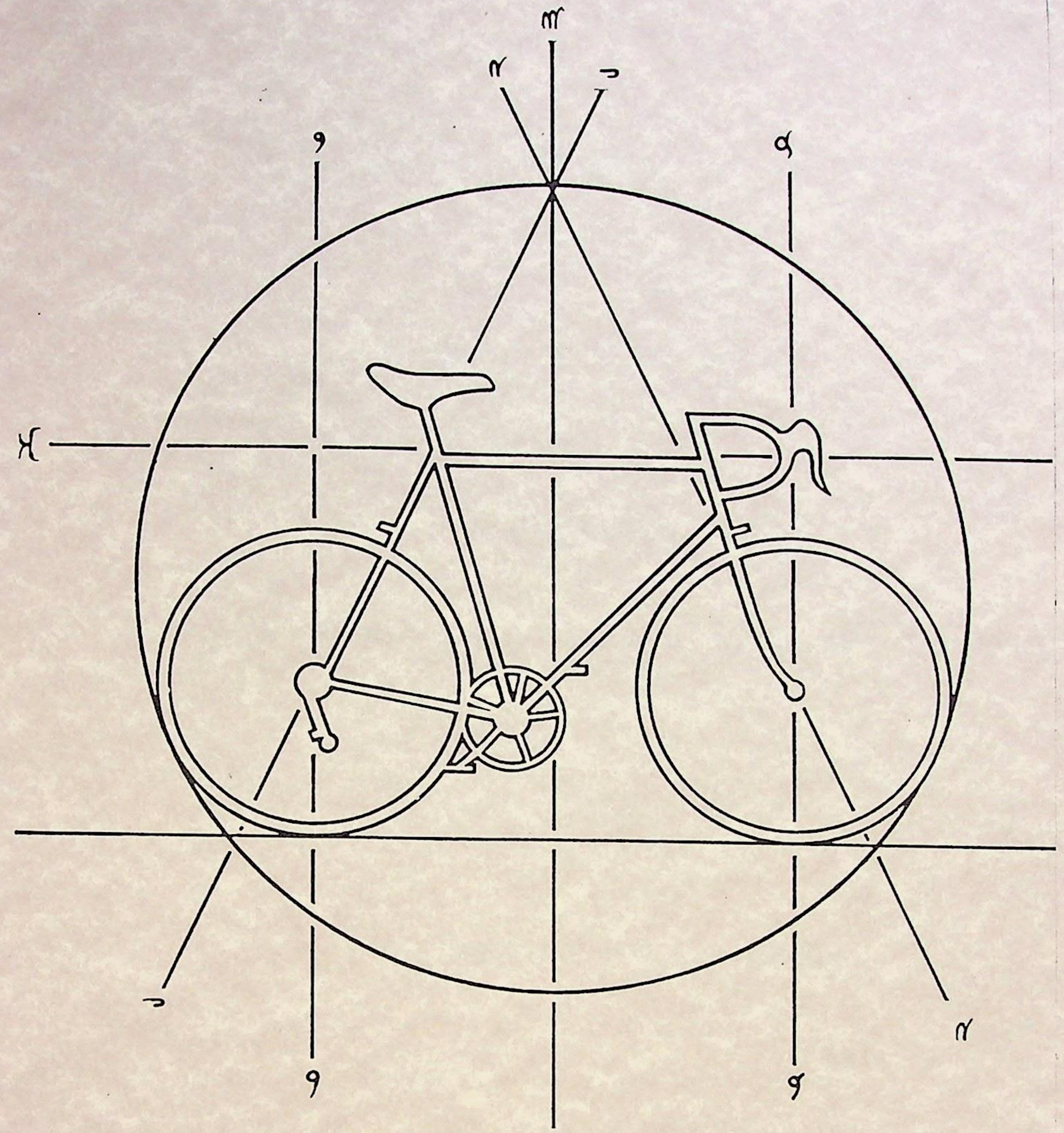


RACING BICYCLE DESIGN

THE NATIONAL COLLEGE OF ART AND DESIGN

"RACING BICYCLE DESIGN"

A thesis submitted to:

THE FACULTY OF HISTORY OF ART AND DESIGN AND COMPLEMENTARY STUDIES

and

IN CANDIDACY FOR THE DEGREE

by

NIALL O SULLIVAN

DEPARTMENT OF INDUSTRIAL DESIGN

FACULTY OF DESIGN

MARCH 1990

CONTENTS

CONTENTS ii

INTRODUCTION iii

CHAPTER 1
RACING BICYCLE HISTORY 1

CHAPTER 2
THE AESTHETICS OF THE
RACING BICYCLE 12

CHAPTER 3
HE BICYCLES OF
CYCLE SPORT 18

BIBLEOGRAPHY 28

LIST OF ILLUSTRATIONS

Fig 1	The Hobby Horse made by Monsieur De Sivrac	Page 1
Fig 2	The English Hobby Horse craze of 1819	Page 1
Fig 3	The Running Machine of Baron Von Drais	Page 2
Fig 4	Macmillian improved Hobby Horse	Page 2
Fig 5	Velocipede Racing	Page 3
Fig 6	The Velocipede made by Pierre and Ernest Michaux	Page 4
Fig 7	The Penny Farthing or Ordinary	Page 5
Fig 8	Penny Farthing Racing	Page 5
Fig 9	A Dwarf Ordinary, The Kangroo	Page 6
Fig 10	A rider with his 'Kangaroo'	Page 6
Fig 11	Dunlop with the first bike fitted with pneumatic tyres	Page 7
Fig 12	The first Humber Safety Bicycle	Page 9
Fig 13	The Modern Racing Frame and its parts	Page 9
Fig 14	Riders of the 1927 Tour De France	Page 10
Fig 15	Tour De France 1989	Page 10
Fig 16	The Elegant Modern Racing Bicycle	Page 11
Fig 17	Energy Efficiency Chart	Page 13
Fig 18	The important modern racing bicycle dimensions	Page 15
Fig 19	Cyclo-cross racing in the mud	Page 19
Fig 20	Riders after a cyclo-cross race	Page 19
Fig 21	Track Racing	Page 19
Fig 22	Mountain Bicycle Racing	Page 20
Fig 23	Tube Transfers	Page 21
Fig 24	A Butted Tube	Page 22
Fig 25	A Double Butted Tube	Page 22
Fig 26	Francesce Moser riding his Low Profile Bicycle	Page 23

LIST OF ILLUSTRATIONS CONT.

Fig 27 American Steve Hegg Page 25

Fig 28 The shape of things to come Page 25

Fig 29 The Glory of it all Page 27

INTRODUCTION

The racing bicycle has developed over the last two hundred years and has become the most efficient form of transport ever devised. A cyclist uses a quarter of the energy that a walker needs to cover the same distance. In motoring terms a cyclists energy expenditure is the equivalent of one thousand five hundred miles a gallon.

The racing bicycle is the pinnacle of ergonomic efficiency, a perfect fusion of mechanical refinement and human potential, a machine whose integrity of purpose is evident in its clean minimal lines. Its most remarkable feature is how little it has changed over the last century.

Its design rests on reconciling the demands of lightness and strength, giving the rider the minimum load to haul whilst coping with rigours of the road and torque that reaches up to three hundred and fifty pounds. The other demand is to reduce rolling resistance to a minimum. Air resistance is the principle opposition to a cyclist's momentum, this minimising has always preoccupied cycle engineers.

Today's machines use computer design technology to overcome the same problems faced by cycle pioneers a century ago, which expensive aerospace materials -alloys, graphic compounds, titanium, carbon fibre - achieve lightness and strength.

However, these technologies are going against the morals of sport. The performance of two men will soon, not be comparable because of these changing conditions. It is becoming a competition between machines. The most important component of any racing bikes should remain its rider.

CHAPTER 1: RACING BICYCLE HISTORY

INTRODUCTION

Bicycle racing is as old as the bike itself because man being the competitive animal he is has seized every opportunity to compete. This chapter traces the developments in bicycle design from its introduction in 1971 up until the present day.

The first 'bicycles' were, in effect, adult toys. The craze was initiated in 1791 by a Monsieur de Siurac, who put a second padded saddle on the hobby horse and started a fashion amongst rich young Parisians. They scooted and strided these cumbersome machines around the gardens of Palais Royal and raced them along the Champs Elysees. The machine, which he called a celerifere looked more like a child's rocking horse on wheels. Fig 1,2

Basically it was a pair of unsprung wheels connected by a heavy beam of wood or iron. The rider straddled uncomfortably across the beam and scooted along by pushing his feet alternately against the ground. Although quite fast, especially downhill, anything more than a walking pace only served to highlight its design defects which were simply that no provisions had been made for steering or stopping. There must have been some painful and spectacular accidents while racing on the champs Elysees as they weighed approximately fifty pounds. (Watson and Grey London 1987)

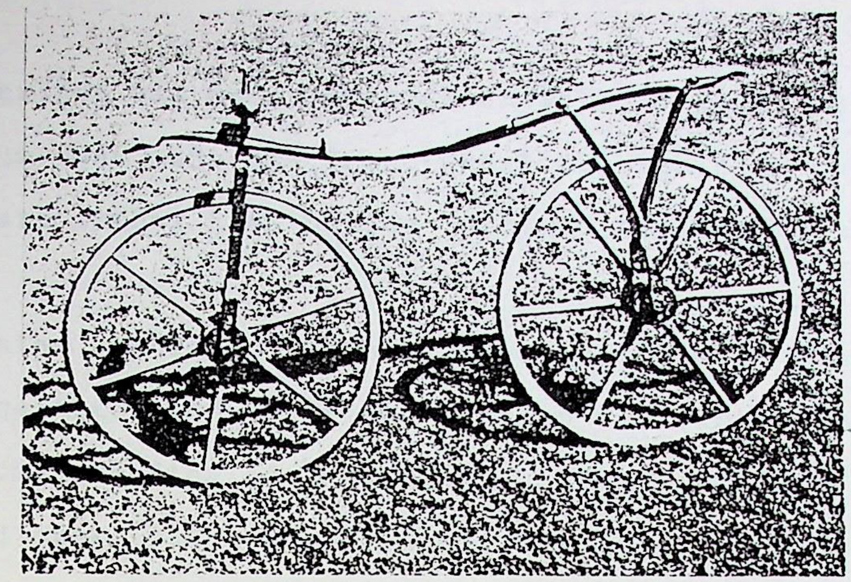


Fig 1 THE HOBBY HORSE MADE BY MONSIEUR DE SIVRAC

Fig 2 THE ENGLISH HOBBY HORSE CRAZE OF1819

The celerifee was much improved in 1817 by Baron von Drais de Sauerbrum, who made the front wheel steerable by the use of handlebars rather than having it fixed rigidly to the frame. Fig 3

His machine was fitted with an upholstered seat and a balancing board against which the rider pressed his elbows supposedly to assist the steering of the machine. There was also a cord-operated brake and a prop-stand, while the seat height could be adjusted. In time trials it proved itself four times fasted than the local post coaches.

