MEASUREMENT NEWS

November 1989 Issue #38

Route king makes world go round

HOME TO MORE ROADWORK

FROM MOROCCO TO MILAN AND BACK . . . meticulous Westoe Colliery man Paul Hodgson on the home straight again. His commitments can vary between the 14-mile Morpeth-Newcastle Road Race to the Gateshead Charity Festival — a series of snap races — or a full-blown marathon anywhere. It will take him just a couple of hours to run the rule over a five-mile event, but the big one, 26 miles 385 yards, entails a solid day's work.

PITMAN Paul Hodgson talked today of his job-and-a-half going round the world's marathon circuits making every metre matter on saved-up rest days and holidays.

Morpeth Harrier Paul, 36, does it the hard way with a stop-start routine on a borrowed bike, pounding the roads with a specific aim — to accurately "clock" routes for the Amateur Athletic Association and its international brotherhood.

By TUDOR JONES

He is just back from the **Milan**-staged World Cup Marathon, where as Northern Counties' course measurement co-ordinator assigned to another country he did the business . . . as a matter of course.

His carriage awaits — first a bike to do his 26-mile-and-a-bit rounds, then a V.I.P. place, travelling like royalty in the front car ahead of the runners.

His Milan order came with three weeks to go from London Marathon co-director **John Disley**, famed ex-Olympic bronze medallist who did the perfect wheeler work from **Greenwich Common** to **Westminster.**

Fun run start

"He was delighted to give me the Italian job," said Paul, unit planner at **Westoe** Colliery, Co. Durham.

Last year it was Cassablanca, where he found the route conspicuously short — by 800 metres.

It all started for him four years ago with fun-run invitations where he got the measure of the job.

Next step? He was "metering" the **Morpeth-Newcastle** run before international call-outs came.

Paul never travels without his bizarre gear and props which would make a cricket umpire gasp.

In his precious bag go a steel tape, thermometer to check the tape temperature, a tool to highlight baselines — masonry nails or waterproof crayons — and a can of spray paint as a road marker.

Inevitably, he runs into trouble with frigid frisking going through Customs where he is often stopped as a prime suspect fugitive when his gear shows up on X-ray spotters.

On last year's mission to Morocco he duly arrived safely in Cassablanca to find his baggage, stuffed with a stock of essential instruments, still at Heathrow.

That hold-up did not unsettle the Moroccans, instilled with a relaxed *Manjana* mentality.

Yet Paul's more than just a route-perfect technician of the road.

He is a respected sub-3hr. marathon runner in his own right with two **London** Marathon finishes, the **Glasgow** Marathon done in 2hr. 57 mins. and a best-time 1hr. 20mins. half-marathon specialist.

Admits Paul: "I look on myself as an average club runner.

"I recognised early on I was not going to make the grade so I decided to concentrate on the organising side."

And yet, while he combs the county and links up the world it's British Coal, he emphasises, who pay his wages and Westoe Colliery the mortgage.

Hodgson's Theory works for the best — around the world.

THAT'S HIM . . . in the Durham Cathedral relay race, alongside the River Wear.

BASE-LINE WORK . . . at a service station in Washington, Co. Durham.

OFF THE ROAD. Relaxed Paul takes a breather besides his bike in central Cassablanca, where the Marathon course was found to be 800 metres short. Nearby, the race organising committee held a meeting in the Town Hall to decide the next step.

From <u>Coal News</u>, May 1989

MEASUREMENT NEWS

#38 - November 1989

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RRTC GUIDELINES TO INTERPRETATION OF VALIDATION MEASUREMENTS

TAC Rule 185.3 concludes "Performances made after January 1, 1985 will not be accepted if the remeasurement shows that the actual course distance was shorter than the stated distance." TACTIMES, January/February 1988 says "In scientific environments, shows means proves, clearly demonstrates or similar and we believe it was chosen for this very meaning." RRTC concurs.

A standard validation measurement consists of four pre-measurement calibration rides, one measurement ride, and four post-measurement calibration rides. The measured distance is determined based on the average calibration count and the count obtained on the measurement ride.

For a single measurement as above, a band of uncertainty of 0.05 percent (5 m in 10 km) on either side of the measured value is considered to exist, based on the technology as we know it today.

If the stated distance of the course falls within this band, the measurement will be considered as indeterminate, in that the course has not been shown to be either longer or shorter than the nominal distance.

In any case where more than the "standard" data exists, the above interpretation may not apply, and the measurement will be evaluated by the Validations Chairman, with advice from others in RRTC as requested.

THINGS TO BE DISCUSSED AT THE TAC CONVENTION

1) Drop and separation, and treatment of point-to-point courses

2) International measurement seminar. Finish lines may be covered too. Where? When?

3) Replacing the Jones Counter. Supplies won't last more than a few more years.

4) Dealing with the time lag between setting a pending record and validation. We have unused validation time in the spring and overload in the fall. Is there a way to spread out the work?

5) Post-validation adjustments. What to do with a course that remeasures barely above nominal, but less than 1.001 of nominal?

6) Wind measurement.

Please send your ideas for agenda items to Pete Riegel fast!

The Athletics Congress of the USA

The Governing Body for Athletics in the United States including Track and Field, Long Distance Running and Race Walking for men and women and boys and girls at all age levels.

WAYNE B. NICOLL
Ragged Mountain Club
Potter Place, New Hampshire 03265
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~~(603) 735-5284~~
(603)735-5721

1989 Annual Report - Vice Chairman East

Accomplishments of the past year are discussed below. The figures shown will be actually be slightly higher since this report was prepared in mid-October.

1. Number of certificates (from other certifiers) receiving a final review before entry on the national course list: 352
2. Number of certificates issued by me: 102
3. Number of reviews of applications already reviewed by a certifier in training: 27
3. Appointment of new certifiers with final signatory authority: Mike Wickiser - IN.
4. Appointment of certifiers in training: 1 John Sissala - MD; Kevin Lucas - NY certifier, stepped down. Amy Morss was appointed certifier in training for NY State.

Special Activities:
1. Verification measurement of the Boston Marathon course.
2. Provided regular input to the TAC/USA LDR Officials Project.
3. Increased technical assistance to the National Race Walk Committee and to several race walk events.
4. Participated in the final review of the revised Measurement Procedures manual.

A special note of thanks to the certifiers and reviewers who have been working with me this past year. The number of measurers in each state continues to grow steadily and the quality of the measurement work is always improving. Validations, a function so important to the serious athlete, is a task that requires considerable volunteer time, extended travel and social and technical skill. I especially appreciate the participation of the eastern region certifiers in the validations program.

Respectfully submitted,

Wayne B. Nicoll
VC-East, RRTC

ANNUAL REPORT – VICE CHAIRMAN WEST

During the past year, I have continued to perform the usual Vice-Chairman functions of reviewing all Western course certificates (before sending them on for National listing), and of measurer and certifier training. In addition:

New certifiers were appointed for two states: Michael Franke for Iowa and Karl Ungurean for Nebraska. Michael and Karl replaced Jim Lewis who has been a dedicated certifier and measurer for many years. Jim decided to step down, as the press of his "real" life made it too difficult for him to continue as certifier. (Jim remains a Final Signatory, although no longer a certifier.)

Two certifiers appointed last year, Don Potter in Arkansas, and Dave Poppers in Colorado, were promoted to Final Signatory this year.

In South Dakota, Charles Tiltrum, who was appointed certifier last year, decided he didn't really want the job, so I am currently serving as South Dakota certifier until somebody local can be found for this position.

A special project I participated in this year was revision of the RRTC *Course Measurement* manual. As part of this revision, I wrote the all-new chapter on calibration course measurement.

I also did mathematical modeling of the effects of hills and wind on running performance, to provide data that might aid in revising the TAC rule on drop and separation. (See my articles on 2nd Order Hill Effect in the Jan '89 issue of *Measurement News*, and on Physiological Modeling in the present issue.)

Bob Baumel

Bob Baumel
RRTC VC-West

BOB BAUMEL'S PHYSIOLOGICAL MODEL

In this issue you'll see a 10 page article by Bob Baumel. When he told me it was coming, and its probable length, I begged him to boil it down to a manageable size for MN, because 10 pages is a lot. I threatened to print it in reduced size. Bob condensed it as much as he could, and when I read it I thought it was too good to be reduced. I didn't understand all the math, but I found it not too tough to follow.

I think it's worthwhile reading, especially in view of the recent interest in wind and hills. Give it a try.

Pete

October 10, 1989

ANNUAL REPORT
Validations Chairman, RRTC

The table presented below reflects the course validation activity for 1989, 1988 validations completed after the 1988 report and assignments currently in progress.

DISTANCE	ID#	NAME	MEASURER	VALIDATOR	DATE	LENGTH
5K	NY89003WN	Freihofers	W. Nicoll	A. Morss	6/3/89	5.009+
5K	CA86068PR	Carlsbad 5000	J. Collias	W. Nicoll	9/89 *	
5K	RI87010SV	Norwood Wms	R. Nelson	W. Nicoll	12/29/88	5.005+
8K	CA88057RS	City/Alhambra	B. Hickey	T. Knight	2/12/89	8.002+
8K	DC86045RT	Nike/Wms	R. Thurston	W. Nicoll	4/16/89	8.008+
8K	IA86014JL	Fifth Season	K. Ungurean	B. Glauz	7/1/89	7.995+
8K	OR87009PC	Spring Classic	L. Barrett	T. Knight	8/26/89	8.004+
10K	NC86082ACL	Old Reliable	AC Linnerud	W. Nicoll	11/21/88	10.008+
12K	IL85140RR	Oktoberfast	R. Staback	J. Wight	11/13/88	12.047+
15K	OR83002TC	Cascade Runoff	K. Peters	T. Knight	8/26/89 *	
15K	FL87037BH	Gasparilla	E. McDowell	W. Nicoll	10/31/88	15.007+
20K	WV85054PR	Elby's Dist	P. League	M. Wickiser	11/18/88	20.111+
25K	MI87008SH	Old Kent	R. Dewey	M. Wickiser	8/20/89	25.020+
10Mi	DC86004RT	Cherry Blossom	R. Thurston	W. Nicoll	4/89*	
10Mi	IL85106PR	Park Forest	J. Nair	J. Wight	7/22/89	10.007+
10Mi	MI84011AP	Bobby Crim	S. Hubbard	M. Wickiser	8/19/89	9.992+
10Mi	MI89010SH	Bobby Crim	S. Hubbard	P. Riegel	9/17/89	10.003+
10Mi	NY84019AS	Trevira Twosome	B. Noel	R. Thurston	10/7/89	9.907+
½ Mar	IL87041WG	Club Shore	P. Basbagill	J. Wight	6/14/87	21124.4+m
100K	TX86004ETM	Gulf RaceWalk	S. Demaree	ET McBrayer	7/6/89	100.176+

* Signifies previous validation applies based on evidence submitted.

