
Opening Extract from...

The Bicycle Book

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INTRODUCTION

'The gross and net result of it is that people who spent most of their natural lives riding iron bicycles over the rocky roadsteads of this parish get their personalities mixed up with the personalities of their bicycle as a result of the interchanging of the atoms of each of them … you would be surprised at the number of people in these parts who nearly are half people and half bicycles.'

FLANN O'BRIEN,

THE THIRD POLICEMAN

A bicycle undoubtedly has its downsides. It won't shelter you from the elements, or protect you from the fury of your fellow traveller. It lacks the romance of a sailboat or the simplicity of your own two feet. It will not give you the same sensation that sitting in £180,000-worth of over-charged horsepower does. It is miserable in the wet. No other form of transport ever takes it seriously. It is sliced up by cabs and menaced by buses. It is loathed by motorists and loved by the sort of politicians who would never dream of actually using it. It can't transport you from one

end of the world to the other in time for Christmas. It doesn't have a particularly distinguished industrial history. It gets stolen, on average, every minute and a half. It delivers you at the end of your journey covered in a light film of sweat and toxic diesel particulates. It requires a lot of silly clothing. And, of course, it is occasionally fatal.

And yet cycling obsesses people. They take it up for practical reasons – health, economy, twelve points on their driving licence – and before they know it they're gleaming with zeal and talking slightly too fast about fixies and resting BPMs. Things that they hadn't thought about since they were children start to preoccupy them – the stuff of bikes, the speed of them, their grace or style or character. It doesn't take long before the daily commute to work becomes a journey to be looked forward to, an adventure instead of an ordeal. There are conversations with colleagues about bikes and the experience of cycling; new connections are made. On the road, they start silently checking out fellow converts. Looking for short cuts and alternative routes, they ride past bits of the city – intriguing, come-hither bits – they never knew existed. In their houses, items of bike kit start to multiply. Tyres and lights now take up as much space as hats and coats. They persuade themselves that lugging a muddy vintage steel-framed roadster up three flights of stairs at night is a reasonable way to get fit. Cycling starts to become as much a way of life and a philosophy as it does a form of transport. It spreads from work to weekends to holidays. They nominate themselves for sponsored rides and charity marathons. They stop thinking in miles and start thinking in

kilometres. Almost by mistake, they find themselves in possession of a whole fleet of bikes: one for work, one for speed, one for the wet, one for annoying other people who know about bikes. They realise that one of the major advantages to cycling is the ability – more than that, the *need* – to consume their own bodyweight in spag bol and chocolate cake every day. Instead of road-tripping it round America as in the old days, family holidays are now spent hurtling through the Austrian Tyrol like two-wheeled von Trapps. They arrive at work early every day now, radiant with sweat and self-satisfaction. At home, they talk about getting rid of the car. In the evenings, they admire their newly altered profile in the mirror; the helmet hair, the buns of steel, the bloody knees. After a while they find themselves making unexpected judgement calls – can one cycle elegantly in a pencil skirt, what is the optimum number of children per bicycle, how wet is too wet, is Kent too far, perhaps an Étape might be nice. They discover that the thing about cycling isn't that it's healthy, or environmentally friendly, or fast, or convenient, or politically correct. The thing about it is that it's fun.

Part of that is the straightforward childlike joy in riding a bike, the urge to yell, 'Whheeee!' on the way downhill. There's a huge pleasure in going places cars can't go, in dodging and weaving, in a bike's simple agility. It makes previously unknown districts more accessible and familiar ones more difficult. It reinvents familiar geography, opens up towpaths or riverbanks or favoured rat runs across town. It offers the little tremor of happiness from bending urban by-laws back to suit the individual, and the constant

delight in going straight to the front of the queue. It allows one to feel smooth and charged and graceful in a world full of blocks and obstructions. It has the peculiar attraction of being healthy, dirty and risky all at once. It offers the interesting discovery that getting to and from work need not necessarily mean the abandonment of sanity. It can be companionable or solitary, competitive or amicable. And, like the horse or the sailboat, it feels somehow as if it's exactly the right pace for a human to travel.