In the early 1840's the evolution of the bicycle took a turn for the better when a Scottish blacksmith named Kirkpatrick Macmillian built a improved hobby horse. It was propelled by treadles which were attached to rods that turned cranks on a large rear wheel. This system worked but Macmillian passed up the chance of becoming the world's first bicycle manufacturer and development stagnated for another twenty years. (McGurn, James, London 87 p.23) Fig 4

It was Pierre and Ernest Michaux's Parisian firm that in 1860 gave the two wheeled machine a much needed boost by fitting cranks to the front axil and pedals to the cranks. This machine became better known as the 'boneshaker'. Although putting feet on pedals was a huge advance in design it also led to steering problems as it was difficult to steer and pedal the same wheel simultaneously. When the rim of the wheel came in contact with the riders inside leg it caused trouser wear and

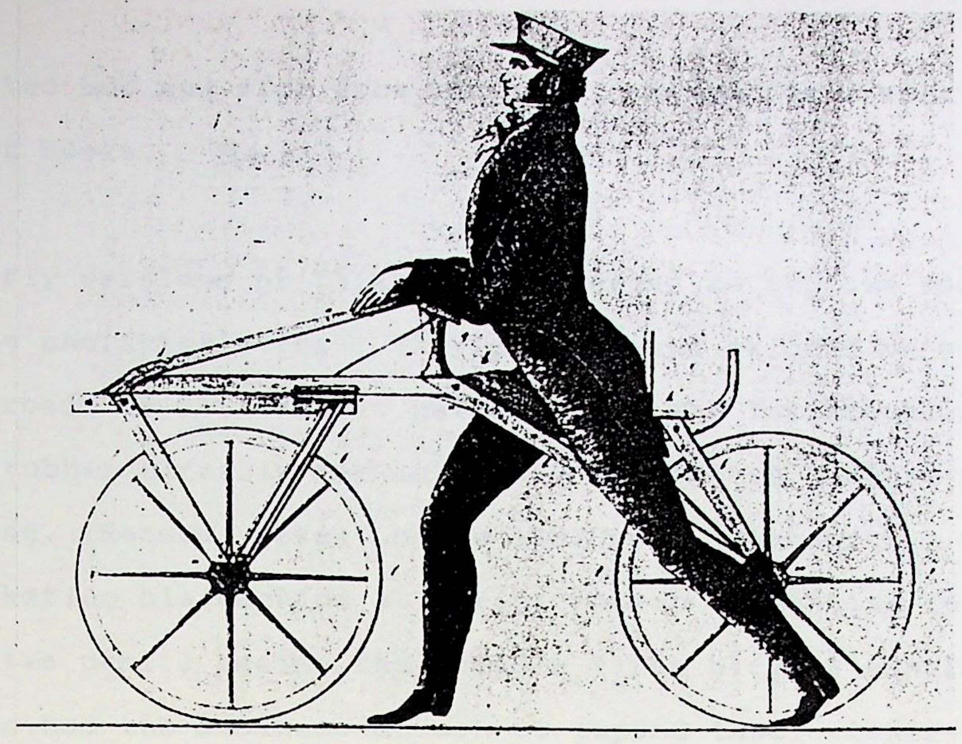
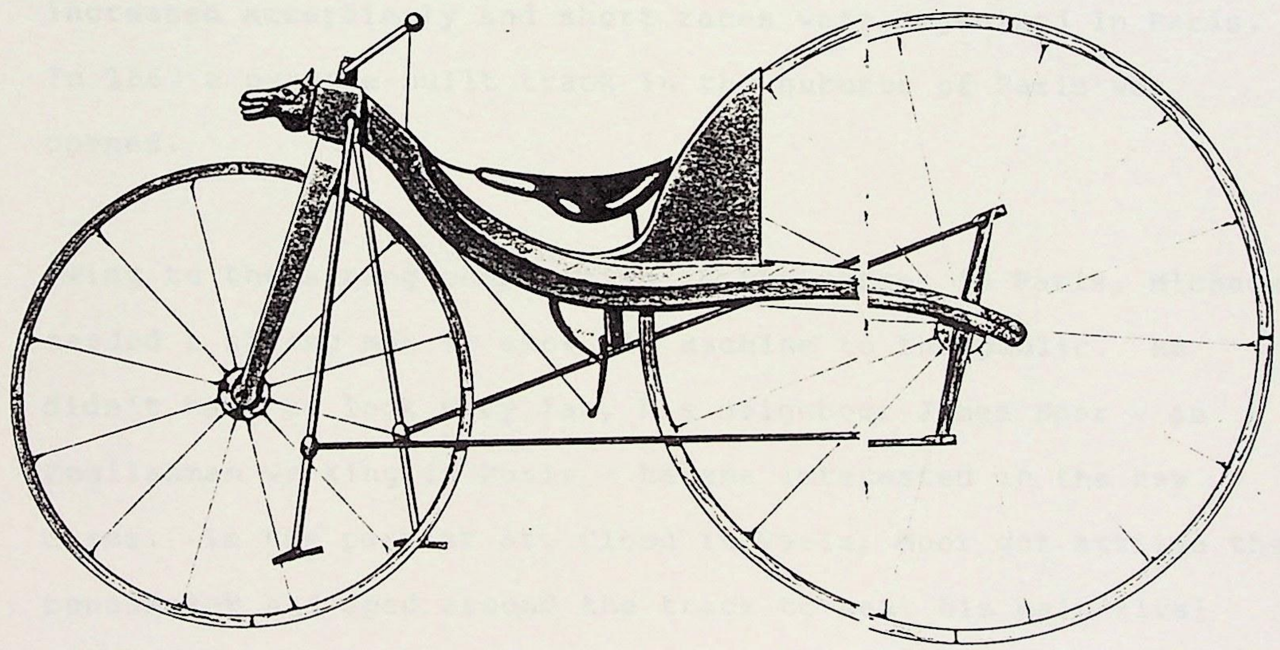


Fig 3 THE RUNNING MACHINE OF BARON VON DRAIS



30

Fig 4 MACMILLIAN IMPROVED HOBBY HORSE

deposited mud and dirt from the road. Some riders wearing high leather boots. Fig 5

The early versions of this machine failed to improve road-holding characteristics. They slipped and skidded on muddy earth roads as well as wet paved ones. The introduction of solid rubber tires in the late 1860's improved comfort and handling. (Robson, Peter London 1987 p) Michaux had the luck to marketing his machine at a ripe moment and having found a receptive public became the world's first bicycle manufacturer. He also had the business acumen to expand fast. Other companies were quickly established. Shortly there were around sixty other producers of the Boneshaker. Michaux built a new factory employing 300 men who completed five Boneshakers per day. As the popularity of the bike grew, production was increased accordingly and short races were organised in Paris. In 1867 a purpose-built track in the suburbs of Paris was opened.

Owing to the strong competition in the market in Paris, Michaux needed a strong man to show his machine to the public. He didn't have to look very far, his neighbour James Moor - an Englishman working in Paris - became interested in the new craze. In the park at St. Cloud in Paris, Moor got astride the boneshaker and sped around the track to beat his main rival Castra of France. This form of advertisement was very successful for Michaux and has always been at the heart of racing bike development. Manufacturers have always sought faster machines to gain advantage over their competitors.