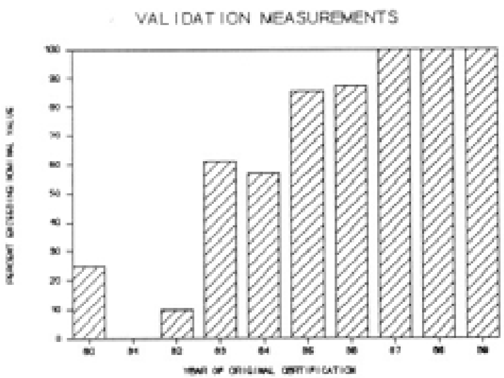
<u>Currently assigned,not completed</u>:

5K	FL86016/17BH	Run For Pies	D. Alred	W. Nicoll
8K	CA89001TK	Fifty Plus	Carpenter	T. Knight
	IN87077PR	IN Gov's Cup	D. Carr	M. Wickiser
	VA89007RT	Nissan Shamrock	CE George	R. Thurston
	FL89001BH	ICI Masters	L. Allhouse	D. Loeffler
10K	FL88013WN	Red Lobster	W. Nicoll	D. Loeffler
15K	FL89001WN	Gasparilla	W. Nicoll	D. Loeffler
20K	NY89006WN	Phelps Sauerkraut	G. Tillson	W. Nicoll
	OR84039PC	Pear Blossom	Gustafson	L. Barrett
30K	CA87015CW	Foundation	C. Wiser	Knight/Barrett
½Mar	FL85016WN	Citrus Bowl	W.Nicoll	D. Loeffler
1Mi	NY87002DB	Sri Chinmoy	D. Brannen	R. Edwards
8K	MI85010AP	Levagood Pk	A. Phillips	M. Wickiser
10K	NY86072PR	Robt Moses	N. Dudziak	Nicoll/Edwards
50M	OH 84014PR	Wolfpack	P. Riegel	M. Wickiser
.9709251mi/.2212mi/100K	NY88002DB		D. Brannen	R.Edwards

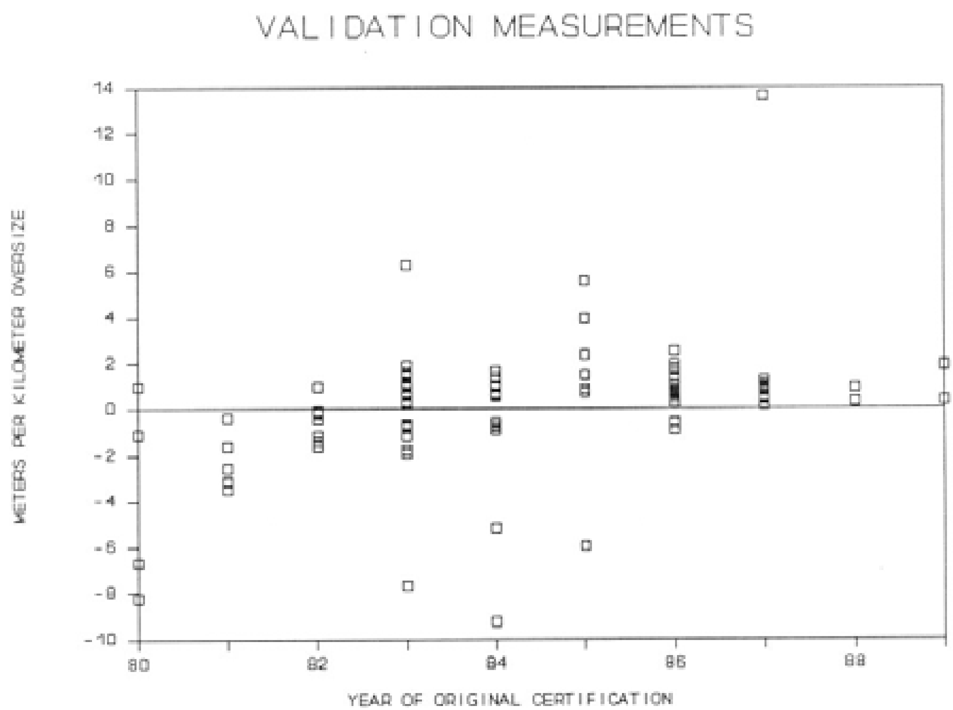
Sally H. Nicoll
Sally H. Nicoll

VALIDATION MEASUREMENTS

Our layout procedures seem to be working pretty well. As the years go by, and more and more courses are checked, the percent of acceptable courses has risen to 100 percent for courses laid out during the last three years. As more of today's courses are checked, we'll probably see a few fail, but the trend is definitely encouraging.



YEAR MEASURED	NUMBER OVER NOMINAL	TOTAL COURSES VALIDATED	PERCENT OVER NOMINAL
80	1	4	25
81	0	5	0
82	1	10	10
83	11	18	61
84	8	14	57
85	6	7	86
86	14	16	88
87	11	11	100
88	2	2	100
89	2	2	100



Course Registrar -- Annual Report

The list of certified courses continues to grow at the rate of about 100 per month. We have 6,113 courses presently on file.

Our course listing service is becoming increasingly active. This year there has been a definite upturn in the number of course lists and certificates requested. We have sent out about 30 course lists and 50 copies of certificates upon written and telephone requests. This is a doubling of last year's activity, and indicates that word of our service is spreading. This is encouraging, since it makes little sense to keep lists that nobody reads, or file courses that are never retrieved.

Through the magic of FAX, we supplied a course map to pinpoint the splits for a race taking place the next day. Floppy disks travel through the mail at a fraction of the cost of a complete printout, keeping committee members up to date. A running publication is also supplied with this list. Best of all, runners themselves are calling for information on races they plan to run.

Joan Riegel

3717 Wildwood Drive
Endwell, NY 13870
October 24, 1989
(607) 754-2339

Peter S. Riegel
3354 Kirkham Road
Columbus, OH 43221

Dear Pete,

The activities of the Road Running Technical Committee Finish Line Committee for 1989 included:

A. Finish line column in measurement news covering topics:

1. Non-computer results
2. Race-day registration
3. Information which one can provide on result printouts
4. Certified Officials
5. Age-group awards

B. Computation of hill second order effects to validate Bob Baumel's theory.

C. Converted Bob Baumel's program for doing road race measurement computations

D. Evaluated a new finish line select timer, the Time Machine.

Sincerely,

Alan Jones

Alan Jones

DOLLAR VALUE OF CERTIFIED COURSES

This course breakdown is one I did last month in a letter to TACSTATS. It reflected the number of common-length certified courses we presently list. We can get an idea of the value of what we do by figuring how much it would cost to hire all the measuring work done. To figure this, I assumed that paperwork and map would take 2 hours per course, and the riding and note-taking would take 25 minutes per kilometer of course length. The measurer was assumed to earn $10 per hour for the work. This is not what one pays a skilled worker, but it's the number I used. Overall I'd say my estimate is on the low side.

If you don't like my assumptions, make your own. The conclusion still remains that RRTC has guided and performed about half a million dollars worth of work since 1982.

DISTANCE	COURSES	HOURS	DOLLARS
10K	1787	11020	$110198
05K	1355	5533	55329
08K	526	2805	28053
05M	386	2066	20661
Mar	305	5973	59729
HMar	223	2407	24065
15K	162	1337	13365
10M	117	1019	10185
01M	109	291	2911
20K	85	878	8783
12K	54	378	3780
25K	50	621	6208
30K	48	696	6960
Cal	40	97	967
50K	38	868	8677
50M	32	1137	11368
2.5K	31	94	943
100K	29	1266	12663
Trck	25	54	542
20M	15	231	2311
100M	8	552	5523
Total	5425	39322	$393223

Pete

THINGS DON'T ALWAYS GO THE WAY YOU'D LIKE

The following is an edited version of a letter received from Doug Loeffler:

Dear Pete -- September 28, 1989

I'm just back from LA and want to fill you in on the results of my trip to (a foreign city that requested a quickie AIMS validation).

As Joan probably told you, they requested help at just about the last possible moment. The only way I could help them was to travel from LA on the night before the race and measure the morning of the race. I proposed such a schedule to Mr X who was my telephone contact, and he accepted.

I arrived in the city at 1:00 am the morning of the race. I was met at the airport by Mr. Y who indicated that he was the course manager. On the way to the hotel and after arriving at the hotel, I explained my requirements, i.e.: to measure a calibration course, to have a second bike rider, to have a bike and preferably to begin my measurement prior to the start of the race. All of these things had been requested earlier by FAX. I offered to proceed directly to the start/finish area and measure the calibration course. They weren't willing to do this and said we would go to the start at 6:15 am.

I slept for about 1 hour and was ready to leave the hotel at 5:45. We didn't actually leave until 6:45 and arrived at the stadium where the race was to start/finish at 7:10 am. The race was scheduled for an 8 am start.

At 7:30 I was able to convince them that a cal course was an absolute requirement and began to measure one. It was obvious that I wouldn't be able to measure 1000m, so I settled on 300m. At 7:55 they found a bike for me so I installed the Jones counter and also installed a spare Jones on a second bike to be ridden by a young lady named C. I quickly briefed her about what I needed to do and proceeded to calibrate. While calibrating, the women's portion of the race started. We completed our calibration and began our measurement at 8:20 am, 10 minutes before the men's start. Since she had never measured before, I led -- hoping she would follow my path.

Riding through the women's race allowed me to see the tangents to be followed. I had a police motorcycle escort who warned the women of my approach from behind, so I was able to ride the course fairly tight. There were a few problems where the spectators were out on the route, preventing me from riding next to the curb, but I feel that the measurement was fairly accurate. I passed the lead women at about 30-35k and finished about 5 minutes ahead of them.

According to my calculations, the course is 203.6m long. If a 1.001 SCPF were used, the course would be 160m long. I would not recommend to the race director that the course be shortened, due to uncertainties caused by people on the course and my unfamiliarity with the route.

Although I requested a map from Mr Y, he did not provide anything to me. Following the course during the race was one thing, but finding the course after the race was quite another, and I am unable to document the path without help from the organizers.

Ed. note: Doug got 42399 meters for the course length. Miss C got 43714.

FINISH LINES

TIME PLACE

1:10:22 1989

Finish Line Sub-Committee
Alan Jones, Chairman
3717 Wildwood Drive
Endwell, NY 13870
(607) 754-2339
November 1989

OPEN CLASS, AGE BRACKETS AND AWARDS ... WHAT'S RIGHT?

When I started scoring races years ago I would award open winners and age-group winners as is done now but with a "hole" in the age categories. For example, we would have age brackets 14 and under, 15-19, 40-49, 50-59, 60 & over. Generally, but not always, the overall winner would fall in the hole. However, if a 19 year-old won the race, he would receive the overall trophy AND the 15-19 age-group award. No big deal! He DID win the open and his age-group. But then I ran into meet directors who want to "spread the wealth" and not give duplicate awards. So, now we have people who "win" their age-group and walk away with a First Place award but actually have several people ahead of them.

I now have found someone who says it better than I. Joe McDaniel, Race Services Manager, for the Oklahoma Runner hands out a beautiful packet of information to race directors in his state. He covers the age-group/open subject in a section with a title which I've stolen and have used above. The following is taken from Joe's packet (used with his permission):

> Runners can be scored two ways in a road race. One is the open or overall finish and the other is the age bracket finish. Which is the most important and which should be recognized? Most events publish complete results by overall finish and by age bracket which gives complete information. But what about trophies or awards?
>
> Runners who finish high in the Open Class generally speaking have no interest whatsoever in their age bracket finish. On Open Class runner can be most any age in Oklahoma from 10 years to 50 years in the female and from 16 to 45 in the male division. Open simply means a person's overall finish regardless of age. If all the good runners in the state were entered in one race, the Open Class would almost invariably fall in a 15 year range of 20-34. This has been proven in the Tulsa Run where a tremendous field has always participated. In fact, the top 100 times by both sexes has been recorded in this age group.
>
> Runners who do not have any chance of finishing among the top overall finishers are usually interested only in their age bracket finish. However, just about everyone to some extent is interested in their overall (open) AND in their age bracket finish.
>
> This inequity can be illustrated in a recent women's race with a large field. Six of the top ten women were age 35-39. In this particular race the first 20-24 runner finished 76th overall, but first in her age bracket. Now keep in mind that there is no ability gap to speak of in the 20-34 group, but in this particular event three of the top ten female runners did not receive an award but the 20-24 female received a big age bracket trophy!! What could be more unfair than this? This happens too often in Oklahoma events.