And so the bicycle – old, and cheap, and slightly comic – has become the twenty-first century's great transport success story. Since the millennium, its use in Britain has doubled and then doubled again. Thousands now cycle to work, and more take it up every day. It has allowed the reinvention of the British landscape, opening up miles of Forestry Commission land to mountain bikers, and in doing so has given us back both the countryside and our sense of ourselves. It's introduced thousands of people to racing and to the world of European pro-touring. It's offered those of middle-aged mind and limb a chance to see themselves renewed. It has connected people through events and races and just hanging out. It has become the fastest and most reliable form of transport for people all over the country. In trial after trial, it is the bike which reaches its urban destination faster than the car, the bus, the tube or the pedestrian. It represents the power of self-reliance and the triumph of straightforwardness. Cycling has recycled itself. It is an ancient idea, and its time has finally come.

I started writing this book because I wanted to read something good about cycling and bikes, and there didn't seem to be that much around. There were books, certainly, but none of them were written for people like me. There were route guides or sports science manuals or conspiracy theorists poring over Lance Armstrong's doping record or biographies of individual heroes. There were instructions on mending a puncture at 10,000ft or nerdy accounts of club cycling. There were breathless records of difficult trips and books hung just on the cycling-related pun in the title. But there wasn't anything for the sort of cyclist who liked cycling, and reading, and stories, and who had long ago given up any desire to experiment with exogenous EPO.

This, then, is not designed to tell the reader how to differentiate between brands of derailleur or explain why riding a bicycle is good for your health. There is plenty missing. I've left out most of the political and environmental debate (provision of facilities, zero emissions etc.) because it is either obvious or it is already well served by innumerable blogs and forums. I haven't included anything on track cycling on the grounds that if you need a velodrome to do it then it is out of most people's reach. There's nothing on folding bikes, Moultons or recumbents because they look ridiculous and can't corner. I cannot tell you about your VO2 max or how to lace a wheel. I don't know how to stop your bike getting nicked and or how you become an Iron Man. I've picked and chosen quite shamelessly from all the available information on the basis of what I felt was interesting and useful. Because almost all cyclists feel a strong sense of ownership of both the bicycle

and the experience of cycling, there will almost inevitably be some I can't satisfy, and who will wish I'd included less of some stuff and more of another. That, I'm afraid, is an occupational hazard of writing about a subject about which so many people feel so passionately. The other occupational hazard, common to all non-fiction, is discovering that half the best stories come to you after the book is published. People write in, talk to you at book events, offer fabulous heaps of gold-mine material. Sometimes you get to include some of that material in future editions. Even if you don't, there's always the pleasure in knowing that the subject has inspired readers to dust off their own untold stories.

My own background is straightforward. I ride a bicycle every day in London, I do as much mountain biking in Scotland as I can, I've done long tours abroad, I've taken part in sportives and audaxes, and that's it. Like thousands of other cyclists around the country, I also use every other form of public and private transport available – cars, cabs, trains, planes, buses, the London Underground. I'm not a cyclist because I hate cars or can't understand the pleasure of driving – I'm a cyclist because I reckon there is no lovelier form of transport.

ONE

Framebuilding

Far away in a corner of Lincolnshire, there are men looking at the sky. They stand in a row in a car park and they stare at the clouds. They stay like that for quite a long time. In order to see the sky more closely, most of them have got cameras with huge white lenses of the type generally used by paparazzi photographers to take covert shots of celebrities' deodorant marks. The lenses are the size and shape of ships' foghorns, and are so heavy that they require a whole separate entourage of kit to support them – sandbags, tripods, vans, wives. Despite their supporting role, the wives do not seem to be that interested in either the cameras or the sky. Instead they sit patiently, sharing out home-made pasta with other wives or lying back on deckchairs soaking up the flatland sun while the men swing their lenses from ground to cloud and back again.

When the men have looked at the sky for long enough, they go and stare at a wall instead. Directly opposite the car park is a wooden perimeter fence a couple of metres high. With a small stepladder, it is easy enough for the men to press their lenses to the gaps or for the taller ones to see over the top. Anyone passing down the road from the

nearby town can see a long line of men wobbling on their ladders with their noses pressed to the planks. It looks like a convention of trainee window cleaners, or maybe peeping toms – very British, but a little bit sinister too.