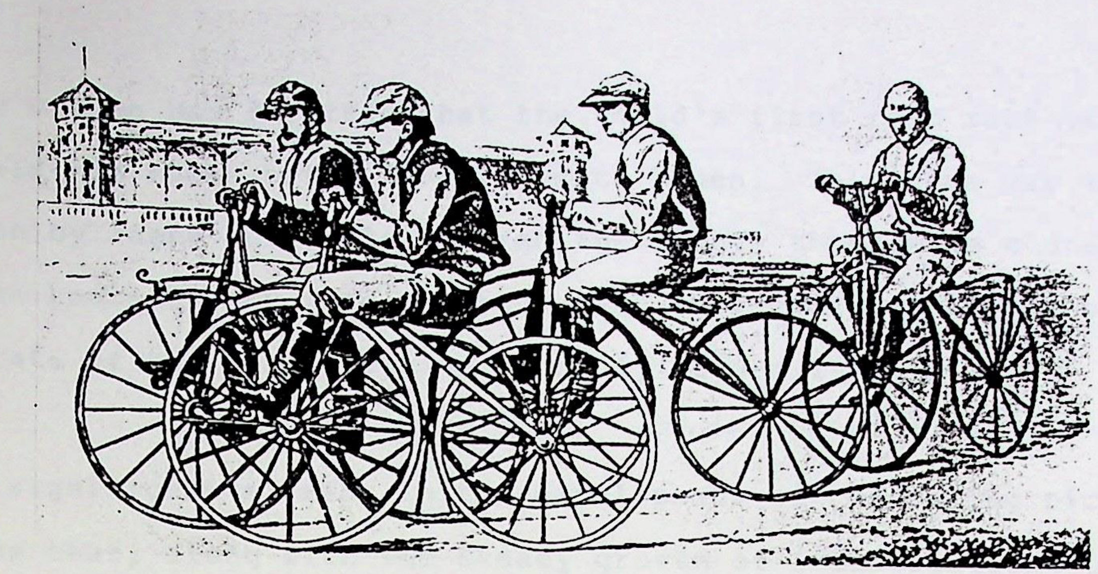


Fig 5 VELOCIPEDE RACING

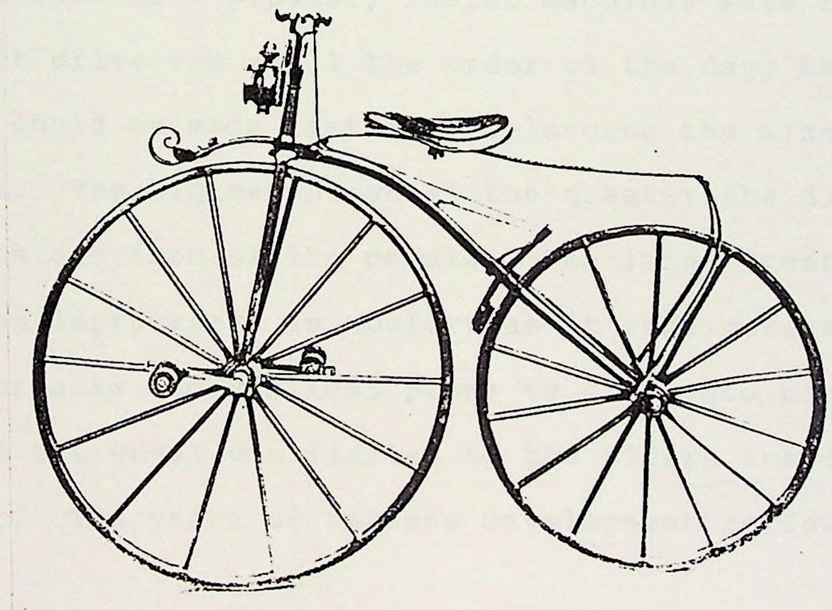


Fig 6 THE VELOCIPEDE MADE BY POERRE AND ERNEST MICHAUX. IT WAS RIDDEN BY JAMES MOORE, WHO WON THE FIRST EVER ROAD RACE.

It was on May 31, 1868 that the world's first road race was held the route being from Paris to Rouen. This race was also won by James Moor, who covered the eighty three mile course in ten hours twenty five minutes, very fast considering the poor state of the roads (Cyclist Monthly London 1984).

A significant element in the development of the racing bicycle was that, along with the steady growth of industrialization, the last century also witnessed the gradual shift from amateurism in the science towards professionalism and specialization. Mechanical institutes were founded, which published periodicals discussing new materials and manufacturing processes. All of this aided the development of the bicycle.

As racing became more popular, faster machines were required. Since direct drive was still the order of the day, the Boneshaker could be made faster by enlarging the size of the front wheel. The bigger the wheel the greater the distance covered with one turn of the pedals. The large front wheel also gave an improvement in comfort as it rode more easily over bad road surfaces and was less prone to drop into potholes, but the size of the wheel was limited by the riders inside by measurement. Ten years of intense development followed.

One of the biggest break through was the ball bearing. It was introduced in 1869 by Jules Suriray, Superint-entent of Prisoners Workshops. The balls , finely polished by Suriray's captive workforce, were used in the wheels of a number of top racing machines in 1869. Instead of the stiff wooden radical spokes. It was in 1874 that James Starley invented a wheel with tangential wire spokes, another leap forward in the evolution of the racing bicycle. Shortly afterwards, Starley perfected and patented the cross-braced dished spouked wheel. This system has remained unchanged to this day. It was rightly considered a marvel of modern science on its introduction, capable of bearing loads and absorbing stresses out of all proportion to it's apparent flimsiness (Robson, Peter London 1985).

Ironically, the technical innovations produced by the cycling boom of the 19th century were the pave the way for the eclipse of the bike, as master of the roads, by the car and motorcycle. Early aeronautics also owed a profound debt to cycling's mastery of tubing and tension - a debt aerospace engineering has recently repaid with carbon and graphite materials.

By the mid-1870's the Ordinary, later to be called the Penny Earthing, had superseded the 'Boneshaker'. Ball bearings and dished spoked wheels became common. The size of the front wheel of an Ordinary which tended to be between four and five feet in diameter, could also be limited by the riders courage for the saddle was situated on the top of the wheel and the taller the wheel the further one fell. Falls wee frequent, for these machines were quite dangerous. Fig 7,8

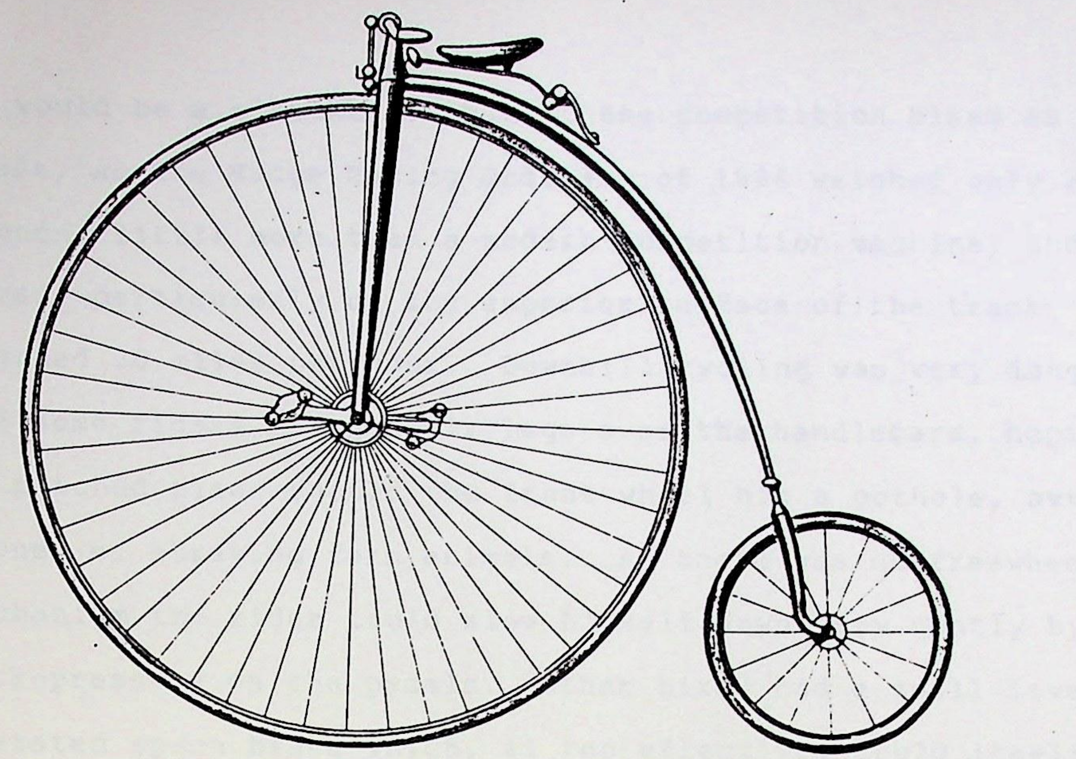


Fig 7 THE PENNYFARTHING OR ORDINARY

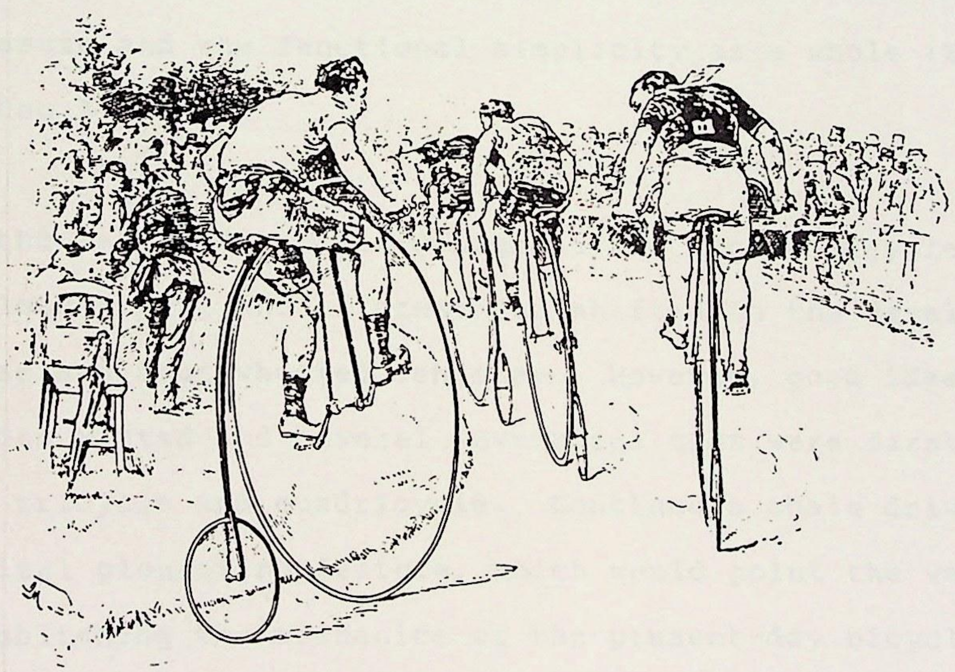


Fig 8 PENNY FARTHING RACING

It would be a mistake to think these competition bikes as crude, as the Rudge Racing Ordinary of 1884 weighed only 21 1/2 pounds, little more than a modern competition machine, and speed, particularly on the superior surface of the track reached 30 miles per hour. Downhill cycling was very dangerous and some riders slung their legs over the handlebars, hoping to be pitched clear should the front wheel hit a pothole, awkward stones or straying farm animals. As there was no freewheel mechanism the rider could slow himself down very gently by back-pressure on the pedals. Other bikes had a small lever-operated spoon brake which, if too effective, could itself cause the rider to be thrown over the handlebars. Even misjudging back-pedalling could send a man over the top. On the other hand, riders could claim a strong sense of intimacy with their machines thanks to the proximity of the front wheel, the control of the wheel through back as well as forward pressure and the functional simplicity as a whole (Evans, K London 1979).