Joe then talks about the effect on the award ceremony when the open winners are then called up again to receive age-group awards. Then follows his suggestion to solve this problem. He continues:

> There is only one way to present awards to the winners of a long distance road race. Select the number of Open (overall) finishers in each sex REGARDLESS of age that will receive awards. A good number would be a minimum of 15 depending on the size of the event. Make the Open Class winner's trophy larger than the next 14. The next 14 should be the same size and should also be the same size as the 1st place age-group trophies. These trophies should have plates which read: "1st Open Class", "2nd Open Class", etc. If the winner of the Open is first in the 25-29, have a plate ready to attach to this trophy which reads "1st 25-29." Each Open trophy should have plates to be attached designating an age-group finish up to three deep.
>
> IN THIS MANNER YOU ARE RECOGNIZING BOTH THE OPEN AND AGE BRACKET FINISH. A runner then has the option of saying he/she finished 4th overall, for example, and/or first in his/her age group. You may ask, what about the person who finished first in the 20-24 bracket? You may give this age bracket trophy the same as any other or some races exclude it altogether.
>
> THE WORST SYSTEM OF ALL IS TO EXCLUDE THE OPEN FINISHERS FROM THE AGE GROUP. That is, give the top runners a trophy and not also consider these same runners for the age-group awards. Suppose in the same race where the 6 women finished in the top ten that this system was used. This means that the 7th female finisher in the 35-39 group would receive the 35-39 first place age-group trophy although she actually finished 7th!! Some runners will actually refuse a trophy when this system is used and rightly so.

The only place I disagree with Joe is on the inclusion of age-group brackets in the 20-35 range. I would just not have any age-groups in this range since there is very little difference in ability across the range. Then one is not presented with the ridiculous situation of someone who is 76th overall winning the 20-24 age-group award.

I have to admit that I have described what I would like to see. However, I am no longer a meet director so I tend to go along with the meet directors. No guts, eh?

LAST MONTH'S PUZZLE

Your editor wins.* (SORT OF) Mine was the only solution to Ken Young's query about the distance and bearing from Barrow to Reykjavik. My solution involved a tetrahedron with vertices at Barrow, Reykjavik, north pole, and earth center. Here's how things came out. In my distance calculation I assumed Earth has a circumference of 40,000 km. I don't know what Ken used.

	Pete	Ken
Distance, km	4570.02	4576.19
Bearing, degrees E of N	28.06	28.1

* ALL RIGHT! I DID PEEK AT THE ANSWER, GOT IT RIGHT ON THE SECOND TRY. Pete

Physiological Model of Distance Running Performance (Including Hill & Wind Effects)

by Bob Baumel

Everybody knows that a long race requires a slower pace than a short race. The precise variation of running performance with race distance, as well as the mechanism behind such variation, have intrigued many authors over the years. I present here a simple physiologically-based model of running performance (actually a class of models) that explains this variation, and also predicts an optimal pacing strategy for any distance. (Not surprisingly, this optimal strategy consists of even pace unless hills or wind are present.) I derive the model first in the absence of hill or wind effects, but will then generalize the model to include those effects.

I should point out that this is purely a model of **Distance** running performance. The model does not cover sprinting events because it ignores such factors as: the energy used in acceleration, the transient anaerobic energy sources that act only in the first few seconds of exercise, the mechanical force the runner can generate against the track, the runner's maximal speed of muscular contraction, etc.

The model is obtained by first considering the metabolic energy cost of running as determined in exercise physiology labs, and by then introducing a measure of fatigue, which I assume to be depletion of the runner's glycogen supply. The rate of glycogen consumption is assumed to be a *non-linear* function of metabolic rate. (Non-linearity of this function is essential in predicting the optimal even-pacing strategy.)

The metabolic energy cost of running (level surface, no wind resistance) is proportional to the distance covered, but the energy consumed per kilometer is essentially constant, regardless of the runner's speed. In an equation,

$$\Delta E = a_0 \, \Delta x \qquad (1)$$

where ΔE is energy cost per unit body mass [in joules per kilogram (J/kg)] and Δx is the distance run [in meters (m)]. The coefficient a_0 is about:

$$a_0 \approx 3.9 \text{ J/(kg·m)} \qquad (2)$$

Thus, a 60 kg runner consumes about 230 kJ (kilojoules) in running 1 km, no matter whether he runs that kilometer in 3 min or 6 min. If both sides of Equation (1) are divided by the running time Δt, the relationship becomes

$$M(v) = a_0 \, v \qquad (3)$$

where $M(v)$ is metabolic rate in watts per kilogram (W/kg) while running at speed v in meters per second (m/s). [Note: 1 watt = 1 joule per second.] The *rate* of energy consumption is directly proportional to running speed.

To complete the model, I assume that performance is limited by exhaustion of the runner's glycogen supply. (Glycogen is a form of carbohydrate stored in muscle and liver tissue.) Glycogen depletion is generally understood as the mechanism responsible for "hitting the wall" in a marathon. It may also limit performance in shorter events involving proportionally more anaerobic work, because glycogen is consumed very rapidly when the exercise becomes anaerobic. (Thus, the rate of glycogen consumption increases rapidly when the work rate exceeds the runner's "anaerobic threshold.")

I assume that the rate of glycogen depletion R (measured perhaps in grams of glycogen per second) is a function of metabolic rate M:

$$R = R(M) \tag{4}$$

The form of the function R(M) is not known experimentally, but it seems reasonable to assume that it has the following properties:

a) The graph of R(M) passes through the origin: $R(0) = 0$.
b) R(M) is monotone increasing: $R'(M) > 0$ for all $M > 0$. (5)
c) Graph of R(M) is concave upward: $R''(M) > 0$ for all $M > 0$.

Numerous functions satisfy these properties. A particularly simple example is the power law:

$$R(M) = \alpha M^{\beta} \tag{6}$$

where the exponent β may be any number greater than 1. Different choices for the functional form of R(M) lead to different formulas for the relationship between racing time and distance. As we will see, assumption of the power law (6) leads to a power law relationship between distance and time as favored by Pete Riegel (see Sept '89 *Measurement News* page 28, or Aug '77 *Runners World* page 61). Assumption of a slightly different form for R(M) leads to a quadratic form of the distance-time relationship which I once published in *Canadian Runner* magazine (Nov '81 page 6).

For now, I do not assume a particular functional form for R(M), but simply investigate consequences of the properties (5). Let G be the runner's glycogen supply at the beginning of the race. The runner's task is then to run a given course as fast as possible (or in some events to run as far as possible in a given time) given the constraint that the total glycogen consumed does not exceed G. For the (usual) fixed-distance race, the runner must choose a speed v(x) at each position x along the course to solve the problem:

$$\text{Minimize} \int_0^D \frac{dx}{v(x)} \quad \text{with Constraint} \int_0^D R[M\{v(x)\}]\,\frac{dx}{v(x)} \le G \tag{7}$$

For the fixed-time situation, the runner must choose speed v(t) at each time t in order to solve the problem:

$$\text{Maximize} \int_0^T v(t)\,dt \quad \text{with Constraint} \int_0^T R[M\{v(t)\}]\,dt \le G \tag{8}$$

where D in problem (7) is the given race distance, or T in problem (8) is the given race time.

As we are ignoring hill and wind effects, the metabolic rate M(v) is the simple linear function of v given by Equation (3). Under this condition, the solutions of problems (7) and (8) have the following properties, which all follow from conditions (5) on the function R(M):

i) The *inequalities* in the constraint conditions in problems (7) and (8) actually become *equalities* for performances solving the problems; i.e., in a maximal performance, the runner completely exhausts his glycogen supply by the end of the race.

ii) Problems (7) and (8) have the *same* solutions; i.e., any solution of problem (7) is also a solution of problem (8), and vice versa.

iii) The solutions of problems (7) and (8) consist of *even-paced* running; i.e., the speed V is constant for the duration of the race (although this constant speed will naturally be slower in a long race than a short one).

Given a functional form for R(M), the speed V described in property (iii) can be found using property (i); i.e., the fact that the runner's entire glycogen supply is consumed. For example, if R(M) is given by equation (6), then the total glycogen consumption, expressed in terms of problem (7) is:

$$R[M\{v\}]\,\frac{D}{v} \;=\; \alpha\,(a_o v)^{\beta}\left(\frac{D}{v}\right) \;=\; G \qquad (9)$$

which can be solved for V:

$$V \;=\; \left(\frac{G}{\alpha\, a_o^{\beta}}\right)^{1/(\beta-1)} D^{-1/(\beta-1)} \qquad (10)$$

This can be rewritten as

$$V \;=\; c\,D^{-\gamma} \qquad \text{or} \qquad T \;=\; c^{-1}\,D^{1+\gamma} \qquad (11)$$

where

$$\gamma \;=\; 1/(\beta-1) \qquad (12)$$

Pete Riegel has found that equations (11) hold quite well for performances from about 5 km to the marathon with $\gamma \approx 0.07$, corresponding to $\beta \approx 15$.

Including Hills and Wind

So far, we have been ignoring hills and wind. To include these effects, the only change required in the model is to correct the metabolic energy cost of running (equations 1, 2 and 3) to account for the energy cost of climbing hills or fighting wind resistance. The relationship between metabolic rate and glycogen consumption (equations 4, 5 and 6) remains unchanged, and we still find the optimum performance by solving equation (7) or (8). In practice, however, I now consider only the more common situation of fixed-distance races (equation 7), because the notion of fixed-time events (equation 8) on courses with variable hilliness and wind conditions presents difficulties that I'd rather not deal with (for example, one runner might have to climb a hill that a slower runner never even reaches!).

The energy cost of running uphill or downhill (still without wind) is known fairly well from exercise physiology experiments. As in the case of level running, the energy cost per kilometer is still, to a good approximation, independent of the runner's speed. It does, however, depend on the incline. Thus, the only change required in equations (1), (2) and (3) is to replace the constant a_0 by a function $a(\theta)$ depending on the angle of inclination θ. For example, equation (3) becomes:

$$M(v) = a(\theta)\, v \tag{13}$$

The function $a(\theta)$ may be expanded in a power series in $\sin\theta$:

$$a(\theta) = a_o + a_1 \sin\theta + a_2 \sin^2\theta + \ldots \tag{14}$$

so that equation (13) becomes:

$$M(v,\theta) = a_o v + a_1 v \sin\theta + a_2 v \sin^2\theta + \ldots \tag{15}$$

Expansions (14) and (15) are closely related to the expansion in my "Hill Effect to Second Order" article (Jan '89 *Measurement News* page 41). The effective course length used in that 2nd Order Hill article is defined by

$$a_o\, \Delta x_{eff} = \Delta E = a(\theta)\, \Delta x \tag{16}$$

and the coefficients A and B used in the 2nd Order article were:

$$A = a_1/a_o \quad ; \quad B = a_2/a_o \tag{17}$$

The first order (a_1) term in the expansion (15) can be understood in terms of mechanical work performed against gravity. Given the experimental value $a_1 \approx 17$ J/(kg·m), this term can be written:

$$a_1 v \sin\theta \approx 1.75\, g\, v \sin\theta = 1.75\, P_g \tag{18}$$

where $g \approx 9.8$ m/s^2 is gravitational acceleration, and P_g is the mechanical power per unit body mass (in watts per kilogram) expended against gravity. The 1.75 coefficient is a dimensionless ratio expressing the notion that every joule of mechanical work performed against gravity requires consumption of an extra 1.75 joules of metabolic energy (beyond the energy normally consumed in steady-state level running). Thus it represents sort of a "differential efficiency" of conversion between metabolic energy and mechanical work.

