarding the use of 'Automobile Speedometers'. He says they vary greatly and should be checked against an accurately measured distance immediately before the course is measured. Slight variations in the tyre pressure will make a big difference in the wheel circumference which could be of significance in measuring a marathon.

MOBILE DISTANCE RECORDER.

I am indebted to Deputy Commander Walter Batson, O.B.E., Vice President of the R.R.C. is well as to Messrs. H.C. Harvey and E.G. Stephens of the Metropolitan Police for enabling me to

inspect this piece of equipment which has already been mentioned in these notes. The Mobile Distance Recorder of the Metropolitan Police is, as far as I know, the only such recorder in existence although some of the big car manufacturing companies may have a similar contrivance. Although athletics organisers have neither the time nor the wherewithall to build such a piece of equipment, it is of considerable interest because the various sources of error in the surveying wheel have been overcome. It was invented by a Superintendent of the Police and some interesting work on its accuracy was carried out in conjunction with the National Physical Laboratory some years ago. This is the only example of work carried out by a scientific body on the accurate measurement of road distances which I have been able to trace. The Mobile Recorder which weighs 2-cwt. consists of two running wheels mounted in a substantial frame which is towed behind a car. A measuring wheel which can be retracted when not in use is mounted between the two running wheels.

The measuring wheel is spring-loaded onto the road when in use, and the number of revolutions it turns is registered by a counter mounted on the Mobile Distance Recorder itself and, for convenience, another electrically driven counter is mounted on the dashboard of the car. The measuring wheel which has a pneumatic tyre is calibrated before use and checked afterwards as follows. A thin chalk line is made across the tyre of the measuring wheel and the car driven very slowly forward so that as the wheel rotates a chalk mark is left on the road. The car proceed until 10 revs of the measuring wheel have been completed and the distance between the first and the tenth mark is measured with a steel tape to one eighth of an inch. Hence the distance covered by one rev., or, if considered more convenient the number of revolutions per mile, is calculated.

The Mobile Distance recorder has been tested by the National Physical Laboratory as being correct to +/- 2 2 yds. per mile. This is a liberal figure to cover all conditions and the working accuracy is normally +/- 1-yd. per mile. As the Recorder possesses considerable weight and stability and the measuring wheel is spring loaded onto the road, bouncing and wobbling are eliminated and a high degree of accuracy is attained. It might be mentioned here that such wheel devices are used by the motor industry for the measurement of distances in acceleration tests, and are known as 'Fifth Wheels'. They resemble a cycle wheel with a counter and are towed, but are not precision instruments and have to be calibrated.

CYCLISTS' METHOD (Road Time Trials Council).

The measurement of road distances might be considered to be of greater importance to racing cyclists, competing in Time Trials, than to road runners because the cyclists compete on a basis of time recorded and not directly against one another. The competitors start at time intervals and the usual distances are 25, 50, 100-miles, 12 and 24-hours.

Further since times are compared on different courses all over the country, 50-miles in Kent must be the same as 50-miles in Yorkshire. As a matter of interest it may be noted that the courses are so designed to obviate any advantage of terrain, i.e. in general out and home courses are used.

The cyclists have gone into road measurement in a very thorough way and all courses are approved by District Committees after measurement in a standard way for which precise

directions have been laid down. It is a pity therefore that liaison with the cyclists was not established a long time ago by athletic circles.

I am indebted to Mr. Amey, National Secretary of the RTTC, E. Shead, Dixie Deane and S.G. Oliver (previously mentioned for his check in Priory Lane) for their co-operation.

The accuracy of this method was quoted as +/- 10-yards in 25-miles. This extremely high accuracy was received with some scepticism by the author in view of the errors which had been found with the surveyors wheels. However, it was recognised that should such accuracy in fact be attained the method would answer all our problems, because it also possessed simplicity and speed. The premise of an investigation such as this, was to take nothing for granted but to establish facts for oneself. The RTTC method of road measurement has been mentioned in this report previously and is described in full in a publication of the RTTC, entitled, 'Recommendations regarding the suitability of courses for Road Time Trials, and on the methods of Course Measuring'.

The basic method consists of riding a bicycle fitted with a counter registering the number of revolutions of one of the wheels, over the route to be measured. Immediately before, during, or immediately after the measuring, the bicycle is ridden over a known and very accurately measured 'standard distance' and, from the readings obtained, the number of the revolutions of the wheel per mile is calculated. This becomes a 'constant' for that particular measuring occasion and this constant is used to calculate actual distances from the revolution counter readings.