By the late 1870's, the design of the racing bicycle was more-or-less static and interest had shifted to the development of three and four wheeled vehicles. However, good ideas are seldom wasted and several inventions that were first used on the tricycle and quadricycle. Continuous chain drive was also a vital pioneering feature, which would point the way to establishing the mechanics of the present-day bicycle.

Variations of the Ordinary appeared around 1884. These models had mildly apologetic names like the 'Bantam' and the

'Kangaroo'. They used a geared-up wheel which enabled the size of the front wheel to be rescued. Many racing cyclists refused to believe that these squat and graceless machines could be faster than their own magestic high bicycles. The bicycle companies employed racing cyclist to break records on the new machines and gradually the contempt changed to interest and eventually to enthusiasm. Fig 9,10

The Dwarf Ordinary enjoyed a few years of success before being superseded by a new generation of bicycles with chain-driven rear wheels. Subsequently, the rear wheel was enlarged to cover a greater distance with each revolution, this enabling the front wheel to become smaller. The overall effect was a much lower, safer bicycle. The time had come for the bizarre tall-wheeler to give way to a more rational type of machine which would bring about the last and greatest cycling boom. The new type of machine was known as the 'Safety'; the very name implying a criticism of the 'Ordinary' as it was self-evidently much safer to ride. (Landoni, Edizioni Italy 1983)

One other vital improvement still had to be made, namely the pneumatic tyre. It had in fact been invented and patented in 1845 by Robert Johnson, a Scottish engineer. Had he thought of it a few years later, his name instead of Dunlop's might have become a household word, (today).

However, it was John Boyd Dunlop, a Dublin veterinary surgeon who re-invented the pneumatic tyre in 1887. He fitted the first new tyre to his son's bicycle, who had the honour of Fig 11

Fig 11 DUNLOP WITH THE FIRST BIKE FITTED WITH PNEUMATIC TYRES

testing the prototype. Dunlop was granted a patent for an inflatable inner tube and a separate outer cover which had to be glued or taped on to the rim. The rather sausage like tyres were at first ridiculed by the racing cyclist, until they quickly proved their superiority over the narrow section solid.

Within two years William Harvey du Cros had founded the pneumatic tyre company to produce Dunlop's idea. Like the cycle manufacturer's, de Cros saw the value of publicity through sport, and his company fielded a racing team on Safeties fitted with pneumatic tyres. So successful were these machines against the racing Ordinaries of the day that the founder's son Arthur, the champion of Ireland, was once banned from competition in England. Pneumatic tyres were fitted to some high wheelers too, but the problems were literally enormous. Within the next few years this firm had bought patents for rims, valves, fixing, and most important, bought the patent for detachable tyres.

Robert Johnson, who had invented the tyre, took Dunlop to court. A long-drawn out court case ensued before Dunlop's firm finally triumphed. (Cycling Monthly, London 1983) Fifteen years of searching for the ideal safety bicycle frame format followed. Many versions were produced, the two largest companies being Humber and Rove - later to become prominent car manufacturers.

In 1890, Humber introduced the first diamond shaped frame. This meant it had four main sets of tubes forming a diamond shape. Fig 12

The diamond was strengthened by a tube from the saddle to the bottom bracket. This was originally curved but later straightened. This frame seems to have finally convinced most of the industry that the straight tubed diamond layout was the most functional, aesthetic and commercial compromise available and that there would be little profit in carrying on a search for an alternative. Fig 13

Consequently, the most remarkable feature of cycle design over the last century is in fact how little it had changed. The diamond frame and its chain driven rear wheel locked into fundamental laws of human ergonomics which have proved difficult to defy, even for the computer-equipped engineers of today. Certainly, the machines used during the first Tour de France riden in 1903 were in essence little different from their modern counterparts, how ever refined their accessories have become.

In the early days of the Tour de France riders had to tend to their own punctures and straighten their own bent frames -

Fig 12 THE FIRST HUMBER SAFETY BICYCLE.

without any of the supporting teams of mechanics that attend today's stars. Riders were not allowed to replace parts until 1923 and quick release wheels did not arrive until the 1950's. (Winning Belgium 1985 p 39)

The rigours of the race and the varying demands of mountainous climbs and fast descents have always been a challenge to cycle engineers as well as riders. The racing bikes needed to be relentless climbs with brakes able to pull up a bike plummenting down an Alpine valley at 60 miles per hour.

Gearing of a bike is still one of the major sources of doctrinal dispute amongst technically-minded cyclists. The speed and precision of the shift, the range of gearing are the main points of dispute. Today riders can use any of a dozen gears to maintain their speed and rhythm. The derailleur gear, which shifts the chain between different size sprouckets at the back and different chain wheels at the front, was invented in 1899 and remains unchallenged despite its idiosyncrasies. Amazingly, its use was outlawed up until the early thirties. Instead, riders had different sized sprockets on each side of back wheel. When they came to a climb they dismounted, turned the back wheel around the other way, and carried on in a lower gear.

The early tours were in truth the stuff of legend's, Eugene Christopher (the first man to wear the coveted yellow jersey of the Tour leader on its introduction in 1919) once carried his bike down a mountain after he had broken his forks and crashed,

fig 14 RIDERS OF THE1927 TOUR DE FRANCE WITH SPARE TYRES ON THEIR SHOULDERS THE POCKETS OF THEIR JERSIES LADEN WITH TOOLS

Fig 15 | TOUR DE FRANCE 1989

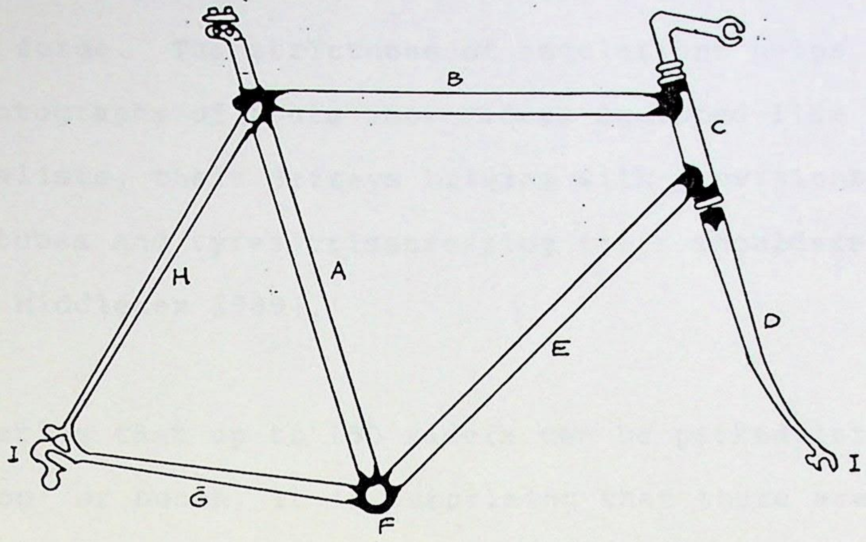


Fig 13 THE MODERN RACING FRAME AND ITS PARTS

A. SEAT TUBE (THE LENGTH OF THIS GIVES THE SIZE OF THE FRAME)
B. TOP TUBE OR CROSS BAR
C. HEAD TUBE
D. FORKS
E. DOWN TUBE
F. BOTTOM BRACKET
G. CHAIN STAYS
H. SEAT STAYS
I. FRONT AND REAR DROP-OUT

and welded his bike back together himself at the local smiths. He was later penalised for allowing a boy to pump the bellows of the forge. The strictness of regulations helps explain why old photographs of tours show riders equipped like survivalists, their jerseys bulging with provisions, tools, spare tubes and tyres crisscrossing their shoulders (Bicycle Action Middlesex 1989).

Considering that up to 150 riders can be packed into the 'peloton' or bunch, it is surprising that there are not more crashes. Novices are told not to touch the brakes for fear of causing an accident. Tactics in road racing consist of either sheltering in the bunch or attacking (alone or in a team) to steal a march on the pack. Timing sprints and attacks from the slipstreams of other riders, being in the right gear, speedy grabbing at the feeding stations and pacing oneself over hours, days or even weeks in the stage races are all crucial elements.

The modern era of road racing has thrown up some notable heroes - Italy's Fausto Copp, in the fifties, France's Jaques Anquetil in the sixties, Stephen Roache and Sean Kelly in the eighties, all men who could pound the pedals over the greasy cobbles of the low lands and dance up thousand foot climbs.

Fig 16 THE ELEGANT MODERN RACING BICYCLE

CHAPTER 2: THE AESTHETICS OF THE RACING BICYCLE

INTRODUCTION

This chapter discusses the aesthetics of the bike and how it is a product truer to it's function than other products. It also investigates the dimensions of the racing bicycle and how they are dictated by the shape of the human body.

To most people the bicycle doesn't hold the greatest of aesthetic qualities. But in my eyes and in the eyes of the engineer, the philosopher and the athlete it is seen as a beautiful object or a 'type object'. 'Type objects' are objects that once established and perfected, have long periods of use. No essential improvement in the safety pin has been made since the bronze age. In weaving, there has been no essential modification of the loom for over a century. When the form of a type object has been achieved, the sooner the machine retreats into the background and becomes a discretely silent fixture the better.

Having worked in a number of industrial design companies, I have been involved in re-designing well established products. When completed, they have undergone no essential change, but look as if they have. Extraordinary ingenuity is exercised by publicity directors and designers to hasten style obsolence, fake varieties are introduced in departments where it is irrelevant, not in the interest of order, efficiency or technical perfection but in the interest of profit and prestige; two very secondary and usually sordid human motives. Instead of lengthening the life of the product and lowering the cost to the consumer, products are designed in order to raise the cost to the product and causing him to be conscious of mere stylistic tricks that are without any human significance or value. This practice saps the vitality of art.