To incorporate wind resistance into the model (at least to lowest order), it seems reasonable to assume that the ratio 1.75 in equation (18) applies not only to work against gravity, but also to work against air resistance. We therefore generalize equation (13) by adding a wind term as follows:

$$M = a(\theta)\, v + 1.75\, P_a \tag{19}$$

where P_a is the mechanical power (per unit body mass) expended against air resistance. From fluid dynamics, it is known that

$$P_a = \frac{\rho A_D}{2m} v (v-w)^2 \operatorname{sgn}(v-w) \tag{20}$$

where ρ is density of the air (about 1.2 kg/m^3 at sea level), A_D is the runner's "drag area" (which I'll assume to be 0.5 m^2), m is the runner's mass (which I'll take as 65 kg), v is the runner's speed in meters per second, and w is the ambient wind speed in meters per second (positive if a tailwind), and "sgn" is the "sign" function, equal to +1 for positive arguments, and -1 for negative arguments. Combination of equations (19) and (20), using the assumed numerical values for the various constants, yields:

$$M = a(\theta)\, v + k\, v (v-w)^2 \operatorname{sgn}(v-w) \tag{21}$$

where $k \approx 0.008$ m^{-1}.

In a given race, the course profile is defined by a function $\theta(x)$ giving the angle of inclination θ at position x. And the wind speed w may also be a function $w(x)$ varying with distance x along the course. Equation (21) can therefore be written more explicitly to indicate dependence of the metabolic rate on both the runner's speed v and position x on the course:

$$M(v,x) \quad = \quad a(\theta(x))\,v \;+\; k\,v\,(v-w(x))^2\,\mathrm{sgn}(v-w(x)) \qquad (22)$$

And the problem of finding the optimal pacing strategy (equation 7) can be written as:

$$\text{Minimize} \int_0^D \frac{dx}{v(x)} \quad \text{with Constraint} \int_0^D R[M\{v(x),x\}]\,\frac{dx}{v(x)} \;\le\; G \qquad (23)$$

The problem (23) can be solved for the optimal velocity profile $v(x)$ using methods of the calculus of variations, with a Lagrange multiplier to handle the constraint. This yields the result:

$$v\,\frac{dR}{dM}\,\frac{\partial M}{\partial v} \;-\; R \;=\; \lambda \qquad (24)$$

where λ is a number that is constant for the duration of a given race. The value of λ can be found from the condition that the constraint inequality in equation (23) becomes equality when the problem is solved (condition (i) at bottom of page 2):

$$\int_0^D R[M\{v(x),x\}]\,\frac{dx}{v(x)} \;=\; G \qquad (25)$$

For the particular forms of R and M given by equations (6) and (22), equations (24) and (25) become:

$$\left(\beta - 1 + \frac{2\beta k v^2 \left|v-w\right|}{M}\right) M^{\beta} \;=\; \lambda/\alpha \qquad (26)$$

and

$$\int_0^D M^{\beta}\,\frac{dx}{v(x)} \;=\; G/\alpha \qquad (27)$$

with M expressed in terms of $v(x)$, $w(x)$ and $\theta(x)$ by equation (22).

As a special case of these equations, consider an arbitrary elevation profile given by $\theta(x)$ but suppose that, for the moment, we continue to ignore wind resistance (equivalent to assuming $k=0$ in equations 22 and 26). In this case, equation (26) implies that the metabolic rate M is constant for the duration of the race. Thus on a hilly course in the absence of wind resistance, the optimal strategy is not even pacing, but consists instead of *even energy output*; i.e., the runner speeds up on the downhills, and slows down on the uphills, just enough to maintain a constant rate of metabolic energy expenditure. And although the runner does not maintain constant *speed*, he covers *effective* course length (equation 16) at a constant rate.

The case of a hilly course without wind resistance can be described fully by the notion of effective course length (equation 16). In effect, I have already treated this case completely in my "Hill Effect to Second Order" article. Mathematically, the reason for this simple description in terms of effective length follows from the assumption (equation 13) that (in the absence of wind resistance) M depends only *linearly* on the running speed V. This linear dependence on V applies no matter how many terms of the expansion (15) we choose to consider. But a simple description in terms of effective course length no longer suffices once we include the *wind* term in equation (21) or (22), with its strongly *non*-linear dependence on V.

To summarize the behavior of effective length for hilly courses without wind resistance (as described in my 2nd Order Hill article): To first order in equation (14) or (15), i.e. the a_1 term, every meter of climb *increases* the effective length about 4 meters, and every meter of drop *decreases* effective length about 4 meters. For a course with equal uphill and downhill, the first order contributions of the uphills and downhills cancel out. To second order, i.e. the a_2 term, every segment of the course with non-zero slope (either uphill or downhill) will *increase* effective length a bit; thus the contributions of uphills and downhills do *not* cancel out.

It should be understood that the above results concerning effective length do **not** depend on runners of a particular mass or ability. They apply to light runners as well as heavy runners, to fast runners as well as slow runners.

It is worth noting that the approximation of neglecting wind resistance, i.e. ignoring the wind term in equation (21) or (22), is **not** equivalent to assuming calm conditions ($W=0$). Even with $W=0$, the wind term is non-zero because the moving runner hits the still air with relative speed V. Wind effects vanish only in lab exeriments on treadmills (although not in wind tunnels!), or in outdoor running with a tailwind exactly matching the runner's speed ($W=V$).

In the remainder of this article, I will **not** neglect the wind term. I will, however, assume that the course is flat ($a(\theta) = a_0$). Actually, given the computer code I've already written, it would not be hard to generalize to include both hills **and** wind, and this might even show some interesting interactions (for example, a hill forces the runner to speed up or slow down, which in turn changes the wind force). But for now, I consider the wind effect only on flat courses:

Wind Effects—Numerical Examples

I will present examples based on a computer program that numerically solves equations (26) and (27). The program computes a runner's optimal pacing strategy and resulting performance, given a wind profile $w(x)$ and four parameters: the coefficient a_0 from equation (14), the constant k from equation (21), the exponent β in equation (6), and the quantity G/α in equation (27). I don't need the coefficients a_1, a_2, etc. from equation (14) because I consider only **flat** courses. Note also that the model depends on G and α only through the combination G/α.

Input to the program consists first of the values of a_0, k, and β, and then of a "reference performance" (time for some race distance under calm conditions) from which the program computes the parameter G/α. Finally, the user describes a desired course and wind profile by specifying the course as a set of discrete intervals with constant wind speed on each interval.

If the specified course consists of N intervals, then equation (26) actually consists of N equations (one equation on each interval), while equation (27) is just a single equation involving a sum over all N intervals. Corresponding to these N+1 equations, we have N+1 unknowns: the runner's speeds on the N intervals, and the unknown quantity λ/α (the Lagrange multiplier).

This system of N+1 equations in N+1 unknowns is solved as follows: Given a trial value of λ/α, each of the N equations in (26) is solved for the speed V on the corresponding interval by scanning over possible values of V. Once we have the speed profile $V(X)$ for a given λ/α, we check how well equation (27) is satisfied. Finally, this whole procedure is repeated for different trial values of λ/α until we close in on the solution of equation (27).

Output from the program follows: I first consider **constant** wind speeds. (Thus, the course consists of just a single constant-wind-speed interval.)

MODEL PARAMETERS: a0 = 3.90 J/(kg·m) k = 0.00800 m^{-1} beta = 15.00
REFERENCE PERFORMANCE: 10000 m in 30:00

Distance (m)	WindSpeed (m/s)	RunSpeed (m/s)	MetRate (W/kg)	Time	EffShort (m/km)
10000	-10.000	4.111	22.580	40:33	-352
10000	-9.000	4.265	22.636	39:05	-303
10000	-8.000	4.420	22.690	37:43	-257
10000	-7.000	4.574	22.742	36:26	-214
10000	-6.000	4.728	22.792	35:15	-175
10000	-5.000	4.879	22.840	34:09	-138
10000	-4.000	5.028	22.886	33:09	-105
10000	-3.000	5.171	22.928	32:14	-74
10000	-2.000	5.308	22.968	31:24	-47
10000	-1.000	5.437	23.005	30:39	-22
10000	0.000	5.556	23.038	30:00	0
10000	1.000	5.662	23.068	29:26	19
10000	2.000	5.755	23.093	28:58	34
10000	3.000	5.831	23.113	28:35	47
10000	4.000	5.887	23.128	28:19	56
10000	5.000	5.922	23.137	28:09	62
10000	6.000	5.933	23.140	28:05	64
10000	7.000	5.948	23.143	28:01	66
10000	8.000	5.987	23.153	27:50	72
10000	9.000	6.049	23.169	27:33	82
10000	10.000	6.134	23.191	27:10	94

The above table, computed for a runner capable of 30 min for 10 km in calm conditions, shows the runner's performance at 10 km with various constant wind speeds. Wind speeds are positive for tailwinds and negative for headwinds. The results for tailwinds are similar to those presented by Pete Riegel on page 7 of Sept '89 *Measurement News* (although Pete used a much simpler approximation than I've presented here). Not surprisingly, given the nonlinearity of the wind effect, a 10 m/s (36 km/h) headwind *hurts* the runner's performance nearly four times as much as an equally strong tail-wind *helps* him!

Note that in these tables, the metabolic rate is lower with headwinds than tailwinds. This apparently counter-intuitive result is easily understand. A headwind increases the time needed to cover the course. As the runner's glycogen supply is limited, he must decrease the rate of glycogen consumption with exercise of longer duration; thus, he must decrease his metabolic rate.

The "Effective Shortening" column in these tables is really just the time difference (relative to performance at zero wind speed) expressed in parts per thousand. It cannot, strictly speaking, be considered a change in effective course length, as the percentage change in race time corresponding to a given wind speed is not universal (as is the hill effect), but differs considerably for runners of different ability. For example, while the preceding table was for a 30 min 10 km runner, here is the corresponding table for a 50 min 10 km runner:

REFERENCE PERFORMANCE: 10000 m in 50:00

Distance	WindSpeed	RunSpeed	MetRate	Time	EffShort
10000	-10.000	2.532	13.055	1:05:50	-317
10000	-8.000	2.722	13.118	1:01:14	-225
10000	-6.000	2.906	13.175	57:22	-147
10000	-4.000	3.075	13.225	54:12	-84
10000	-2.000	3.221	13.266	51:44	-35
10000	0.000	3.333	13.296	50:00	0
10000	2.000	3.400	13.314	49:01	20
10000	4.000	3.417	13.318	48:46	25
10000	6.000	3.464	13.330	48:07	38
10000	8.000	3.569	13.357	46:42	66
10000	10.000	3.736	13.398	44:37	108

Note that the slower runner receives considerably less aid from a 2 m/s tail-wind than the fast runner (on previous page). But the slow runner receives *more* aid than the fast runner from a 10 m/s tailwind. (This apparently odd behavior is related to the location of the "s-bend" noted by Pete Riegel on pp. 6-7 of Sept '89 *Measurement News*.)

The model I've presented covers not only hill and wind effects, but also describes the variation of performance with race distance. Thus, for the 30 min 10 km runner, here are predicted marathon times at various wind speeds:

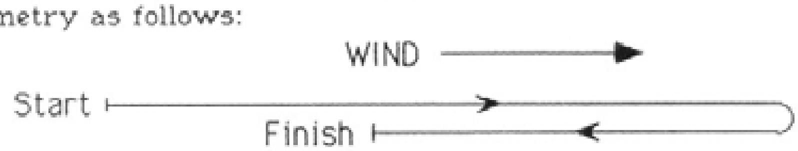
Distance	WindSpeed	RunSpeed	MetRate	Time	EffShort
42195	-10.000	3.766	20.394	3:06:45	-346
42195	-8.000	4.049	20.493	2:53:41	-251
42195	-6.000	4.330	20.585	2:42:24	-170
42195	-4.000	4.601	20.669	2:32:50	-101
42195	-2.000	4.851	20.742	2:24:58	-44
42195	0.000	5.067	20.802	2:18:47	0
42195	2.000	5.233	20.847	2:14:23	32
42195	4.000	5.333	20.873	2:11:53	50
42195	6.000	5.358	20.880	2:11:15	54
42195	8.000	5.432	20.899	2:09:28	67
42195	10.000	5.592	20.939	2:05:46	94

As described earlier, the model is not limited to constant wind speeds, but covers courses with different wind speeds on different intervals. Here is the optimal performance for our runner (capable of 10 km in 30 min) if he runs a 10 km course including equal distances with and against a 5 m/s wind:

Interval (m)	WindSpeed (m/s)	RunSpeed (m/s)	MetRate (W/kg)	Time
5000	5.000	5.912	23.094	14:06
5000	-5.000	4.887	22.880	17:03
		Overall	10000 m in	31:09

With equal distances of headwind and tailwind, the headwind will always dominate; in the example above, the runner's time is more than a minute slower than he could run in calm conditions. The optimal pacing strategy involves *nearly* constant metabolic rate, although it's not exactly constant: the runner does maintain a slightly higher metabolic rate on the tailwind segment than the headwind segment. (Recall that for an arbitrarily hilly course in the absence of wind resistance, the optimal strategy is *exactly* constant metabolic rate.)