The revolution counter used resembles in appearance a normal cyclometer and has a similar method of operation, i.e. a striker fitted to the cycle wheel which engaged a 'star' wheel on the counter attached to the frame or forks. The counter registers the actual number of revolutions of the cycle wheel and does not, as in the case of the cyclometer, convert readings into miles and fractions of a mile. The RTTC have tried several types of counter but only one, the 5 star type made by Veeder Roots Limited has proved satisfactory.

Note:- The counter is a 'small star wheel revolution counter' with a Gib mounting B-100725, obtainable from Veeder Roots Ltd., of King Henry's Drive, New Addington, Surrey or Dundee, Scotland, or from Veeder-Root Incorporated, 28, Sargeant Street, Hartford 2, Connecticut. It is not made in the UK but imported from the USA, price 31/7d. Anyone interested in this method of road measurement is invited to contact the author.

The RTTC publication refers to details of standard distances, or measured miles which can usually be obtained from the District Council Secretary.

Organisers of road running races might find it useful to contact cycling clubs for the purpose of having courses measured or checked. The First RRC Marathon at Coventry was held in fact over a course which had been checked by the local cyclists, as will be the 1961 RRC Marathon at Bristol.

One section of the report is of considerable importance and is quoted in full. 'No reliance should

be placed on information regarding distances supplied by Local or County Authorities or by the Police, as such information is often inaccurate and the methods of measuring employed are very rarely to the high standard of accuracy required by the RTTC. Neither should any reliance be placed on milestones as they are generally very inaccurate, and where road alterations have taken place since they were installed, are often many furlongs out of place.

The measuring of a 'standard distance' has already been described in this report.

A few specific points in the cyclists instructions may be added to what has already been said in these notes about our standard distance in Priory Lane. The cyclists emphasise the care necessary to define the start and end of the standard distance so that any subsequent measurer will be able to recognise and ride over the exact path of the standard; the exact terminal points can coincide with some permanent and accurately definable points, and where necessary reference to precise alignment should be made, together with some suitable permanent marking.

A straight road is considerably desirable but not essential but more important is that the road edge or kerb is permanent and clearly defined, so that the measurement can be taken at some fixed distance (usually 2 or 3-feet for convenience) from it. The measurement is always taken on the same side of the road unless it is dead straight. Extreme accuracy is required (3-ins- per mile, the Priory Lane Standard and a cyclists standard checked to 1-inch per Mile). The RTTC point out that Surveyor's Chains are generally insufficiently accurate and Linen Tapes should on no account be used.

As regards the measuring, the rev. counter should be checked to see that it is fitted and working satisfactorily and the cycle wheel set to start in the Zero position, i.e. with the striker on the point of leaving the star wheel. The tyre of the measuring wheel should be sound and free of any suspicion of leakage. It should be inflated hard but not 'board' hard.

When riding over the standard distance to obtain the constant, the measurer should ride exactly in the same manner and in the same position as he will adopt during the actual course measuring, and must follow the exact line of measurement of the standard distance. It is, of course, necessary to obtain a fresh constant on each separate measuring occasion. When testing the Priory Lane standard fractions of a revolution were calculated from the spokes, there being 32-spokes on the front wheel used. The spoke carrying the striker was marked near the hub and the number of spokes past or short of the counter were counted at the end of the measurement. Hence the distance to 1/32nd of a revolution i.e. 2 1/2" was obtained. We did in fact use an old tyre in the first measurements but the measurements on our standard 1,100-yards had an average difference of 2/32nd revs; 'two spokes' in cyclist's parlance, i.e. 0.2-yards per mile. The mean difference on riding over the 1,100-yards again (after measuring the course) was only 0.6-yards per mile average. It is important that the standard distance is ridden over at least twice: the readings should not differ by more than 'two spokes', i.e. 0.2-yards.

We found that the mean accuracy of the method without any special precautions was around 0.5-yards per mile, as claimed by the R.T.T.C.

The Cyclists convert the revolution counter readings to actual distances by the aid of conversion tables but we used simple arithmetic available to everybody as follows: multiply the number of revs. taken to cover the course (or lap) by the standard distance (in yards) and divide by the average number of revs. taken to cover the standard distance. The result is of course in yards, but this can easily be converted into miles and yards.