The racing bike is indeed an art form, simplicity and elegance of line always being at the heart of a well-designed bike. The diamond frame has a purity of purpose, which locked into the fundamental laws of human ergonomics, have proved hard to defy, even for the computer-equipped engineers of today. It's basic shape is virtually unchanged since it evolved a century age. (Arena, London 1989)

If we take the racing bicycle as a tool, then it is an efficient one. If we compare the mechanical efficiency of a man walking and a man cycling, it is found that the cyclist needs only one quarter of the walker's expenditure of energy to travel four times faster. This improves on nature, thus making the cyclist the most efficient of all moving animals and machines. (Evans, K. London 1989 p.) Fig 17

A well set up machine becomes an extension of the riders limbs and his physical potential. On a good day and feeling strong a riders stiff, yet responsive frame feels like an inseparable part of his legs and shoulders as he powers along the road. His back is at the right angle for delivering power through the whole length of the thigh, using only the strongest muscles and also holds the rib-cage in a relaxed position for full, deep breathing. The toe-clips on pedals bind his feet tightly to the cranks, making him feel part of his machine. There is not one ounce of power lost as his legs pull upwards and thrust downwards in a smooth rotary motion. With every turn of the pedals he feels the balance between mechanical efficiency and human potential. To overcome air resistance requires most of the riders work but the airflow carries away the heat generated by the rider's efforts. This natural cooling effect is vitally important. Without this cooling effect the ride would overheat and 'blow up' after ten minutes. Yet on the open road, fast time trialist can keep the same pace for up to four hours.

Simple and elegant lines have always characterised the well-designed racing bicycle. These lines are dictated by the fundamental laws of ergonomics, and different frame dimensions are required to enable all riders, whatever their physique, to achieve maximum power. So let us look at frame dimensions in relation to the riders body.

FRAME SIZE:

In general the size of a frame is the length of the seat tube (Diagram 8 Dimension A). Standard frame measurements usually range fro+m 18 - 23 1/2 inches and occasionally larger. The correct frame size is found by measuring the inside leg from crotch - bone tot floor and subtracting nine inches.

SADDLE HEIGHT:

The most important measurement is the height of the saddle. this is achieved by the rider placing his heel on the pedal with the crank in line with the seat tube. The saddle is then adjusted so that the leg is straight while sitting on the saddle.

FRAME ANGLE:

The frame angle refers to the angle between the cross bar and the seat tube and the angle between the cross bar and the head tube (see diagram 5). Both of these angles are critical because they determine the characteristics of a bicycle in terms of steering, handling and comfort. To calculate the exact angle for a particular rider is complicated. The aim of the formuli used is to achieve a 45% front, 55% rear weight distribution. A short - thighed rider needs a steep seat angle to place him nearer to the handlebars and a tall rider with long thighs needs a shallow angle to place him further to the

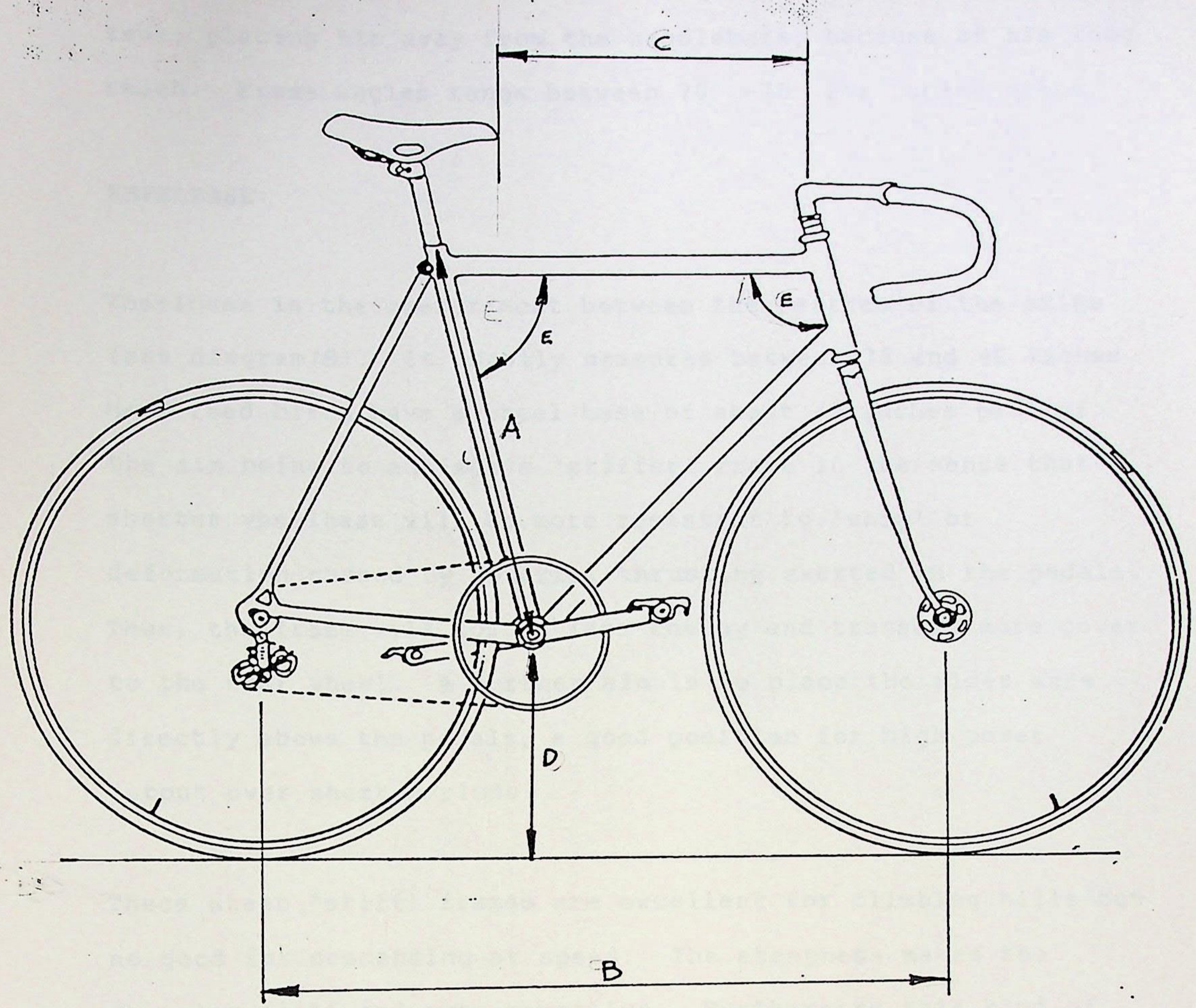


Fig 18 THE IMPORTANT MODERN RACING BICYCLE DIMENSIONS

A. SEAT TUBE LENGTH

B. WHEELBASE

C. HANDLEBAR REACH

D. BOTTOM BRACKET HEIGHT

E. FRAME ANGLE:

rear, placing him away from the handlebars, because of his long reach. Frame angles range between 70 -75 for racing bikes.

WHEELBASE:

Wheelbase is the measurement between the centres of the axles (see diagram 18). It usually measures between 38 and 46 inches. Most road bikes have a wheel base of about 40 inches part of the aim being to achieve a 'stiffer' frame in the sense that a shorter wheelbase will be more resistant to 'whip' or deformation caused by powerful thrusting exerted on the pedals. Thus, the frame will absorb less energy and transmit more power to the rear wheel. A further aim is to place the rider more directly above the pedals, a good position for high power output over short periods.

These steep 'stiff' frames are excellent for climbing hills but no good for descending at speed. The steepness makes the steering light and over sensitive. Furthermore this kind of frame transmits road shock to the rider, for more than the longer shallower frame. A harsh and bumpy ride can also be experienced which can be extremely tiring.

BOTTOM BRACKET HEIGHT:

This is the height from the centre of the bottom bracket axil to the ground (see diagram 18). It usually varies between 10 and 11 inches. A high distance is more desirable on racing bicycles as it enables the rider to pedal around corners without the pedal digging into the road.

REACH TO HANDLEBARS:

To calculate the correct distance between the saddle and the handlebars, the rider places his elbow against the nose of the saddle, thus his fingertip should reach the centre bolt on the handlebar stem (see diagram 18). This dimension is adjustable by sliding the saddle back or forward the required amount.

The above dimensions demonstrate that the dimensions of the racing bicycle are dictated by the human body. It is a perfect solution to a complex problem.

Many designers of today believe that the form of a product should follow its function while others say the function should follow the products form. But, the racing bicycle is an outstanding design where form and function have coalesced during its evolution to create a masterpiece of modern design.

CHAPTER 3: THE BICYCLES OF CYCLE SPORT

INTRODUCTION

Road racing is the most popular of all the cycle sport activities. It is the ultimate in excitement and variety, the king of sports. However, there are other cycle sports which are now gaining popularity. This chapter looks at these alternative cycle sports and the technology used in their construction. It also looks at present day materials which are used. The future of the racing bicycle design is also discussed.

Cyclo-cross is a specialised winter sport carried out, usually on circuits of about two miles a lap. The circuit takes riders over hilly fields and country roads. the going can vary from fast riding on grass slopes and tarmac to exhausting slog. Fig 19
Usually the rider is unable to cycle the complete circuit and has to carry the bicycle on his shoulder over mud, streams ditches logs and specially constructed hurdles. In effect it is cross-country running with the aid of a bicycle. There are both professional and amateur categories in cyclo-cross.