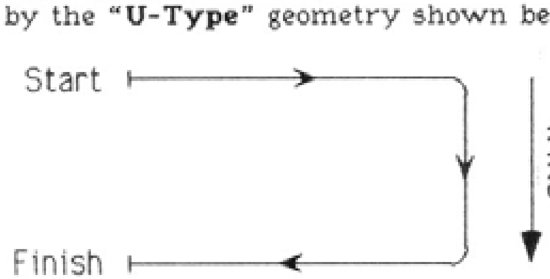
Consider now a course with some **Separation** between the Start and Finish, where the distances with and against the wind are *not* equal. I've run calculations for two such course geometries. The first is an "**Out & Back**" type of geometry as follows:



A sample calculation of this type, for 40% separation and 3 m/s wind is:

Interval	WindSpeed	RunSpeed	MetRate	Time
7000	3.000	5.826	23.095	20:01
3000	-3.000	5.179	22.968	9:39
		Overall	10000 m in	29:41

Almost all efforts to model wind aid on courses with non-zero separation (including all of Ken Young's calculations on this subject) have made use of the "Out & Back" type geometry shown above, on the assumption that this is the "worst case." But recently, Pete Riegel realized that there is an *even worse* case, given by the "**U-Type**" geometry shown below:

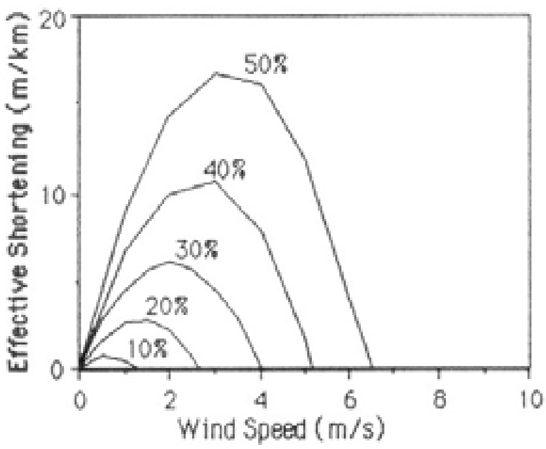


A sample calculation with this geometry, for 30% separation and 3 m/s wind:

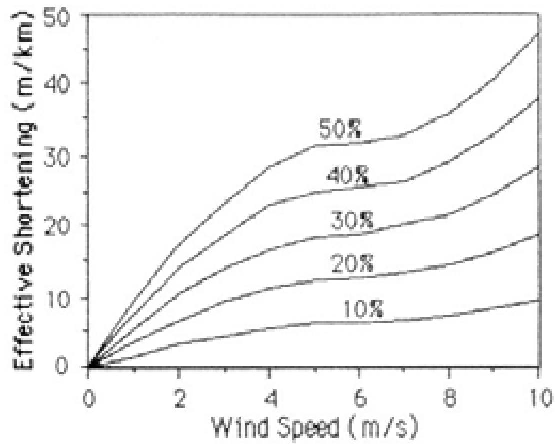
Interval	WindSpeed	RunSpeed	MetRate		Time
3500	0.000	5.555	23.037		10:30
3000	3.000	5.831	23.116		8:34
3500	0.000	5.555	23.037		10:30
		Overall	10000 m	in	29:35

I have run the program for many examples of the two geometries described above. Results are shown in the following graphs. For convenience, I've displayed "aid" in terms of "effective shortening" in m/km, even though the notion of effective shortening is not as universal in the case of wind as it is for hilly courses. Thus, these graphs apply only to a runner capable of 30 min for 10 km, and apply to the specific race distance of 10 km.

Out & Back Type Geometry



U-Type Geometry



The graphs show "aid" as a function of wind speed for courses with various separations. Interestingly, the aid provided in the "Out & Back" type case (for any given separation) is limited to low wind speeds; higher wind speeds have a negative effect on performance. Please note the difference in vertical scale between the two graphs. The "U-Type" geometry provides considerably more aid than the "Out & Back" type geometry. (But in both cases, the aid provided by wind is usually a lot more than the errors in our measurements of course distance, which are presumably less than the 1 m/km Short Course Prevention Factor.)

Finally, I must observe that the model presented in this article is correct only for winds parallel to the running direction. Due to non-linearity of the wind effect, the component of wind force in the running direction is **not** identical to the force that would be generated by only the component of wind in that direction. A possibly more correct version of equation (21) is:

$$M = a(\theta)\,v + k\,v\,(v-w)\sqrt{(v-w)^2 + w_c^2} \qquad (28)$$

where w is the component of wind parallel to the running direction, and w_c is the perpendicular component (crosswind). For a pure crosswind ($w=0$, $w_c \neq 0$), the wind resistance from equation (28) is greater than in calm conditions. Thus, the aid provided in the "U-Type" geometry might not be quite as great as indicated in the graph above.

Oct 10, 1989

Pete,

I recently gave a measurer in Mississippi a hard time because all of his measurements showed six (6) digits. I asked him what was going on; told him Jones counters have only five (5) dials/digits. On the next measurement he sent me a photo (ed: it showed a six-digit counter).

It would be nice to know about such changes or did I miss an announcement?

Best Regards

Doug Loeffler

PS I bought two counters from Bill Noel within the last 3-4 months & both were the same old 5 digit counters.

* * * * * * *

October 16, 1989

Doug Loeffler - 2000 NE 4th Way - Boca Raton, FL 33431

Dear Doug,

JONES COUNTER VARIATIONS

The Jones Counter has had several variations during its evolution. At first the counter had six digits, but this was reduced to 5 digits to save cost, since the six-digit Veeder-Root counter is significantly higher in price.

Those who purchased counters years ago got six-digit counters, and those buying today get 5 digit counters.

Another variation involves the gear drive. On one of my earliest reviews, back in 1982 or so, I got data that showed a constant of about 19500 per mile, or 12100 per kilometer. I thought the guy might have been riding a child's bike with a 20 inch wheel. In response to my inquiry I learned that the gear on his counter had 26 holes instead of 20 holes, and was the drive for a speedometer for a bike with a 20 inch wheel. On the spoke side of the drive gear the number "26" was stamped, while almost all of today's counters have a number "20" stamped there. This counter thus recorded 26 counts per revolution of the bike wheel.

As I recall, Alan Jones confirmed that a few variations like this were made, but they are quite rare.

All of the counters sold today have 5 digits and record 20 counts per revolution of the wheel.

I'm sorry about the lack of communication on this - this is the first time I've heard about it being a problem.

Best regards, Pete

THE ATHLETICS CONGRESS
OF THE USA

Road Running Technical Committee
Peter S. Riegel, Chairman

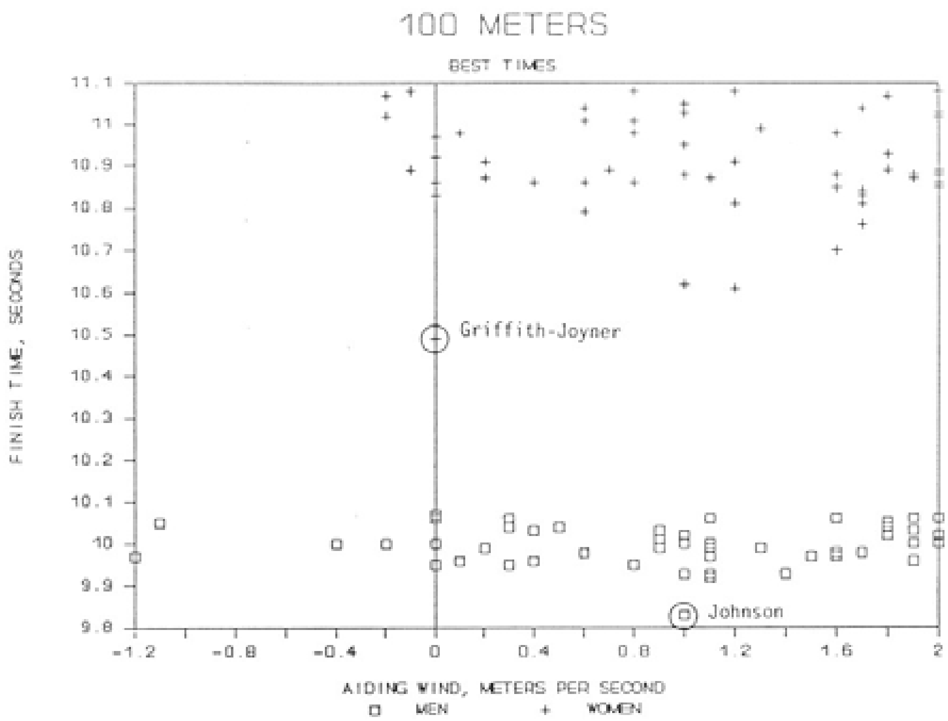
3354 Kirkham Road
Columbus, OH 43221
614-451-5617 (home)
614-424-4009 (office)
telex 245454 Battelle

October 3, 1989

David E. Martin, Ph.D - Dept of Cardiopulmonary Care Sciences
Georgia State University - Atlanta, GA 30303

Dear Dave,

Many thanks for the best-performances data for the 100 meters and long jump. I didn't think my casual inquiry would bring such a fast response. Here's a graph of how the 100 meters looks:

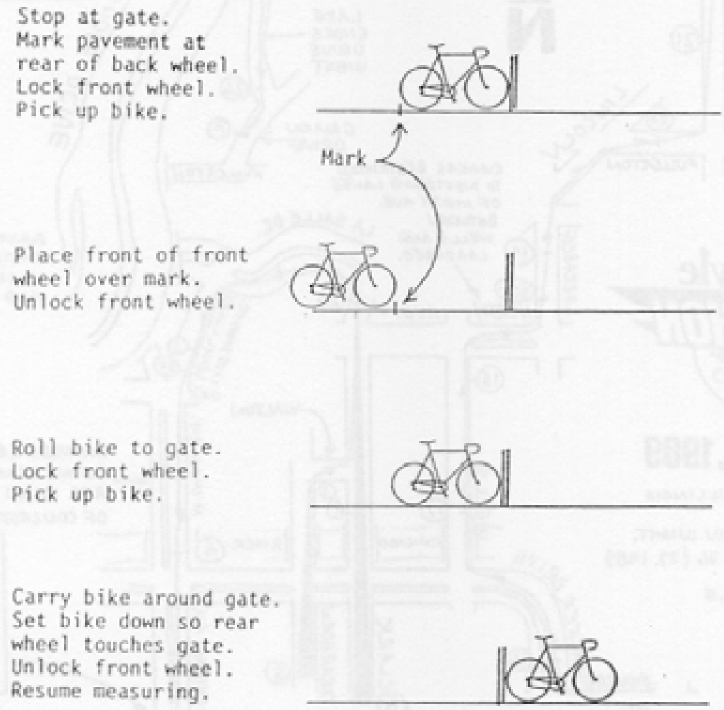


I ran a regression of time-vs-wind, but the correlation was so poor I felt it was without value. Still, it is obvious that any sprinter who wants to try for a 100 meter record had better pray for a tailwind. I've no idea what this may mean to road runners, but I'll put this in Measurement News and maybe somebody will be able to find something of use in it. Thanks again.