Measurement of a road circuit.
Priory Lane Constants.

The 1,100-yard stretch was covered twice and required the following number of revolutions of the cycle wheel. 496 23/32 and 496 24/32. i.e. The number of revs. to cover the road circuit was 5254 11/32.

The cycle was again ridden over the 1,100-yards in Priory Lane and 496 25/32 revs. were required.

Mean constant 496 24/32, equals 496.75.

Hence length of lap is $\frac{1.100 \times 5254.34}{496.75}$ = 11635.2 = 6 miles 1075-yards.

A few other points concerning the measurement of course are (i) cool, dull days are best as a hot sun expands the tyre and alters the constant; (ii) no part of the course should be walked; (iii) it is inadvisable to measure more than 50-miles on a single occasion; (iv) a riding speed of 10-12 m.p.h is suitable; (v) the importance of keeping permanent records is stressed and also of taking intermediate readings so that the whole course need not be remeasured if road alterations are made.

We must warn against trying to short circuit the calibration on a Standard Distance by marking the cycle wheel with chalk and measuring a few revolutions on the road with a tape as is done with the Mobile Distance recorder. Conditions are however entirely different in case of the cycle and such measurements are useless.

It is pertinent to ask if having taken the trouble to use up such an accurate method, whether it can in fact be used on the road in an actual course measurement in view of the different paths the measurer might take on the road in his cycle. It was found that after the course had been measured by this method a number of times the results were, in fact, surprisingly similar.

Five well-known road courses in the London area were each measured twice and it was found that the average extent to which the measurements differed was 0.3- yards per mile.

The average accuracy of the measurements was +/- 0.6-yards per mile. These results were obtained using an old inner tube on the front wheel. This was replaced by an 'Airseal' tube, of synthetic rubber with much less permeability and more precise measurements still were obtained. Thus on one occasion, the calibration before riding to the course and measuring it, a total

distance of over 50-miles, agreed exactly to the 'spoke', with the recheck back on the standard at the end of the day after the courses had been measured.

Hence no significant alteration in the calibrated tyre was ever found to have taken place during the measurement of the course.

Measurement to a precision greater than 1-yard per mile which in fact has been obtained without difficulty, may be considered a little academic and more than adequate for road race measurements.

The RTTC method of road measurement and the results of our checks, have now been described in some detail. We have found this method to be very simple to use, with marked advantages over the surveyors' wheel, not only as regards accuracy but also as regards quickness, since it can be used to cover the ground five times as fast as the wheel. The biggest job to be tackled, is measuring the standard distances and, as already mentioned, the Cyclists have a number of these in different parts of the country. The calibrated cycle wheel method therefore fulfils the requirements for the measurement of road race courses and is to be thoroughly recommended.

The checks on our Priory Lane Standard, the Metropolitan Police Mile and the RTTC Mile have been mentioned under the section 'Standard Distances'. There were at the same time checks on the accuracy of the RTTC method.

MAP MEASUREMENTS.

The question as to how accurately a road can be measured from a map is of considerable interest. Apart from the usefulness that maps can have in planning a course, they can also serve as an excellent means of checking wheel measurements against gross accidental errors. The possibility that large scale maps might give a road distance of sufficient accuracy for our purposes was therefore examined. Since in any case a number of organisers had in fact measured their courses from a map, it was pertinent to find out how accurate such measurements might be.

As regards the United Kingdom the following types of Ordnance Map exist, taking the well known 1 inch series as the smallest scale which is likely to be of use to us, The smaller the scale of the map the larger the area on any one sheet compared with the larger scale maps described below.

One Inch. This is the popular series known to everybody. All roads are shown and the whole country is covered.

Two and a Half Inch.(1:25000) the scale is accurately 2.534 ins. per mile and shows the country in greater detail than the 1 inch map. A useful area is covered on each sheet.

Six Inch. (1:10560). This is the largest scale covering the whole of the country.

Twenty Five Inch. (1:2500) may be more aptly described as a plan since it shows all information

in its correct size and position which is not possible in the smaller scales above, where the information is generalised and conventionalised. A detailed picture of all houses is given in this scale. This scale is obviously important since the width of a road is shown in correct scale. The whole country is covered by the 25 inch maps with the exception of the moorland and mountainous areas.