It's midsummer in the countryside, and this is the sort of scenery to make you believe in England again. Somewhere nearby, there are canals, bright expanses of poppies and the occasional heart-lifting lilt of a lark's call. Once in a while a hare lollops out of the high fields of green grain and tears off into the distance, pursued by invisible demons. In the distance Coningsby's church tower sails over the surrounding fields and the proper old-fashioned bell still tolls the hour. Even so, the men with long lenses have not picked a particularly restful place to sit back and picnic. Every twenty minutes or so there is a low rumble from somewhere far away. The men take it as a cue to start twiddling dials and taking urgent meter readings. The wives get up suddenly and run for the cars. The rumble moves closer, resolves itself into an approach from east or south and alters from a mutter to a roar. A small black dot appears over the tree tops. It is moving very fast. The sound has sharpened and is suddenly so huge that you have no choice but to stop whatever you're doing and turn towards the source, so huge it blots out everything except itself. And then for a second a vast black triangle slides over the sun. It is very low now, low enough to see every detail. The men with the lenses click silently, their movements frantic. Indifferent, almighty, the triangle heads towards the runway. Even with your hands over your ears, the sound of it is now so overwhelming it makes your vision

go fuzzy. Its passage makes your heart squeeze tight with fear and excitement, and when it has gone it leaves a stinking rip in the summer air.

This is RAF Coningsby, home not only to the surviving RAF Battle of Britain planes (a Lancaster bomber, several Spitfires, a couple of Hurricanes and a Tiger Moth), but to the British contingent of Eurofighter Typhoons. The Lancasters and Spitfires alone would probably bring the planespotters in their droves, but the combination of nostalgia for World War Two and anticipation for the thrills of World War Three is almost irresistible. During particularly busy periods, including training days for the Battle of Britain displays, the car park and the whole surrounding area is full of people all busily destroying what remains of their hearing. Each man has his camera and a little notepad on which to keep track of dates, times, radio frequencies and serial numbers. If you like fighter planes, this place is Mecca.

So it's fortunate that Dave and Debbie Yates are keen on engineering in general. Their smallholding is about half a mile from the end of Coningsby's runway, and life for them is punctuated by the roar of approaching bombers. They moved here four years ago from the North East, and have set the whole place up as a smallholding. In the winter, they train spaniels as gun dogs. And in the summer, Dave makes bicycles.

Dave Yates is famous for his frames. In his time, working either as part of larger manufacturers or for himself, he has built the basic skeletons of over 12,000 bikes of every shape and size. Most of his time is spent here in the workshop

either putting together bespoke frames for clients or repairing their old favourites. The rest of his time is spent teaching the secrets of framebuilding to others. It's a rare skill. Once, there were thousands of small-scale framebuilders all over the country, producing a few steel-framed bikes a year for their local markets. But few individual framemakers managed to survive cycling's long decline in popularity, and fewer still were prepared to teach what they knew to a new generation. Dave is one of only a handful of those who kept the faith. And after half a professional lifetime working for small-scale companies in the North East, he and Debbie came south and set up here.

His workshop is over in a discreet corner of the farm well away from the main house. One half contains a lot of light industrial machinery – mills, lathes, obscure bits of componentry – while the horizontal bit is a light, comfortable space including three workbenches, a stack of Reynolds 531 and 521 tubing, a jig and several shoulder-height canisters of oxyacetylene gas. Despite the midsummer fields outside, the workshop has a very particular smell to it, a potent combination of metal, fire and instant coffee. For nine or ten individual weeks during the summer months, Dave takes two students (more would be impossible, since so much of his time involves working with things that might explode) and guides them through the construction of their own frame. That frame can be any shape or size as long as it is made from steel, can reasonably be made from scratch in five days and is not something silly like a tandem.

Partly because he's rare and partly because he's good, there is usually a waiting list of about two years for a place

on one of Yates' courses. He has the patience of a born teacher, unflappable, generous with what he knows and truly passionate about his subject. As the week progresses, he begins to remind me of Gimli the dwarf in *The Lord of the Rings*. Not because he's unusually small, but because there does seem to be some irresistible connection between fire and metalwork and dark, bearded Northern men. Besides, no one works with one element for the whole of their professional lives without taking on a few of its characteristics. His father worked in the Swan Hunter shipyard on Tyneside, and Dave took his passion for bikes first into teaching metalwork and then into framebuilding. 'I loved making things, I loved fiddling about with things, I loved building things. But I never had a point where I thought, I want to be a framebuilder, I want to make my living at this. It was just natural that I got stuck into bikes because it was there that there were things needed doing.' In his younger days, he did a lot of racing around the North East, got his pro licence, went to France for a bit. 'I was never good. I was good, but I wasn't *good.* Because I had a switch up there' – he points to his forehead – 'which …' – there is a long pause – '… I wasn't a winner. I didn't want to win at all costs.'