Best regards,

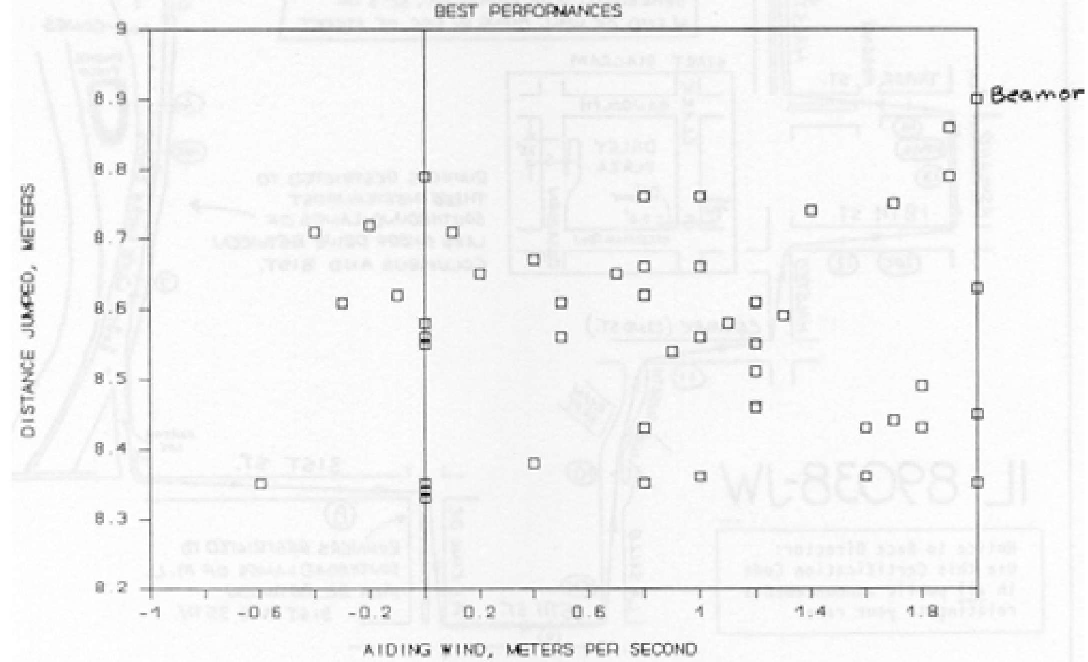
Pete

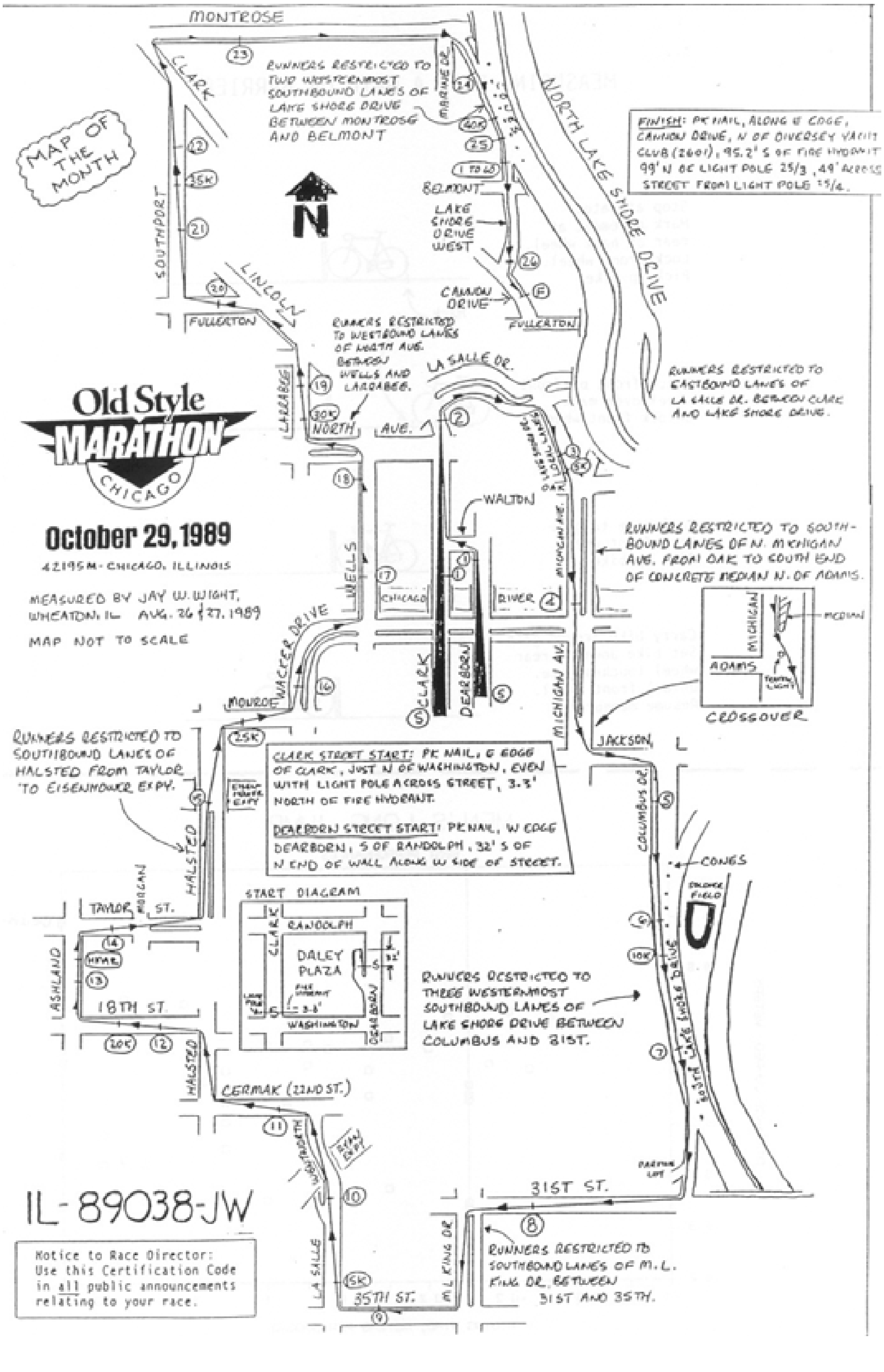
MEASURING PAST A GATE OR BARRIER



MEN'S LONG JUMP

BEST PERFORMANCES




MONTROSE
CLARK
RUNNERS RESTRICTED TO TWO WESTERNMOST SOUTHBOUND LANES OF LAKE SHORE DRIVE BETWEEN MONTROSE AND BELMONT
MARINE DR.
NORTH LAKE SHORE DRIVE
MAP OF THE MONTH
FINISH: PK NAIL, ALONG E EDGE, CANNON DRIVE, N OF DIVERSEY YACHT CLUB (2601), 95.2' S OF FIRE HYDRANT 99' N OF LIGHT POLE 25/3, 49' ACROSS STREET FROM LIGHT POLE 25/4.
N
BELMONT
LAKE SHORE DRIVE WEST
SOUTHPORT
LINCOLN
CANNON DRIVE
FULLERTON
RUNNERS RESTRICTED TO WESTBOUND LANES OF NORTH AVE. BETWEEN WELLS AND LARRABEE.
LA SALLE DR.
RUNNERS RESTRICTED TO EASTBOUND LANES OF LA SALLE DR. BETWEEN CLARK AND LAKE SHORE DRIVE.
LARRABEE
NORTH AVE.
Old Style MARATHON CHICAGO
October 29, 1989
42195M - CHICAGO, ILLINOIS
MEASURED BY JAY W. WIGHT, WHEATON, IL AUG. 26 & 27, 1989
MAP NOT TO SCALE
WALTON
OAK
RUNNERS RESTRICTED TO SOUTHBOUND LANES OF N. MICHIGAN AVE. FROM OAK TO SOUTH END OF CONCRETE MEDIAN N. OF ADAMS.
WELLS
CHICAGO
RIVER
MICHIGAN AVE.
MEDIAN
ADAMS
CROSSOVER
WACKER DRIVE
CLARK
DEARBORN
MONROE
JACKSON
RUNNERS RESTRICTED TO SOUTHBOUND LANES OF HALSTED FROM TAYLOR TO EISENHOWER EXPY.
CLARK STREET START: PK NAIL, E EDGE OF CLARK, JUST N OF WASHINGTON, EVEN WITH LIGHT POLE ACROSS STREET, 3.3' NORTH OF FIRE HYDRANT.
DEARBORN STREET START: PK NAIL, W EDGE DEARBORN, S OF RANDOLPH, 32' S OF N END OF WALL ALONG W SIDE OF STREET.
HALSTED
COLUMBUS DR.
CONES
SOLDIER FIELD
START DIAGRAM
RANDOLPH
DALEY PLAZA
WASHINGTON
TAYLOR ST.
MORGAN
ASHLAND
18TH ST.
RUNNERS RESTRICTED TO THREE WESTERNMOST SOUTHBOUND LANES OF LAKE SHORE DRIVE BETWEEN COLUMBUS AND 31ST.
SOUTH LAKE SHORE DRIVE
CERMAK (22ND ST.)
WENTWORTH
DAN RYAN EXPY
31ST ST.
IL-89038-JW
LA SALLE
M L KING DR
RUNNERS RESTRICTED TO SOUTHBOUND LANES OF M.L. KING DR. BETWEEN 31ST AND 35TH.
35TH ST.
Notice to Race Director: Use this Certification Code in all public announcements relating to your race.

John I. Thornton,[1] *D.Crim. and Jill M. Shirokawa,*[1] *B.S.*

A Trajectory Analysis of Billy Dixon's Long Shot

In June 1874, a mixed group of Comanche, Kiowa, and Arapahoe attacked a trading post in the Texas Panhandle. This engagement is known as the Second Battle of Adobe Walls.[2] A full account of the battle has been recently given by Baker and Harrison [*1*]. The traders and buffalo hunters at Adobe Walls were attacked intermittently for 3 days, after which the Indians withdrew. The Indians were under the leadership of the Comanche, Quanah Parker.[3] During the battle, Quanah was shot in the side, which may have something to do with his subsequent decision to withdraw. Among the 28 white men (and 1 white woman) at the post were William Barclay ("Bat") Masterson and a 23-year-old buffalo hunter named Billy Dixon.[4]

On the third day of the engagement, Billy Dixon shot an Indian at a long distance, most frequently and persistently reported as 1538 yd [*2*]. It was a phenomenal shot for a buffalo rifle with iron sights. The present work is an attempt to review aspects of the trajectory of this shot by means of the TRAG1P [*3*] computer program.

NOTE FOR MEASURERS — A GOOD ESTIMATE IS BETTER THAN NOTHING!

Temperature

With all the whooping and scalping going on outside, the white men bottled up inside the trading post (four of whom were killed in the battle) neglected to record the temperature on June 28th. However, the mean daytime maximum temperature for June (for nearby Amarillo) as given in *The Weather Almanac* [*13*] is 88.2°F, and this figure was used for the principal computer simulation of the trajectory.

At 1538 yd, the remaining velocity of 781 ft/s and the remaining energy of 630 ft · lb is considerably in excess of that required to penetrate human skin, or, for that matter, even human bone [*15*]. The analysis described above indicates clearly that the .50-90 Sharps could indeed carry to that distance and still inflict a lethal wound. The trajectory is believable. Still, with a bullet drop in excess of 318 ft and "Kentucky windage" in excess of 28 ft, it is unlikely that Billy Dixon could have done it twice in a row.