The bikes used have a long wheelbase, a lower saddle, lower gears and shallower frame angles than a road bicycle because of the rough terrain which has to be encountered. Special knobbly tyres are used to give grip on the muddy ground and they throw up alot of mud and dirt. Thus the rider gets exceptionally dirty and the brakes get clogged up frequently. Some riders

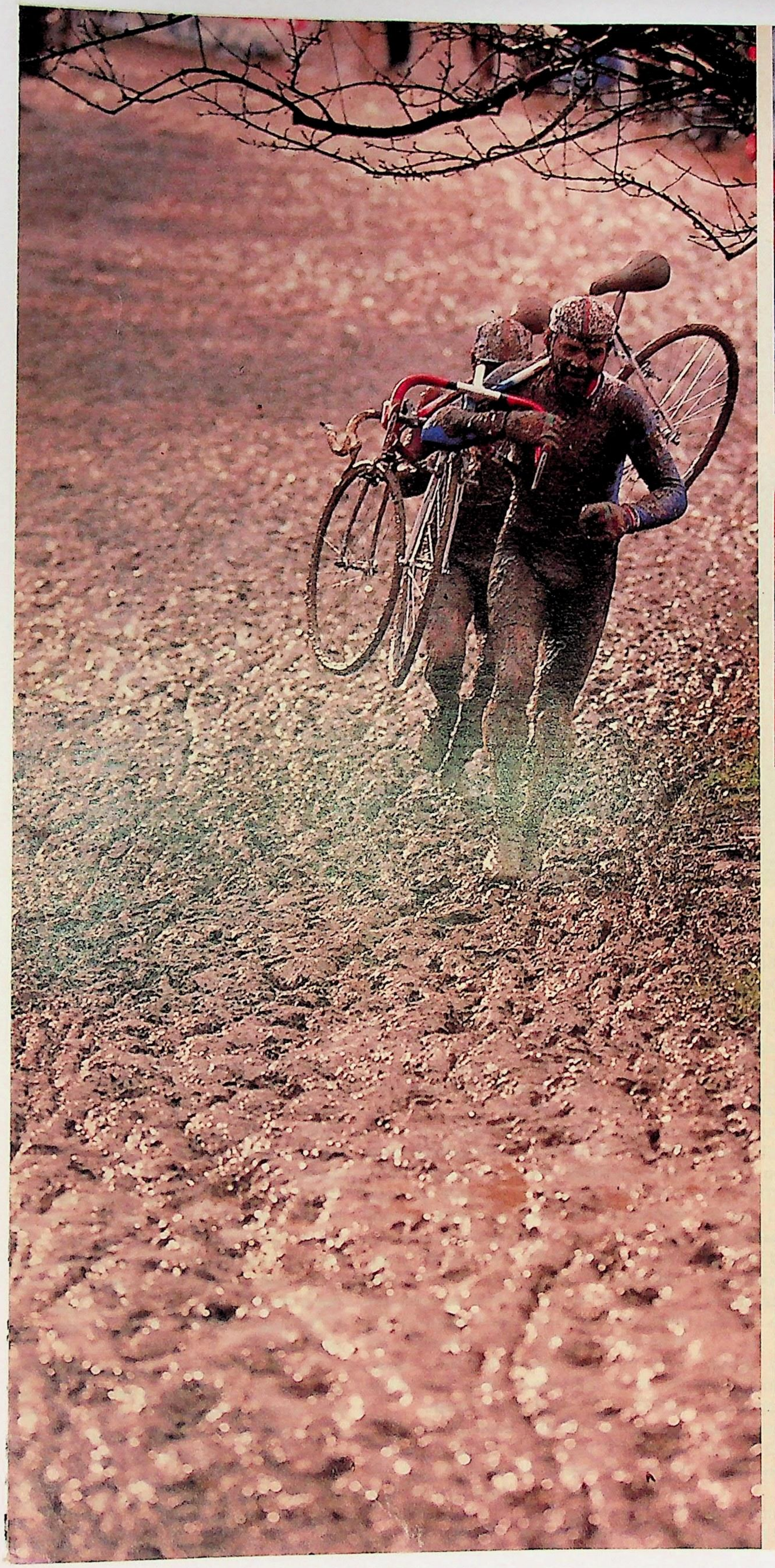


Fig 19 CYCLO_CROSS RACING IN THE MUD

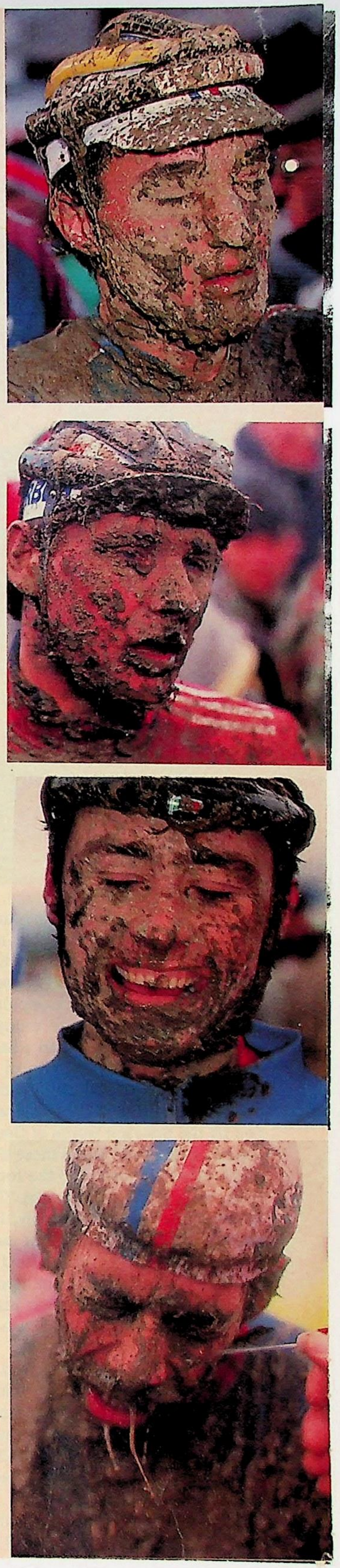


Fig 20 RIDERS AFTER A CYCLO-CROSS RACE

change bikes every lap so that helpers can wash the mud off and clear the brakes and gears. It is a hard and exhausting sport demanding the ultimate in cyclist, bike-handling and stamina.

Track racing is one of the oldest and most specialized sports. Tracks vary from open air circuits on concrete to steeply banked hardwood indoor velodrome. Track bikes are built extra rigid to cope with the sudden out-of-the saddle acceleration. The bike has no gear change mechanism, and are fitted with the same size rear sprockets. Therefore all riders compete on the same gear. Fig 21

Brakes are not fitted because they are of little use on track bikes. When a rider starts he accelerates to his maximum velocity and will keep that speed till he reaches the finish line. There are no obstacles or blind bends, where he would need brakes to stop. When he crosses the line he will roll around the track until the bike stops. Having no gears or brakes, lightens the bicycle considerably and enables the rider to achieve his maximum potential as he races around the track. Owing to its lack of components, it is the simplest and purest speed machine.

During a track meeting a variety of races are held. Riders are individually timed for a certain distance, usually 1 km, 5km or 10km. Obviously the rider with the fastest time wins. Two riders start at opposite ends of the track, the aim being to catch the other rider. The sprint event consist of two riders racing for 3 laps of the track. Many heats are run, and the

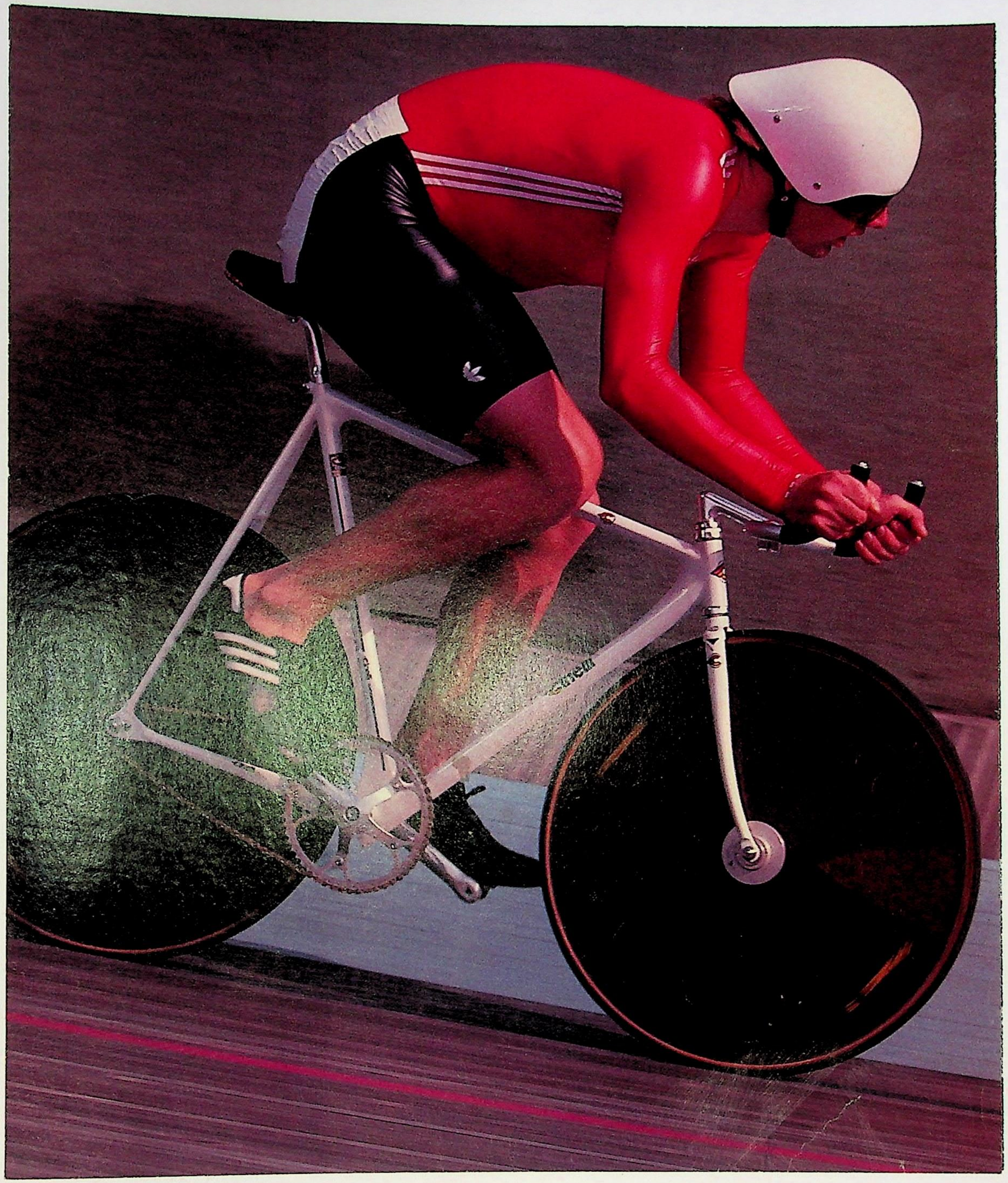


Fig 21 TRACK RACING

two strongest contest the final. Other races consist of 10 teams of 2 riders racing for 50 laps of the track. The winner being the first rider to cross the finish line.