There are two types of people who usually sign up to his courses, he says. There are the experts who have been studying the science of bicycles for a long time and who want to build something to an exact specification. And there are people like Graeme and me, who like bikes but not to the point of perversion. Graeme Symington, who teaches cycling maintenance and road safety courses in Sheffield,

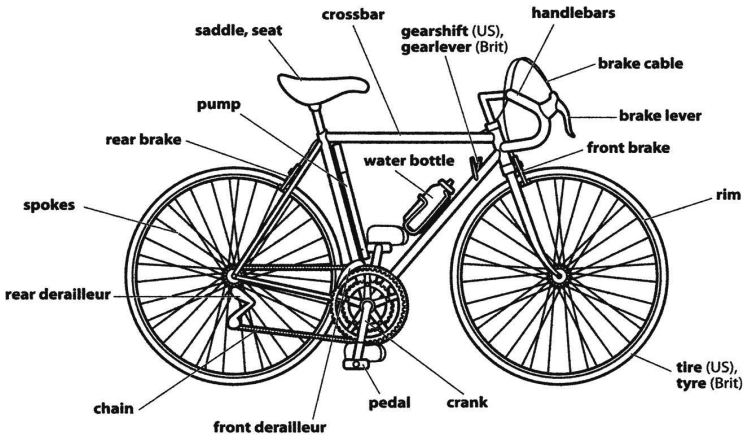
knows much more about frames and framebuilding than I do. He wants to make a big solid classic porteur-style bike, bombproof in its construction but elegant as well. I want to make a classic lugged-frame road bike – a 1950s sort of frame but with modern gears and componentry. Both ambitions are judged to be well within the scope of a week's work, even though Graeme's metalworking experience is minimal and I have none at all.

Obviously, the different demands we're making from our bikes will dictate their eventual shape and weight. Graeme's porteur will be a copy of the strong, elegant bikes once used by messengers and delivery boys to haul newspapers or shoeshine kit round the streets of Paris or Rome. They needed to take big loads at both front and back, so they had to be very stable. They also had to be capable of dealing with all weathers and of surviving for years with minimal maintenance. Graeme intends to use his for commuting, for cycle training in schools, and for 'coping with runs to the shop, where it needs to carry shopping for a family of three'.

Porteurs – and their long-distance equivalents, roadsters – are the spiritual ancestors of hybrids, the bikes which most adults now start out on when they return to cycling. Roadsters were the classic old Edwardian bikes used both for jaunts in the countryside, long-distance touring and city errands. They were big, roomy, comfortable bikes, well made and designed to be ridden slowly but steadily all day. They wouldn't set the world on fire, but nor would they leave anyone looking like Quasimodo at the end of the day. The modern hybrid still has the roadster's practicality, but

has borrowed elements from two other bicycle types. The better ones should have a bit of the sturdiness and adaptability of a mountain bike while keeping the speed and responsiveness of a road bike. In practice, a lot of the cheaper, less well-made ones just have the weight of a truck and that's it. The advantage to them is that they can be loaded with panniers and racks and baskets for groceries and whatnot, and their upright riding position helps to make the rider visible. The downside is that they're dull. Most people treat them as the two-wheeled equivalent of an estate car; the bike you use to get to and from work, do the shopping, take the kids to nursery. Practical and useful, but totally anonymous. Which is fine, because the other very useful thing about hybrids is that they make riding anything else feel thrilling. If you've spent five years riding round town on a heavy bike festooned with laptop bags, then the first time you get on a road bike you're going to feel like Chris Hoy. All that time spent hauling around a lump of cheap badly-adjusted chromoly might not necessarily do you any anatomical favours in the long term, but, in the short term, it'll do your glutes and your confidence a power of good.