Address requests for reprints or additional information to
Dr. John I. Thornton
Forensic Science Group
Department of Biomedical and Environmental Health Sciences
University of California
Berkeley, CA 94720

BITS & PIECES FROM A RECENT ISSUE OF JOURNAL OF FORENSIC SCIENCES.

[10]Those of us who have spent any time at Air Force installations around Amarillo will inevitably suspect, on purely subjective grounds, that *The Weather Almanac* is in error on the low side. However, there is some independent verification of the wind from the Indian side of the battle. In a 1935 interview, Cohaya, an Indian survivor (of both bullets and years), said that "suddenly, and without warning or apparent cause, one of the warriors fell from his horse dead. The wind was blowing and the hide man's rifle was fired from such a distance that the braves had been unable to hear the report when it fired."

COMPARISON OF ENGLISH AND AMERICAN COURSE MEASUREMENTS

At John Disley's invitation I came to England in September to act as instructor/examiner for several experienced UK measurers. Joining me, measurers came from all corners of the UK, and we stayed at the Hostel of the Crystal Palace National Sports Centre, just south of London.

At first we thought it might be instructive to do our measurements in the real world, by measuring a section of the course of the London Marathon. However, we decided that a traffic-free closed loop within the grounds of the Centre would better allow us to achieve our goals.

We bike-reconnoitered the grounds and found a loop of about 2.5 km that seemed to be rideable, although several turns were overgrown with bushes. I made crayon marks on the pavement at these points, and told the class to think of them as curbs, to eliminate riding through the shrubbery and to promote a uniform idea of where the proper line was.

On a straight portion of the course roadway we pounded a nail at one end, and used an existing nail as the other end, to establish a calibration course. We decided to tape it later, since it was raining. I asked everybody to make four precals and four postcals, and as many rides of the whole course as they felt they needed to get a good estimate of the course length.

Precalibration was done by all eight riding one way, followed by eight rides the other way, and then a repeat of the process. Once we were done, each measurer rode off to measure the loop in any way he pleased - it was not done by all of us riding in single file, or even in the same direction. Postcalibration was done by each individual when he was finished with his measurements. When this was done we ate lunch.

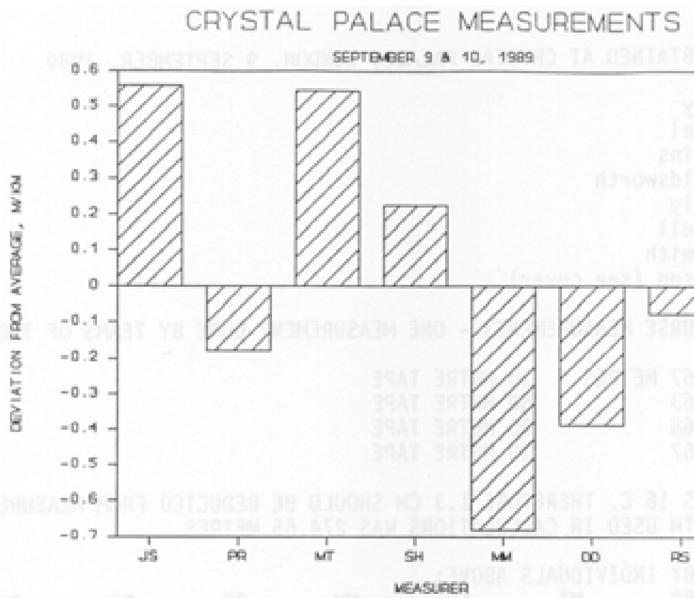
After lunch we divided into four groups of two. Each pair used a different steel tape to measure the length of the calibration course.

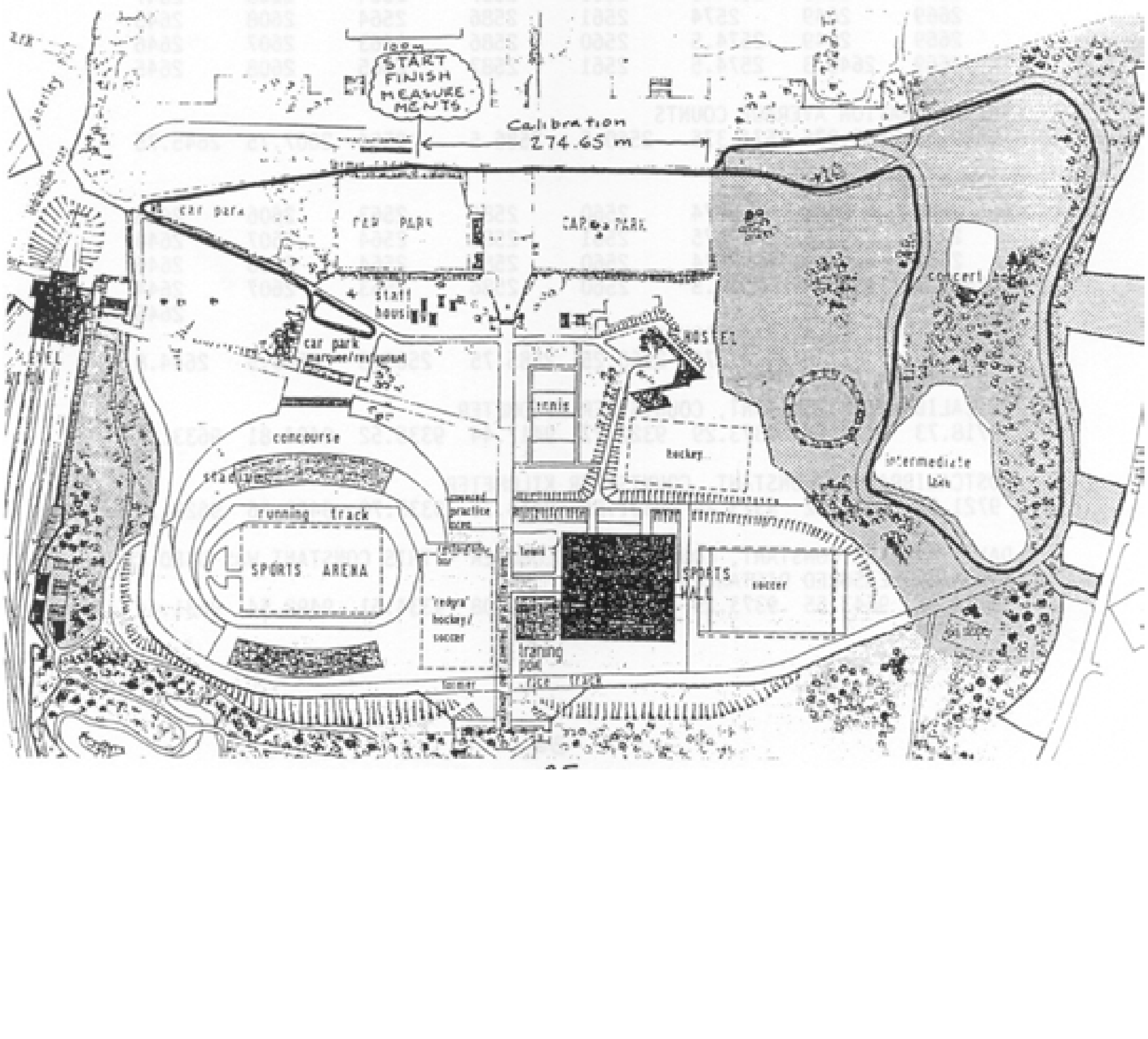
The course chosen for the exercise was not representative of a real race course, in that it had an inordinate number of turns for its length. This caused the differences to be exaggerated. Much of each measurer's ride was spent carefully hugging turns, with few respites. A normal course will not be so twisty. A rough estimate, from eyeballing the map, shows the course to have about 1600 degrees of curve in it, equivalent to about 18 right-angle turns. It might be a reasonable number of turns for a 10k, but it's a lot for a 2.5 km course. Still, even with all the turns, all 8 measurements occupied a span of 3.2 metres. That would be extraordinary agreement for 8 measurements of a 10k, although slightly excessive for 2.5k.

I would judge the quality of the measurements to be similar to those I have seen in US group measurements in which I have participated.

One of the benefits of a meeting like this is that people from diverse places get a chance to meet and compare notes. This has had a beneficial effect in the US, since once people have measured together they gain confidence that the other fellow knows what he is doing. Some of the UK guys had never met, and this gave them the chance to meet and measure with their peers.

Pete


CRYSTAL PALACE MEASUREMENTS
SEPTEMBER 9 & 10, 1989
DEVIATION FROM AVERAGE, M/KM
MEASURER
JS
PR
MT
SH
MM
DD
RS
PH


START
FINISH
MEASUREMENTS
Calibration
274.65 m
car park
CAR PARK
HOSTEL
concourse
stadium
running track
SPORTS ARENA
SPORTS HALL
soccer
hockey
training pool
intermediate lake

MEASUREMENTS OBTAINED AT CRYSTAL PALACE, LONDON, 9 SEPTEMBER, 1989

JS - Jack Selby
PR - Pete Riegel
MT - Mike Tomlins
SH - Stuart Holdsworth
MM - Max McNally
DD - Dave Dodwell
RS - Richard Smith
PH - Paul Hodgson (see cover)

CALIBRATION COURSE MEASUREMENTS - ONE MEASUREMENT DONE BY TEAMS OF TWO

PR & JS - 274.67 METRES	30 METRE TAPE
MT & DD - 274.63	50 METRE TAPE
PH & MM - 274.68	30 METRE TAPE
RS & SH - 274.67	30 METRE TAPE

TEMPERATURE WAS 16 C. THEREFORE 1.3 CM SHOULD BE DEDUCTED FROM MEASURED VALUES. LENGTH USED IN CALCULATIONS WAS 274.65 METRES

DATA OBTAINED BY INDIVIDUALS ABOVE:

	JS(1)	PR	MT	SH	MM	DD	RS	PH
PRECALIBRATION COUNTS								
	2670	2649	2574.5	2560	2587	2564	2608	2647
	2669	2649	2574	2561	2586	2564	2608	2645
	2669	2649	2574.5	2560	2586	2563	2607	2646
	2669	2649.3	2574.5	2561	2587	2565	2608	2645
PRECALIBRATION AVERAGE COUNTS								
	2669.25	2649.075	2574.375	2560.5	2586.5	2564	2607.75	2645.75
POSTCALIBRATION COUNTS								
	2670	2648	2574	2560	2586	2563	2606	2645
	2670	2648.5	2575	2561	2586	2564	2607	2644
	2670	2647.5	2574	2560	2585	2564	2606	2646
	2669.5	2648.5	2574.5	2560	2586	2563	2607	2644
								2645
POSTCALIBRATION AVERAGE COUNTS								
	2669.875	2648.125	2574.375	2560.25	2585.75	2563.5	2606.5	2644.8
PRECALIBRATION CONSTANT, COUNTS PER KILOMETER								
	9718.73	9645.28	9373.29	9322.77	9417.44	9335.52	9494.81	9633.17
POSTCALIBRATION CONSTANT, COUNTS PER KILOMETER								
	9721.01	9641.82	9373.29	9321.86	9414.71	9333.70	9490.26	9629.71
DAY'S AVERAGE CONSTANT, COUNTS PER KILOMETER - THIS CONSTANT WAS USED IN FIGURING MEASURED DISTANCES.								
	9719.87	9643.55	9373.29	9322.32	9416.08	9334.61	9492.54	9631.44

COUNTS OBTAINED ON LARGE LOOP

JS(1)	PR	MT	SH	MM	DD	RS	PH
17959	17767.5	17283	17176	17339	17199	17487	17748
17921	17765	17280	17175	(2)	17199	17488	17745
	17766	17274	17171		17196	17481	17742
					17199	17479	

LOWEST COUNT OBTAINED ON LARGE LOOP

17921	17765	17274	17171	17339	17196	17479	17742

COUNTS OBTAINED ON SMALL LOOP

7327	7241.5	7047	7017	7060	7015	7133	7232
7296.5	7237	7044	7007	(2)	7004	7134	7237
	7236	7044.5	7010		6999	7133	
					7003		

LOWEST COUNT OBTAINED ON SMALL LOOP

7296.5	7236	7044	7007	7060	6999	7133	7232

LOWEST MEASUREMENT OF LARGE LOOP, METRES

1843.75	1842.16	1842.90	1841.92	1841.43	1842.18	1841.34	1842.09

LOWEST MEASUREMENT OF SMALL LOOP, METRES

750.68	750.35	751.50	751.64	749.78	749.79	751.43	750.87

LOWEST TOTAL MEASUREMENT, METRES

2594.43	2592.51	2594.39	2593.56	2591.21	2591.97	2592.77	2592.97

METRES OVER 2590, BASED ON LOWEST TOTAL MEASUREMENT, METRES

4.43	2.51	4.39	3.56	1.21	1.97	2.77	2.97

AVERAGE MEASUREMENT OF LOOP, METERS = 2592.975

DEVIATION FROM AVERAGE, METERS

1.452	-0.465	1.417	0.585	-1.769	-1.008	-0.202	-0.009

DEVIATION FROM AVERAGE, M/KM

0.560	-0.179	0.546	0.226	-0.682	-0.389	-0.078	-0.004

NOTE (1): Selby's figures are those obtained on 10 September, after instruction and demonstration of shortest possible route. The first count is what was obtained initially. The second count was obtained after a discussion and demonstration of shortest possible route.