There is another event where the riders are paced by specially designed motor bikes, so as to achieve high speeds. Usually 8 riders roar around the track at 40 mph, for 50 laps of the track. The pacers pull out with a few laps to go and then the riders sprint to the finish. The variety of events supply the audience with a thrilling show.

Mountain bike racing was introduced in 1984, it is similar in many ways to cyclo-cross. The only difference being that mountain bike racing is held on more rugged terrain. The coarses are designed so as the rider will not have toe carry his bike, unlike cyclo-cross where the rider has to carry his bike over ditches, streams and obstacles. Mountain bikes are rugged but light machines with appropriately fat tyres, fifteen or more gears, powerful cantilever brakes, oversize tubing and wide handlebars. Cheaper mountain bikes are increasingly used as commuter vehicles able to cope with urban potholes and kerbs. The sport is very popular in America and is developing slowly in Europe. Fig 22

All the above mentioned bicycles are designed for very different situations:- the smooth hardwood boards of the track to the rugged mountain terrain. However the fundamental diamond frame is the common element in their design. This

Fig 22 MOUNTAIN BICYCLE RACING

basic form has proven hard to defy since its introduction one hundred years ago.

While the shape of the frame has changes very little as the 20th century progressed, its materials did. Companies such as Reynolds of Britian and Columbus of Italy produced stronger frame tubing with which thinner gauges could be used. These were materials developed for second world war aircraft. Research done during the war also helped hasten the development of aluminium alloys, so that bicycle components such as chain wheels, wheel rims, hubs, pedals and handlebars could forsake the weight of steel for the lightness and often similar strength of appropriate alloys.

The majority of racing frames are made from steel alloys. The makers of the tubing supply a special transfer to the frame builders, toe place on the bike when it is completed. It is a guarantee to the consumer that the bike is made of the specified material. This transfer is usually placed on the top of the seat tube. The tube companies take great pride in their product and the coveted transfer cannot be bought over the counter. People have been known to snip pictures of them out of advertisements and paste these little paper squares to their cheap frames. There was even a forged transfer created for a joke in America, which on close inspection read "Guaranteed not built by Reynolds 531 tubing". Fig 23

The Italians frame make all use Columbus tubing but Reynolds 531 and 753 tubing is the more frequently used tubing

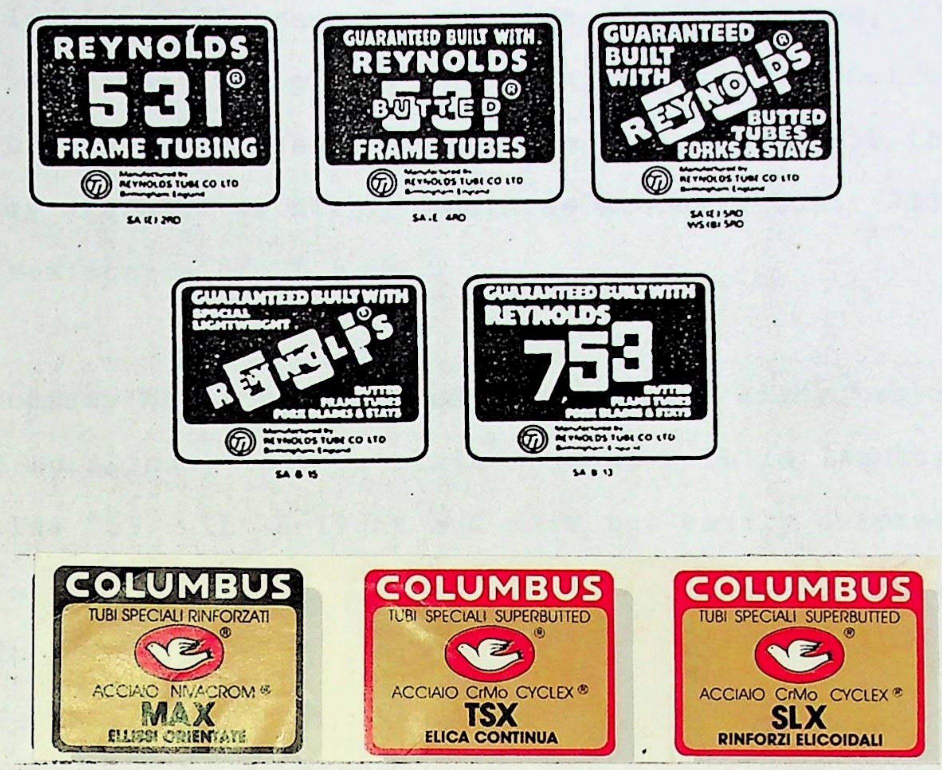


Fig 23 TUBE TRANSFERS

elsewhere. There is very little difference between the weight of the various makers. For example a frame made from Columbus tubing will weigh 2375 grams, a Reynolds 531 2445 grams, Reynolds 753 weighs 2000 grams, which is the more expensive. The walls of its tubes are an incredible 0.3 millimeters thick and yet they are half as strong again as standard 531. 753 has a tensili resistance of 75 tons.

A French company have now produced an aluminium alloy tubing called 979 Duralinox, that is claimed to be a third lighter than Reynolds 753. It is light and fast but easily deformed in a crash - a racing cyclist can expect to crash, on average, three to four times a year at speeds up to sixty miles per hour (Robson, Peter London 1985 p1)

All the tubing manufacturers produce 'Butted' and 'Double Butted' tubing. Butted means that the tubing is internally thickened at one end where the strength is needed. Double butted means that it is thicker at both ends. Plain gauge tubing is the same thickness all the way along. Although correspondingly heavier, a plain gauge is cheaper to produce than the butted tubing. Fig 24,25

Titanium is a material that has been in limited use for a number of years but has never really caught on due to its shattering price. At the London cycle show in 1956 Phillips showed a titanium frame weighing an incredible 2 1/2 pounds which is half the weight of a contemporary frame, it was never marketed. The Speedwell company of Birmingham produced 10,000

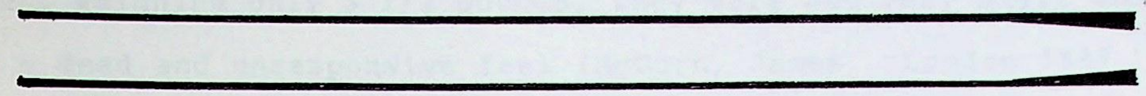


Fig 24 A BUTTED TUBE

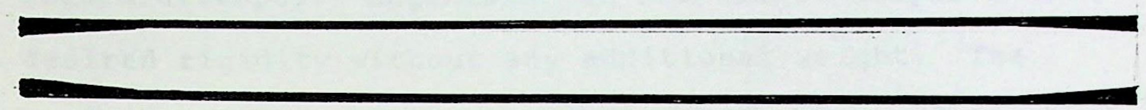


Fig 25 A DOUBLE BUTTED TUBE

frames with titanium tubing in 1973 and although they were light, weighing only 3 1/2 pounds, they were not very stiff and had a dead and unresponsive feel (McGurn, James London 1987 p.127).

Materials from aerospace engineering are now being introduced. Carbon fibre and graphite have been used on special machines for record attempts. Engineers can now create bicycles with the desired rigidity without any additional weight. The materials are exceptionally expensive and are out of reach of the average racing enthusiast.

The properties of these new material allowed a slight change in the geometry of the frame. These new bikes were called 'funny bikes' or 'low profile' and were first introduced in 1986 for the world hour record attempt by Francesco Moser. His bike had a curious frame geometry, the top tube sloped downwards to the head tube. This enabled the handlebars to be shortened thus reducing weight. The seat tube was curved to allow the rear wheel stays to be shortened, giving an extremely short wheel base. Fig 26

The theory behind the use of disk wheels is based on the fact that at 30 mph, the air resistance created is divided into two-thirds by the rider and one-third by the machine. If one considers the relative narrower and smoother surface of the bicycle then it takes an enormous amount of energy to overcome the air resistance acting on the bike alone. This is caused essentially by the phenomenon of the wheel rims cycloidal

Fig 26 FRANCESCO MOSER RIDING HIS LOW PROFILE BICYCLE WHICH HE USED FOR HIS HOUR RECORD.

movement and the subsequent turbulence. It also takes alot of energy to propel the spokes as they chop through the air. The sleek disk wheel cuts through the air creating minimum turbulence. This was an enormous advantage to Moser in his quest for the world hour record.

The record had been previously set in 1972 by one of the greatest cyclist of all times, Eddy Merckx, who rode a normal track bike. It is estimated that Merchx expended 90 watts of power more than Moser during his hour record attempt and had Merckx rode Mosers bike he would have covered 52km in the hour compared to Mosers 51.151 (Winning Belgium 1988 p. 56).

In the lead up to the 1984 Los Angelos Olympics the Americans invested millions of dollars in their cycling teams preparation, which included the design and manufacture of a new generation of track bikes. They were similar in many respects to Mosers special bike, unusual frame geometry, with sloping top tube disk wheels and the stubby handlebars. The new features were unequal sized wheels and 'tear drop' helmets, all assisting to reduce air resistance. The overall impression was of machines carved for some futuristic Flash Gordon landscape. The American bikes were symbolic of a new US determination in cycling and attracted almost as much attention as the riders themselves. A German critic of the NASA - aided US cycle team wondered whether the next scientific improvement might involve a technology which would produce riders with more aerodynamic bodies.