Meanwhile, I'm after something more lightweight. A classic road (or racing) bike is not a thing to be laden at all, but a thing made of air designed for speed and hills and huge distances. It isn't practical in the sense of either transporting big loads or being a particularly comfortable ride, but if both bike and cyclist can be made to match each other, then a good racer is unquestionably a thing to make the soul sing. And building a steel-framed racer here will



Racing bike.

inevitably be a nod to the classic road bikes of the past. Over the past few decades, the drive for faster and lighter bikes has pushed the majority of manufacturers towards newer, stiffer materials. Steel is regarded as a heavy, spongy, tolerant substance which has enormous tensile strength but which is far too slow and unresponsive for modern racers. And so, apart from a few specialist events such as Italy's annual L'Eroica audax, the majority of modern road bikes long ago left Reynolds 531 behind and took to aluminium, titanium or carbon fibre instead. The bikes used by pros in the Tour de France will be made from woven carbon-fibre weighing at or around the UCI (Union Cycliste Internationale – cycling's governing body) minimum of 6.8kg. Anything lighter than that is judged to be too expensive to develop and too unstable to ride. Producing carbon-fibre bikes simply isn't possible for small individual framemakers like Dave Yates. Since the fibres are

moulded rather than brazed or welded, it requires a very different set-up to manufacture. Dave can and does make or repair aluminium and titanium frames, but for teaching purposes he likes to stick to good old-fashioned steel.

If I'd wanted a fast bike purely for the city, I could have gone for a single-speed or a fixie. They're the beautiful pared-down essence-of-bikes which have become increasingly fashionable for urban cyclists in the past few years. For those who live in places without many hills, they're ideal. They don't have racks or panniers or baskets, they don't have derailleurs or cassettes or (sometimes) brakes. They're just a frame, a set of wheels, and a prayer. Single speeds have one gear and a freewheel, fixies have one gear and no freewheel – in other words, the pedals will always be turning while the bike is in motion. Both are light, elegant and good for posing. In most cases they're not about logos and branding, but about riding something bespoke. Hence the occasional double-take sight of someone blazing down the Marylebone Road on a white frame with gold rims or swanking around Hoxton on a frog-green number with hot pink tyres. Most are made of steel, which keeps the price down, but because they come without any of the bells and whistles associated with most bikes, they're still very light. Messengers and fakengers like them because they need almost no maintenance at all apart from a squirt of lube once in a while, and everyone else likes them because they look beautiful and they get you where you want to be, fast. But since I want to climb hills – proper, grown-up hills – then I need a bike with gears: a racing bike.

Once in a while, Dave gets someone who wants to make either a BMX or a mountain bike. Out there on the open market, a really good MTB with suspension at both front and rear can set you back more than a top-of-the-range modern road bike will, and an amazingly fancy one can cost you five figures or more. The money goes on the geometry. The sheer complexity of fitting suspension at both front and rear, and then in making that suspension strong enough to take anything that earth and wood and rock can hurl at it, and then in making it light enough to carry with ease, and then just for good measure making it simple enough so you don't need a degree in aeronautics to repair it all comes at a price. The sheer pounding that a heavily used downhiller takes means that it's no use stinting on materials: anything cheap or badly made will get destroyed by the first tree stump it meets. It isn't that uncommon to hear downhillers complaining of getting through two or three front forks within the space of a single competition, and since the hydraulics in a good-quality fork can cost hundreds if not thousands of pounds, it's not a sport for the parsimonious or faint-hearted.

The bikes Graeme and I want to make are less demanding, and the parts are a lot easier to come by. So our first job is to come up with a series of measurements. To get a proper, comfortable ride on a bike, you need to know how heavy you are, how long your torso is, how long your arms are and what your inside leg measurement is. As a very rough rule of thumb, most men have proportionately longer torsos and shorter legs, while with women it's the reverse. The length of your torso dictates the length of the

top tube, the length of your leg dictates the length of the seat tube and the length of your arms will eventually dictate where and how you arrange your handlebars. Your weight will determine what type of materials you use. Clearly if you're 6ft 3in., 13 stone and use your bike for doing the school run, it's no good welding a couple of metal twigs together and hoping for the best. And so the next job is to pick out the parts we'll need for our frames. There are four main tubes in a classic diamond-frame road bike: the head tube (the short, thick post running down from the centre of the handlebars to the top of the front wheel forks), the top tube (or crossbar), the down tube (which runs from the head tube to the bottom bracket) and the seat tube (which runs from the bottom bracket to the saddle). The forks flare out from the head tube to enclose the front wheel. At the back there are the two chain stays on either side of the rear wheel, and the seat stays, which run from the top of the seat tube to the centre of the rear wheel.