During Jack's ride of 10 September, a gate was closed. Jack rode to one side, until his front wheel touched the fence. He locked the wheel, carried across, and re-started with the back of the front wheel on the other side of the fence. His counts above include an added 13 counts on the big loop to account for the two diameters of the bike wheel not actually ridden on the course.

NOTE (2): Riegel does not possess McNally's measurement figures, but does have his calibration figures. The figures shown were reconstructed from Max's reported distances and constant used.

P. S. Riegel - September 12, 1989

October 20, 1989

Dear Peter Riegel:

I thought you might be interested in how this race (the GHADA Two Mile, Hartford, CT, Oct. 1) turned out.

We got an interesting mixture of ages and sexes winning the $100 prizes for the 10 times that were the lowest percentages of the appropriate theoretical world records. Nobody over 53, (although Mary Haines, a 75-year-old woman, came pretty close), and no women under 48, made it into the top ten, but, still, there was plenty of age/sex variety. If I use the WAVA 10K theoretical records as a guide, my "records" for the 40+ women are too slow relative to the overall "record". I make the assumption that records for all the age groups and both sexes should be the same percentages of the overall best for the distance, for any distance that is heavily competed.

The runners didn't seem to have any trouble handling the cone-defined turnaround with its 15' radius.

Theoretical World Records for Two Miles on the Road:

Ages:	20-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+
Male:	8:14	8:24	8:54	9:14	9:29	9:53	10:13	10:33	11:47	12:56
Female:	9:09	9:34	10:19	10:53	11:08	11:52	12:02	14:16	15:10	16:20

Some national-class age group athletes were attracted to the race. Here are the ten performaces that the computer of Ken Gankofskie of Prime Time determined to be the closest, proportionally, to the above times (note the interesting array of ages and sexes):

Time	%	Sex Age	Name, Town, State, Club*
11:30.57	105.75	F48	Christine Tattersall, Killingworth, CT
9:38.58	108.35	M42	Albin Swenson, Wolcott, CT, HTC
11:52.57	109.12	F48	Jane Arnold, Bloomfield, CT, HTC
9:14.91	110.10	M38	Gary Nixon, Higganum, CT
9:48.66	110.24	M40	Dennis Crowe, Waterford, CT, KP
9:12.69	111.88	M34	Edward Sparkowski, Glastonbury, CT, HTC
10:44.39	113.25	M52	Henry Golet, Old Lyme, CT, HTC
12:37.13	113.34	F52	Zofia Turosz, Hartford, CT, HTC
9:35.14	114.12	M35	Stephen Gates, Windsor, CT, HTC
9:26.88	114.75	M29	Michael Cobb, Hartford, CT, REEBOK

***HTC= Hartford Track Club, KP= Kelly's Pace**

Another time of note was that of the first wheelchair finisher, Tom Foran of Glastonbury Connecticut and the Hartford Track Club. He covered the course in 7:42.32. Any guess as to what percentage that time is to the best that a wheelchair athlete could do for a non-aided two mile?

Sincerely yours,

David Reik

David Reik, 930 W. Blvd, Hartford, CT 06105 (203) 236-9160

Dear Mr Riegel,

Thank you very much for your letter of July 17,1989 and specially for the copy of US Course Measurement Procedures and the Measurement News issue no 36.

Last weeks I ran next three marathons between 2:40 and 3:00: Moscow Peace Marathon August 12 in 2:56.23 among eleven thousands of runners. I met Fred Lebow in Moscow.

I'm very interested in receiving your Measurement News.

I enclose an article about course measurement in Poland. I tried to write not long text. If I made any grammatical mistakes please make correction.

Our Warsaw Peace Marathon is on the list of IAAF International Road Race Calendar 1989 and probably soon we and John Disley will make a certifikation measurement.

I stay in stable contact with David Martin from Atlanta.

If Polish runners will run Columbus Marathon November 12, please send me the list of top results.

Next days I will be in Dębno to compete in the Polish Marathon Championships August 27.

With best wishes

TADEUSZ DZIEKOŃSKI
ul. Chrobrego 4 m. 8
(skrytka pocztowa 14)
15-057 Białystok
POLAND

Białystok,August 22,1989

ROAD COURSE MEASUREMENT IN POLAND

The problem of road course measurement in Poland be
988 year was difficult and required much time and money.

Many races have been run on not correct courses - t
ime too - and these results are doubtful/untrue on all dis
etween 10 km and 100 km. For example: 1th Warsaw Peace Mar
arszawa '79 was held on about 41,5 km - J. Pawlik and J. S
owski /both Poland/ set 2:11.34.

In 1986 year Henryk Paskal - Honorary Member of AIM
eceived one copy of the Jones Counter from his USA friend.

Soon we decided - based on the AIMS publications co
ing to a course measurement - to use the Jones Counter. Fi
easurement we made April 4,1987 in Dębno on the Polish Mar
hampionships course. This course - one loop about 14 km -
easured by the organizer before that day but we did not fi
ny differences. After next measurements we have settled th
he following marathons have been held on a short distances

1. Ślężan Marathon/Wrocław - about 41 km/previous co record 2:20.48/,
2. Victory Marathon/Biała Podlaska/Brest - about 42/ /previous course record 2:20.5

Many Polish organizers do not still understand that
easurement is very important problem this time.

We are very interested to measure more Polish/inter
courses and we want to become totally proficient as an AIMS
ertified measurers. So we worked with pleasure at the time
of preparation the first road measurement seminar in Warsaw
ay 1989 for the Eastern Europe. The report of John Disley
ery favourable for us.

After our experiences we found out that three facto
ost important on a way to make accurate measurement:

1. constant temperature,
2. efficient bicycle,
3. police protection

On our certification document we put: race name, location, distance, description of distance, method of measurement, signatures and signature of an organizing representative.

Most Polish marathons are held on a point-to-point courses but one of them/Olsztyn/ drops about 70 m from start to finish. The winner of 1989 year Adam Musiał/Poland/ broke his personal time frome 2:22.50 to 2:16.41. Now we are going to make certification measurement on this fast course - drop does not exceed 2 m/km but separation exceeds more than 90 %.

Now all organizers - who provide road races on 10 km, 15 km, 20 km, half-marathon, 25 km, 30 km, marathon and 100 km - must understand that road course measurement is very important, because there are too much doubtful results not only in Poland. It is difficult problem in our/my statistical work.

Białystok/Poland, August 21, 1989

Tadeusz Dziekoński

Białystok/Poland

Member of the Cross-Country and
Road Races Commission
and Statistical Commission of
the Polish Athletic Federation.

TADEUSZ DZIEKOŃSKI
ul. Chrobrego 4 m. 8
(skrytka pocztowa 14)
15-057 Białystok
POLAND

POLISH CERTIFIED ROAD COURSE LIST
/using the Jones counter method/

	distance	location	race name	date	measurer
1.	marathon	Dębno	Polish Championships	4.04.87	H. Paskal T. Dziekoński J. Jarosz
2.	marathon	Wrocław	Ślężan Marathon	16.04.88	H. Paskal T. Dziekoński
3.	100 km	Kalisz	Supermarathon "Calisia"	10.07.88	H. Paskal T. Dziekoński
4.	marathon	Toruń	Marathon Chełmno-Toruń	29.07.88	T. Dziekoński J. Jarosz
5.	10 km	Toruń	Between Bridges Race	29.07.88	T. Dziekoński J. Jarosz
6.	20 km	Brzeszcze	Polish Championships	9.08.88	H. Paskal T. Dziekoński
7.	marathon	Warszawa	Warsaw Peace Marathon	3.09.88	H. Paskal T. Dziekoński
8.	marathon	Biała Podl./Brest	Victory Marathon	7.05.89	T. Dziekoński J. Jarosz
9.	10 km	Ełk	Autum Race	14.05.89	T. Dziekoński
10.	20 km	Ełk	Mazury 20 km	14.05.89	T. Dziekoński
11.	half-marathon	Białystok	"Kurier Podlaski" Half-Marathon	17.06.89	T. Dziekoński

as of July 1,1989

Tadeusz Dziekoński

ENCL. NO 5

PZLA

POLSKI ZWIĄZEK LEKKIEJ ATLETYKI

Członek International Amateur Athletic Federation

00-372 WARSZAWA, UL. FOKSAL 19 • TELEGRAM »PEZLA« WARSZAWA

Telefony: Sekretariat 26-63-70, Działy – techniczny i szkolenia 26-73-78, zagraniczny 26-84-43, Telex 812416

Rok zał. 1919

Warszawa, dnia 15 maja 1989 r.

L. dz.

Konto bankowe:
IX O/M NBP Warszawa 1094-664-132

PROTOKOŁ ATESTU TRASY
(CERTIFICATION DOCUMENT)

Komisja Biegów Przełajowych i Ulicznych Polskiego Związku Lekkiej Atletyki przeprowadziła dnia 14 maja 1989 roku pomiar trasy biegu ulicznego:

1. **Nazwa imprezy:** (RACE NAME) Uliczny Bieg Jesieni
2. **Miejscowość:** (LOCATION) Ełk
3. **Dystans:** (DISTANCE) 10 km
4. **Opis trasy:** (DESCRIPTION) Bieg rozgrywany jest ulicami wokół stadionu 1000-lecia – po nawierzchni asfaltowej. Start usytuowany jest w odległości ok. 50 m przed zakrętem z ul. Sikorskiego do ul. 6-go Kwietnia, dalej ul. Moniuszki, Konopnickiej, Nowotki i Toruńską, z metą na wysokości bramy stadionu przy ul. 6-go Kwietnia. Na pełną długość trasy składa się: 7 okrążeń po 1.384,1 m plus 311,3 m.
5. **Metoda pomiaru:** (METHOD) Trasę zmierzono urządzeniem "The Jones counter" – wg regulaminu IAAF/AIMS.

Komisja w składzie:

1. Tadeusz Dziekoński/PZLA/ ....
2. Konrad Całkiewicz/org./ ....

POLSKI ZWIĄZEK LEKKIEJ ATLETYKI

DYREKTOR BIURA
Marcin ...

ENCL. NO 2

POLISH MARATHON CHAMPIONSHIPS