Fifty Inch. (1:1250) 50.688 ins. per mile. This series which is based on a post war survey will cover, when completed, built up areas only.

The prices vary according to the mounting and scale and vary generally from 3/6d. to 7/-d. per sheet. A considerable number of sheets might be needed if one worked with the 50 inch for example but Local Authorities might be able to help in giving race organisers access to maps if they were told what it was all about.

Ordnance maps are produced to an accuracy of 1 part in 8000 to a certain stage and then the detail is filled in to an accuracy of 1 part in 500.

The question of how accurately a road distance could be obtained from a map is an interesting one which could not be answered directly by the Ordnance Survey. Firstly, a map is a two dimensional representation of the earth's surface with its hills and vales. Secondly paper distortion might result in differences of +/- 2- yards and what is known as the Local scale factor for maps in the now National Grid if not allowed for, might be +/-7-yds. in 10-miles. The error introduced by hills is negligible for all ordinary gradients and only becomes significant for really steep gradients such as 1 in 10.

It is in fact only the difference between the hypothenuse and base of a right triangle where the angle between the two is very small. Thus Copse Hill on the Belgrave 20 which is climbed three times only adds a total distance of 1.5-yards on to the 20-miles distance on the map.

An estimation of the accuracy which might be obtained from map measurements was made by comparing the distances of seven road courses which had been measured on the road by the RTTC method, with map measurements. Ordnance maps of different scales were used and these included the 2 1/2, 6, 25 and 50 inch series. The agreement between the map distances and the wheeled distances was remarkably good; the difference between the two, averaged 4-yards per mile, and was the same independent of the scale of the map. Possibly this was to some extent fortuitous. The accuracy attained will to some extent depend on the ability to follow the twists and turns of the road by the map measurer or other device, i.e. on the configuration of the course. It is apparent however that measurement by map can sometimes be satisfactory and reasonable results have been attained even with the 2 1/2 inch series (Road widths are some 3 times exaggerated). The 6 inch scale is perhaps the most satisfactory (Road widths to scale).

A limited amount of work has been done with town plans other than those produced by the Ordnance Survey, and it appears that results of less accuracy are obtained. Needless to say all map measurements must be repeated until satisfactory agreement is obtained between repeat readings. The author prefers a thin piece of cord to a map measurer. This is laid on the map and

manipulated round the bends with the fingers. Measurements can be repeated to 0.05 inch.

MISCELLANEOUS METHODS.

Cyclometer. The same considerations of accuracy apply as with the car speedometer distance recorder. The cyclometer is not a precision instrument and registers only in tenths of a mile. Variations in the circumference of tyre due to varying tyre pressure effect the readings. A cyclometer measurement of the Finchley 20 over-estimated the distance by 0.4-miles, i.e., 35-yards per mile. More satisfactory measurements could be made by a cyclometer calibrated over a standard distance but, as the smallest distance registered is only one tenth of a mile, the standard distance needs to be several miles. In general cyclometers are not sufficiently accurate for course measurements.

Pedometer. This registers the distance a man walks by the number of paces he takes. It resembles a watch which is placed vertically in a pocket, the body movement at every stride causes a pendulum to swing and the movements of this are shown by a pointer moving over a dial calibrated directly in distance. Pedometers are not precision instruments and are not suitable for course measurement.

SUMMARY.

The different methods of measuring road distances have now been examined exhaustively. It is not proposed to lay down a standard method of road measurement but rather to emphasise the facts which have been established and to leave it to the good sense of the organiser to make the best use of them. Circumstances of road events vary and it may not always be possible for any one promoter to use the best method.

Firstly the accuracy required of the measurement must be remembered and the necessity to check measurements.

The surveyor's wheel is not a precision instrument, it can be used to obtain an accuracy just sufficient for road races if its limitations are understood but there will always be an element of doubt regarding the distance of courses measured with a surveyor's wheel.

The best method is without doubt the calibrated cycle wheel as used by the RTTC; it is extremely accurate and rapid as well.

Far greater use might be made of maps, either to check wheel measurements or when it may not be possible to carry these out. Gross errors can be avoided by use of Ordnance Survey maps for checking measurements.

Car speedometers mileage indicators are not suitable for course measurement unless used as in McSweeney's calibrated method. Other unsuitable methods have also been mentioned.