Within those basics, there are a lot of possible variables. The angles will vary substantially from person to person and from bike to bike, and each type of bike has a different geometry. Mountain bikes, for instance, will have long head tubes with slacker head angles to help absorb shock. Road bikes will have a short head tube with a steep angle – usually between 73° and 74° – and an equally upright seat tube. The more upright both head tube and seat tube are, the more responsive but less comfortable the ride. The sharp angles mean that the rider has to reach forward over the top tube, reducing his resistance to the wind. The more

curved the angle of the forks, the more comfortable but less efficient things will be. Road and track bikes are usually designed to be ridden with the saddle higher than the handlebars – in other words, when you're riding it, your bum will be higher than your hands. Which is aerodynamic, but uncomfortable.

According to Dave, the first and most important thing in framemaking is to find out what the bike will be used for. 'The primary requisite is that the frame fits the rider and is suitable for the purpose. So if you want a touring bike, there's no earthly use in making an audax bike. You can do anything on anything – you can tour on a racing bike, you can race on a touring bike, but you'll do neither very well. So you have to get the frame to fit the customer and the purpose. If you're going to build a track frame to ride in Manchester, the position of the track frame is completely different to a touring frame you'd make for riding around the world. With a track bike, the priorities are speed and efficiency. A track bike is not much good for anything other than riding on a track or short trips on the road. A touring bike, other extreme, you want something that's comfortable to sit on all day, that will carry a load. A good racing bike, you steer with your backside and you think it round corners. You don't have to physically steer it, it just goes. It's an extension of the body and everything flows. When you're racing at a high level, the bike is absolutely critical – the rider has to have complete confidence in it. And if there's anything not quite right, it will affect his performance. That's the trick in building a good frame – in getting inside a rider's head, seeing what

his or her vision is and translating that into something that's going to do the job.'

Will a well-made bike make you a better rider? 'No. But it will stop you being a worse rider. There are some people who will never be good racing cyclists. I've seen many riders with the right physical attributes, but nothing up there. They haven't got the confidence, they haven't got the drive to succeed. I've seen riders that wanted like nothing else on earth to succeed and flogged themselves almost to death. But they would never do it because they haven't got the physical attributes – the lung capacity, the heart capacity, whatever. You've got to have those physical attributes, and if you haven't got them, you'll get to a level and that's the size you'll stay. And the best frame in the world won't make a blind bit of difference. A good bike will stop you being any worse. If you put a good rider on a bad bike, he won't ride to his full potential. If you put a rubbish rider on a good bike, he'll still be a rubbish rider.'

He gets quite a few gear freaks, the cycling equivalent of the planespotters outside Coningsby, who love the names and numbers more than they love the ride. 'A classic example is a customer who came to me in the early eighties wanting a frame built. He had a drawing – "Can you make that?" I looked at it. "Yeah, I can make that, who's it for?" "It's for me." "It's not going to fit you, it's far too big for you." 'But that's what I want." "Why do you want this?" And he said, "That's Eddy Merckx's bike. That's the dimensions of Eddy Merckx's bike." I said, 'Yeah, but Eddy Merckx is 6ft 1in. and you're 5ft 4in."' He laughs. 'Not quite, but there

was a disparity. So I made it and I sprayed it and he built it up, and I saw him for years riding round on it looking completely ridiculous – it was far too big for him. It was too long and too big. But that's what he wanted.'

Anyway. Since the four main tubes are those which dictate the basic geometry of a road bike, they come in a variety of different shapes and sizes. The simplest and strongest will be a straightforward plain-gauge steel tube, same idea as a metal curtain pole. Next up will be single-butted tubes, which have one end thicker than the middle, thereby making the frame stronger at the point of connection. And finally there will be double- or triple-butted tubing, stronger at the ends and lighter in the middle. The strength in plain-gauge tubes will be the same throughout their length, whereas the strength in single- or double-butted tubing will be concentrated at the joints. To join these tubes together, there are two alternatives: welding or brazing. Welding raises the temperature to the point where the steel melts and joins to its neighbour. It produces practical but ugly joints – the cheap hybrids and mountain bikes you see with big gobby lumps of steel at the seams will probably have been TiG (or tungsten inert gas) welded. Brazing, on the other hand, uses another metal inserted between the two steel tubes to make a connection. It's less heat and energy intensive and therefore less likely to damage the alloys. With brazing, you can use two methods. Either there are lugs, separate, ready-made joints which are then connected to the tubes with brass filler; or there is fillet brazing, where the joints are filed to a perfect fit, filled completely with brass and then sanded down to

form a seamless connection. Fillet brazing looks beautiful but requires both time and skill, so Graeme and I are both sticking to lugs. Because over the years Dave has built up a good set of contacts among bicycle-makers, he's already got a ready-made supply of new- and old-style lugs and tubes in stock. Having picked out the components we want, Graeme and I stand there for a moment or two, daunted.