The US Olympic team duly tore up the field gaining nine medals - they had not won a cycling medal since 1912. Later it would emerge that their preparation had been a little too thorough their technology extended to the illicit practice of 'blood doping' or 'blood boosting' slamming an extra pint of red corpuscle rich blood into a riders body shortly before competition, to boost his performance on the track. The bikes, though were for real and helped win medals (Watson England 1978 p. 85)

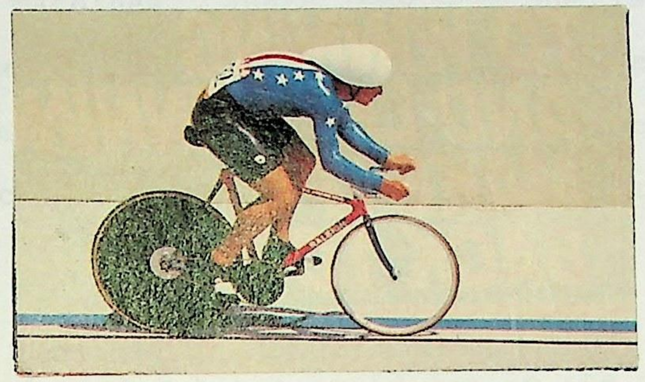


Fig 27 AMERICAN STEVE HEGG RIDING TO VICTORY IN THE 1984 OLYMPICS

CONCLUSION

The extensive use of technologies in racing bike design is now going against the morals of sport. The performance of two men are no longer comparable because of changing conditions. It is as if one racing driver, in a ordinary car, were competing against another in a formula one machine. The sport of bicycle racing is becoming a competition between machines.

Strict rules should be implemented to standardise the competition machines. There should be special events for enthusiast who are more concerned with the performance of the bicycle rather than the rider. As far as cycle sport, in general is concerned the most important component of any racing bike should remain its rider.

The future of racing bikes could lie in the developments in magnetic technology. Suspended wheels by magnetism would have dramatic design implications. It would eliminate the need for spokes, hubs and forks. Opposing magnets connected could steer the rim. Brakes might be reduced to a single button on the handlebars.

All this would reduce the weight and air resistance substantially (see diagram). This bicycle is approximately thirty years away.

Any new developments in racing bicycle design will consolidate the cyclist as the most energy efficient of all animal and machines on this planet.

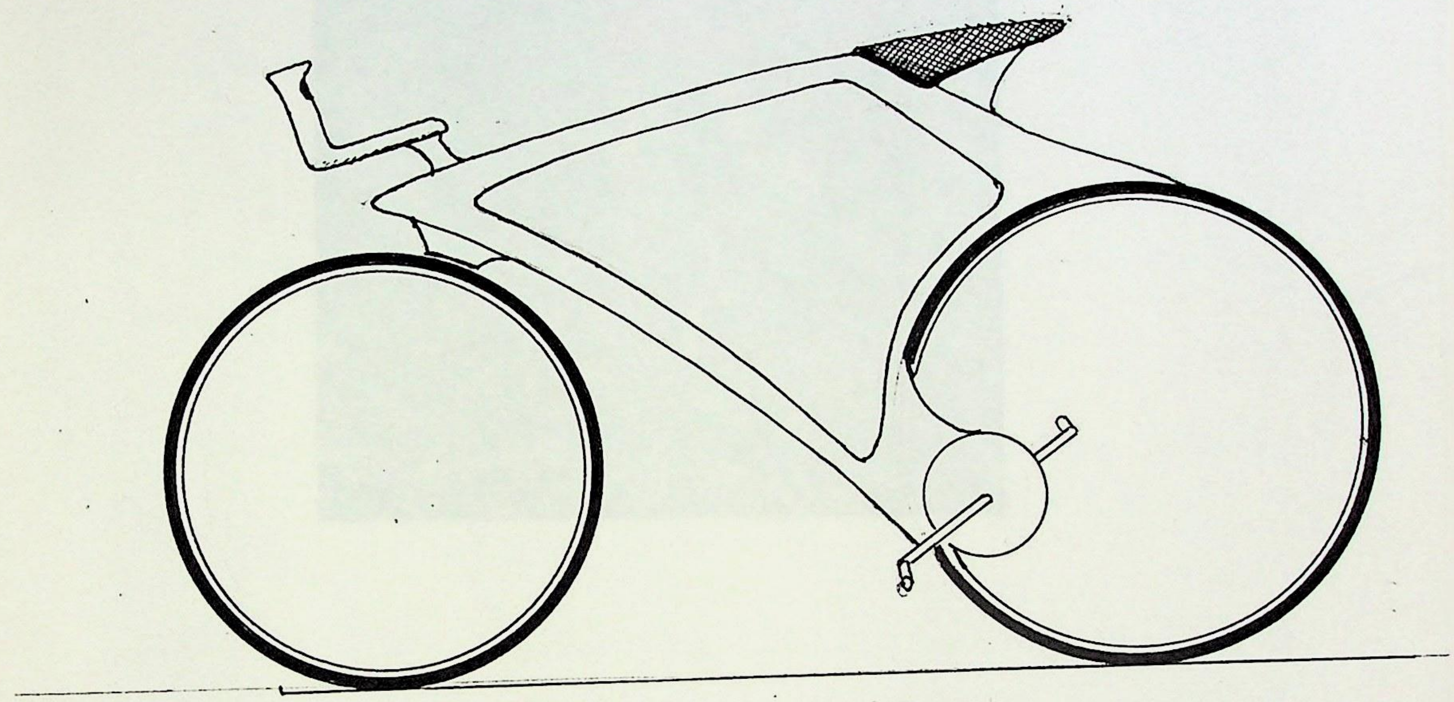


Fig 28 THE SHAPE OF THINGS TO COME

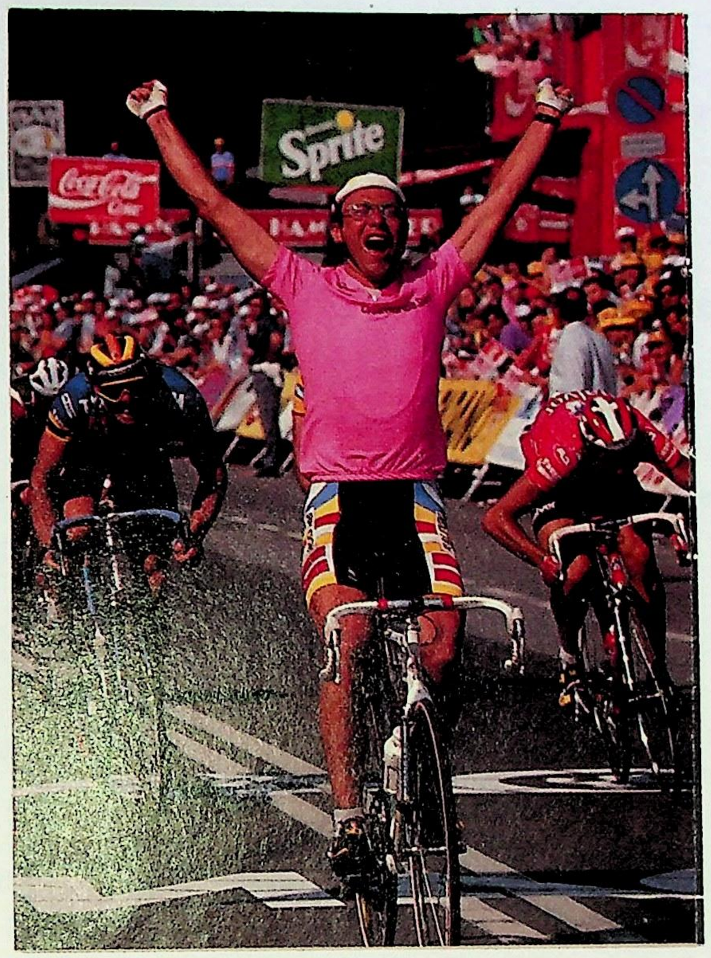


Fig 29 THE GLORY OF IT ALL

BIBLIOGRAPHY

1. McGurn, James. On Your Bicycle, 1st Edition John Murray, London 1987.

2. Watson, Gary. The Penguins Book of the Bicycle Penguin Books Ltd, England 1978.

3. Robson, Peter. The Corgi Book of bicycles and bicycling Transworld Publishers, London 1985.

4. Doran, P. Bord na Mona Book of cycling Irish Cyelind Review, Dublin 1986.

5. Jadault, E. Le Cyclisme Jadult Fils, Courlay, France 1981.

6. Landoni, Edizioni, Agonistic Cycling, Agostine Massagrande, Italy 1984.

7. Evans, K. The Young Cyclists Handbook Hamlyn Publishing Group Ltd, London 1979.

9. Design:UK No. 84 Feb 1987 "Frame of Mind David Wrath" Sharman p. 34-37

10. ID:Magazine of International Design Vol.34, No. 6 Dec 1987 Ken Stevens p. 40-45

PERIODICALS

1. Cyclist Monthly. Vol. 2, No. 4 Sept 1983, Professional Press, London "From James Moor to Laurent Fignon" Dennis Donovan p. 37-38

2. Winning, No. 19, Feb 1988, OFF press Ltd Belgium "World hour record: an explosive Dossier." Leon Michaux, p. 74-78

3. Bicycle Magazine, Vol. 18, Issue 3, Jan-Feb 1982, John Wilconson, p.62-64

4. Winning, No. 59, OFF press Ltd Belgium "Waking Up to Safety" Rupert Guiness, P. 3-4

5. Cyclist Monthly. Vol. 2, No. 8 Jan 1989, Professional Press, London "A Vet Named Dunlop" Dorothy Dunbar p. 30

6. The Bicycle Buyers Bible, June 1984, The Bicycle Cooperative London "Human Powered Vehicles" p. 124-125

7. Bicycle Guide, Vol. 3, No. 4 May 1986, Bicycle Guide Partners, Boston, U.S.A. "Generic Engineering for Bicycling" John Schubert p. 75-79

8. Design Week Vol. 2, No. 15 17 April 1987 "The Bicycle Frames" Graham Vickers, p. 19

9. Design:UK No. 84 Feb 1987 "Frame of Mind David Wrath" Sharman p. 34-37

10. ID:Magazine of International Design Vol.34, No. 6 Dec 1987 Ken Stevens p. 40-45