APPENDIX.

A number of miscellaneous queries crop up in connection with road courses and it was thought worthwhile to make a few measurements to throw some light on them. An exhaustive study was not made.

1. Overtaking Parked Cars.

Measurements were made to find out the extra distance a runner would cover in drawing out from a position near the kerb to pass a parked car. This is a minimum if he draws out some way off. The extra distance covered in passing one car and regaining his position near the kerb was found to be only a matter of inches.

2. Roundabouts.

What is the difference in distance between going round and cutting straight across? Clearly it all depends on the roundabout. The extra distance, may in fact be appreciable, thus the large roundabout on a well known course the difference between following the line of traffic round and cutting straight across is 127-yards. Competitors in another road race save 30-yards by cutting across the roundabout.

Such amounts are cumulative on a lap course. Sometimes an on the spot decision by the Police may determine which way round the race goes as in the 1960 London to Brighton run at the bottom of Brixton Hill where the field went round St. Matthews Church and not straight along the original road which was then one way. The extra distance was 92-yards which may seem insignificant compared with the total distance of the race but Mekler on that occasion broke the record by 24 seconds.

3. Position of Measurement on the Road.

The AAA-IAAF rule states that a road course shall be measured 1 metre (3-ft, 3-ins.) from the kerb in the direction of running. This is of course an idealised condition and is susceptable to individual interpretation i.e., how should a right hand turn be wheeled? Presumably one proceeds straight across a lay-by. Nevertheless it is a useful guide. Since road distances can be measured very accurately by the RTTC method a number of interesting questions can be investigated. The measurements which have been made on a number of road courses, were made on the path actually followed by the runners when no obstructions existed, with a general regard to the AAA rule. This appeared the commonsense way of making the measurement. No one runs according to the Rule but according to the dictates of the circumstances, without running extra distance, and with regard to the traffic and considerations of sportsmanship. The question then arises as to what difference might be obtained if a course is measured according to the AAA rule and the way it is actually run by the competitors. This again clearly depends on the course, if it consisted of a dead straight road there would be no difference. The Finchley 20, a typical lap course, was measured according to the AAA Rule and on the ground actually covered by the runners. The competitors in this case ran only 38-yards less in 20-miles than the AAA measurement. The difference is therefore negligible in this case and, in general, different paths on the road probably make little difference in the course measurement. This does not include the case of competitors cutting corners on the pavement, thus meriting disqualification, but on examining a number of road courses little distance seems to be saved by short cuts, such as the extremely dangerous one

of crossing to the right hand side of the road.

4. Measurement of a number of Road Courses.

Seven well known road running courses in the London area were each twice measured by the RTTC method. The repeatability of the duplicate measurements was excellent on each course and averaged +/- 0.3-yds. per mile difference between the repeat measurements, while the absolute accuracy of each course measurement averaged +/- 0.7-yds. per mile. Hence a 20-mile course was for example measured to +/- 14-yds. Five of the seven courses were found to be short of the full distance the errors being 3.4, 6.0, (Inter County 20 - 3.5, 8.9, 9.8), 11.5 and 25.7-yds. short per mile on each of the five. The figures quoted for the Inter County 20 refer to the 1960 course as measured by three surveyor's wheels, the course was in fact the full 20-miles but had been measured by two other methods. Similarly the measurement of the Inter County 10 mile walk gave an over-estimation of 10.2-yards per mile, here again the course was of the correct distance as given previously in this report, because likewise the measurement had not been made by surveyor's wheel. It is significant that as with our Priory Lane tests, the surveyor's wheel invariably over estimated the distance, the error varying considerably from 3.4 to 25.7-yards per mile, averaging 9.8-yards per mile.

Map measurements on the same courses were also made and these showed remarkable agreement with the RTTC figures, averaging 4-yards per mile difference only. This has been referred to under 'Map Measurement'. The distances of two only of those five courses were within the limits of accuracy previously discussed. The remaining two of the seven courses were over distance but this did not arise from errors in road measurement. One course was 10.6-yards per mile overdistance although it was a county championship. The start and finish had been fixed as a matter of convenience and not to ensure the accuracy of the distance.

The remaining course refers to the Finchley 20 and this has rather an interesting history. It is an excellent example of the organisers taking as much trouble as possible within the limits of accuracy imposed by the known methods available for measurement.