To begin with, everything is divided into a series of sub-assemblies which will then be joined together on the jig at the end of the week. First job is to file a careful mitre to the bottom of the seat tube and then to connect it to the bottom bracket (the big joint through which four tubes meet and the crank axle for the pedals passes). Having given us the necessary briefing on the uses and abuses of oxyacetylene gas, Dave gives both of us a pair of welding glasses, fits the tube and the bracket into the jig, gives it a daub of flux (to prevent the steel from oxidising), sparks up the torch and passes it over. The brass is a long, thin rod which is held very exactly over the joint until it reaches melting point. The aim is to get the brass to melt neatly and without lumps or gaps into the space between bracket and tube. This is not easy. If you don't hold the flame over the lug and the brass for long enough then nothing will happen, and if you hold it for too long you'll burn away the steel of the tube. The intention is to get both the heavy lug and the light brass to the same temperature so that the braze will run seamlessly between them. Both Graeme and I are so nervous before trying it for the first time that our hands shake slightly as we hold the rods.

The gas hisses faintly, and half a mile away the plane-spotters steady their lenses. The lug begins to glow and the air above it shimmers. The brass bubbles, and at a point only Dave can see coming, it melts, vanishing into the gap as we pass the stick round the bracket. Dave stands over us, watching, instructing, telling us to pull away if we get too close to the tube or linger for too long in one place. Inevitably, it takes a while before we work out what the melting point looks like and how fast to move the stick around the join. But when it does go right, it is a moment of purest magic. One metal suddenly liquefies and slips sublimely in between the other as the torch flares round the circumference. When the steel cools, they are joined as solidly as if they had been born like that. All three of us become so absorbed in the work that for several hours we do not even notice that half of Britain's air-defence capability has just passed overhead.

Next is to bounce up and down on the fork blades. There are many types of curve you can give a fork, and all of them will do something to the way the bike rides at the end of the process. In theory no curve at all would send every bump and pothole from the road straight into your arms, while a very pronounced curve may make the ride too squishy and unresponsive. In practice, it's possible to have an entirely straight fork with enough offset to give a comfortable ride. By fitting the blades into a ready-made curved jig and then leaning down on them with our full weight, it's possible to bend them into a couple of EU-approved banana curves, giving a bit of shock absorption but not enough to slow the ride down much. The two

fork blades then get slotted into the fork crown and brazed in, and after that the drop-outs (the pieces which hold the wheels and rear derailleur in place) are attached to the chain stays. All of them are comparatively small joints but tricky, since the steel is thinner and lighter, and the risk of burning a hole consequently that much greater. The slot in the chain-stay must be perfectly angled and mitred, and we seem to end up pushing a lot of brass down what looks like a very deep hole. Once the metal cools, pedants – including me – then get to spend hours filing the join down so it looks more attractive, a detail which, when the bike is completed, will be noticed by no one except other pedants and dachshunds.

Then we join the head tube and seat tube to each other. To connect the two, the end of the seat tube must be perfectly filed down and mitred. If it isn't – if there's too much stress on one part of the joint but too little on another – then it's the joint most likely to crack or fatigue. At this point, my choice of lugs comes back to haunt me. The ones I picked out have frillier edges than normal, and therefore need more careful brazing. Moving round them with the torch, learning the way the heat sucks the brass towards it or pushes it away, remains endlessly fascinating. We mill the end of the head tube down to the right size, stick it in the top of the fork crown and braze them together. Even at this stage, the whole thing has begun to look less like a series of GCSE metalwork assignments and more like a bicycle.

And then there is the moment when, after three days and a lot of coffee, all the different bits and joints are put

into the main jig and brazed together. This is the moment of truth, the point at which everything either comes together into one priceless diamond-frame or disintegrates into a load of unrideable parallelograms. The different components might all look great on paper, but no one can really tell you how harmonious it's going to look when it's all connected or, more importantly, what kind of ride it's going to be. Once it's all been brazed together, it's left overnight in the jig to cool and settle. The following day, we take it out, poke the fork stem up through the head tube, examine our handiwork and agree unanimously that it looks like a bike. The forks are curvy, the bottom bracket proportionate and the top tube so straight you could hang pictures with it. Once in a while, I glance at the point at which the seat stays attach to the top of the seat tube. In mass-produced hybrids, the join is usually done with a big clot of weld. But in old-style racers, there should be a couple of sharp, cleanly pointed ends, like one-sided spears. Having managed to get those brazed and filed down so they come to a perfectly curved point just below the saddle is a moment of deep private satisfaction. One of the last tasks is to swap to silver solder in order to fit in the bottle bosses (the two little holes in the down tube which take the cage for a water bottle). Silver has a lower melting point than brass, and thus the flame has to be held higher and moved away quicker than with most of the brazing. But silver is good for the smaller tasks where a really clean finish is required, and for joining things to the centre of butted tubing where the steel is lighter and potentially more fragile.

At the end of the week, both Graeme and I have frames. Once they have been shot-blasted and all the excess brass removed, they look as clean and professional as half the frames hanging from the rafters in bike shops all over Britain. A few months later, painted an unrestrained blood-red with gold outlines round the lugs and then fitted out by Rob Sargent in Finsbury Park, I have something I think is properly astonishing. It rides like a dream. It accelerates up hills. And, believe me, there are very few kinds of smugness greater than the smugness of being asked where you got your bike and being able to say, 'I made it myself.' Back in Sheffield, Graeme has a similar experience. 'It is a bike that I can't ride without people stopping and asking about it (might be because it's painted bright yellow). I tell far too many people that I built it myself, an immodesty that I put down to my enthusiasms rather than my vanity.' Sitting in the Coningsby café during our lunch breaks, we had stuffed ourselves with dreams of all the places our fabulous new frames would take us. I wanted to try my bike out in the hills and glens of the Scottish Borders and then see how it did in France. Graeme was mulling over the idea of a full-scale north-to-south trip down through America. But the truth of it was that it didn't matter where we were going to take them, or why. What mattered was the dream itself. As Graeme said later, 'There is magic in framebuilding.'

I'd felt the same. Watching Dave with a brazing torch and a stick of brass was as close as I'll ever come to watching an alchemist at work. Not merely because there's something occult about watching that flame scorch its white-hot

pathway across the steel, but because at the end of it all we've been part of the transmutation of those materials from disparate parts to unified whole. And because in the process Graeme and I both learned so much about what a bicycle is and how it works. As Dave says – slightly more prosaically – making a bike is really just plumbing. But it's definitely magic plumbing.

TWO

You Say You Want a Revolution

To get to the place where Dave Yates is now, to be able to calculate so cleanly the angles and weights that separate a mountain bike from a tourer or a BMX from a racer, takes more than just experience. It takes history. Every part and every angle of a bicycle has an ancestry, a time when something else was tried and found either to fit the purpose or to form a mechanical dead end. It doesn't really matter if the aim of the framebuilder was to produce a bike that was light or durable or speedy – in order for Graeme and me to have built our dream machines, someone somewhere long ago had to do the R&D. The loss of a second or a gram or a millimetre of travel will always have been achieved by one man's trial and another man's error.

And, perhaps because the history of the bicycle is relatively short and well documented, much of that history is still contentious. For as long as there are bicycles in the world, there will be people squabbling about who invented them. The truth is that it was a collaborative process – not quite invention by committee, but more a cumulative uncovering of basic mechanical principles. The British contribution was threefold: an Englishman came up with

the tangential wheel and leather saddles, a Scotsman came up with crank pedals and another Scotsman working in Northern Ireland came up with pneumatic tyres. For the sake of European harmony and a quiet life, it's easiest to agree that the French invented everything else.

On the other hand, if you go to Germany they will tell you unequivocally that the bicycle came straight down the line from the draisienne, or velocipede, a heavy, wooden two-wheeled contraption without pedals or steering mechanism invented by a civil servant in 1817. In his professional life, Baron Karl von Drais was Master of the Forests in the Duchy of Baden. In his private life, he was an enthusiastic amateur inventor. His first project – a horseless carriage – had failed, but his new running machine met a more generous reception. Made out of wood and iron, it looked like a big old-fashioned version