The 5-mile circular lap at Ruislip was originally measured using one of the old type wheels and also on a large scale Ordnance map. It was pronounced as virtually 5-miles exact. Since the war road alterations on the new bridge at West Ruislip Station have shortened the road slightly and the start and finish were removed from the main circuit into a side road. Finchley Harriers had not remeasured the course at the time of these alterations, but reckoned the extra distance from the start to the circuit and back to the finish ensured the distance was not less than 20-miles, in spite of the road alterations.This is the only example which has come to light, of a promoter designing a course so as not to be less than the stipulated distance.

Our measurements on the path actually taken by the runners were 20-miles 30-yards and 20-miles 31-yards with a maximum error of +/- 20-yards. As already stated this is 38-yards less than a measurement made according to the AAA Rule, and shows that the Finchley 20 is as near correct as any road course can be.

Finchley have measured the course, according to the AAA Rule very recently and report the

distance by Trumeter to be 20-miles 150-yards. Here again the Trumeter over-estimates the distance by 4.1-yards per mile compared with the RTTC method.

LONDON TO BRIGHTON

Two measurements were made and completed on June 11th, 1961, when no future road alterations were apparent. The road was measured from the start of the Running and Walking Races at the centre of the Clock Tower Westminster to the Finishing point at the Aquarium, using the RTTC method of Measurement. The path which a competitor would take was followed with a general regard to the AAA 1 metre rule.

	1		2	
	Miles	Yards	Miles	Yards
Streatham Hill Station.	4	1692	4	1701
The Greyhound, South Croydon.	9	1352	9	1376
Swan & Sugar Loaf, South Croydon.	10	766	10	789
Purley Cross Roads.	12	919	12	940
'Star" Hooley.	15	1615	15	1640
'Feathers", Merstham.	18	472	18	494
Redhill Cross Roads.	20	307	20	324
'Chequers', Hanley.	24	709	24	712
'George', Crawley.	30	399	30	391
'Queens Head', Bolney.	38	1387	38	1366
'Castle', Hickstead.	40	1179	40	1163
'Kings Head', Aldborough.	43	38	43	21
Pyecombe Post Office.	45	1606	45	1602
'Black Lion', Patcham.	48	1465	48	1462
Finish.	52	711	52	710

Should a race be diverted round Brixton Church, i.e. follow the line of traffic the distance will be increased to 52-miles 900-yards. The Stock Exchange walk follows the line of traffic after crossing Westminster Bridge, making a distance of 52-miles 786-yards on the 'Shortest Route' measurements given above. The accuracy of each of the above measurements is +/- 7.2-yds. Examination of the above measurement shows however that a greater error is introduced by the impossibility of repeatedly following precisely the same path on the road. The overall accuracy of the measurement taking into account this limitation is +/- 32-yards, i.e.. 0.6-yards a mile.

LONDON TO BRIGHTON RELAY.

		Stage		Stage	
		M	Y	M	Y
1st Stage.	Richard Coeur de Lion Statue, Palace Yard, Westminster to Broomwood Road,	4	436	4	436

	Clapham Common.				
2nd Stage.	Broomwood Road to News of the World Sports Ground, Mitcham.	5	249	9	685
3rd Stage.	To Purley Rise.	5	1101	15	26
4th Stage.	To Joliffee Arms, Merstham.	5	27	20	53
5th Stage.	To Prince Albert.	4	821	24	874
6th Stage.	Thorn's Hotel.	2	1396	27	510
7th Stage.	Blue Pencil Cafe.	3	1248	30	1758
8th Stage.	Red Lion, Hardcross.	5	1744	36	1742
9th Stage.	'Castle', Hickstead.	6	52	43	34
10th Stage.	'Star'.	4	61	47	95
11th Stage.	'Black Lion', Patcham.	4	238	51	333
12th Stage.	Finish. Aquarium, Brighton.	3	1008	54	1341

The change over points of some of the stages are slightly off the road whereas the above distances were measured on the road throughout. The difference would however about to very few yards.

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L.C.C. Parks Department for the use of maps; Institution of Civil Engineers, Patent Office Library and the Science Museum.

I will be glad to hear from anyone concerned with course measurement so that our knowledge of this interesting subject may increase and be of use to both road runners and walkers.

J.C. Jewell,
June, 1961