• ABSTRACT

In this paper, I raise some problems with the Social Construction of Technology (SCOT): the separation of its first and second stages, dealing with a technology's development, from its third stage, the wider social context; and its underelaboration of the 'relevant social groups'. (RSGs) by which it claims to explain the third stage. By following up Pinch & Bijker's example of the safety bicycle with a case study on mountain bikes and the technological controversy of mountain bike frame geometry, I show that the third stage is crucial to understanding both the first and second stages. I suggest that the wider context of mountain bikes is postmodernity, and explore how these artefacts have precipitated a shift in the cycle industry's production processes from Fordism to post-Fordism. This wider context is then used to understand the social construction, not just of the artefacts, but of their RSGs and the relations among them.

The Social Construction of Mountain Bikes: Technology and Postmodernity in the Cycle Industry

Paul Rosen

In their paper, 'The Social Construction of Facts and Artefacts', Trevor Pinch and Wiebe Bijker introduce the social constructivist approach to technology studies (SCOT),[1] as an offshoot of Harry Collins's Empirical Programme of Relativism (EPOR).[2] To illustrate the SCOT analyses, they use the case of the social construction of the safety bicycle in the late nineteenth century. Major changes have taken place over the last decade or so in the world of bicycles, especially since the appearance of mountain bikes in the early 1980s. These changes point to shortcomings in Pinch and Bijker's analytical framework. In particular, although SCOT looks closely into the workings of technology, its account of society doesn't allow a sufficiently complex understanding of exactly how it is that social features come to be built into technological artefacts. Since the

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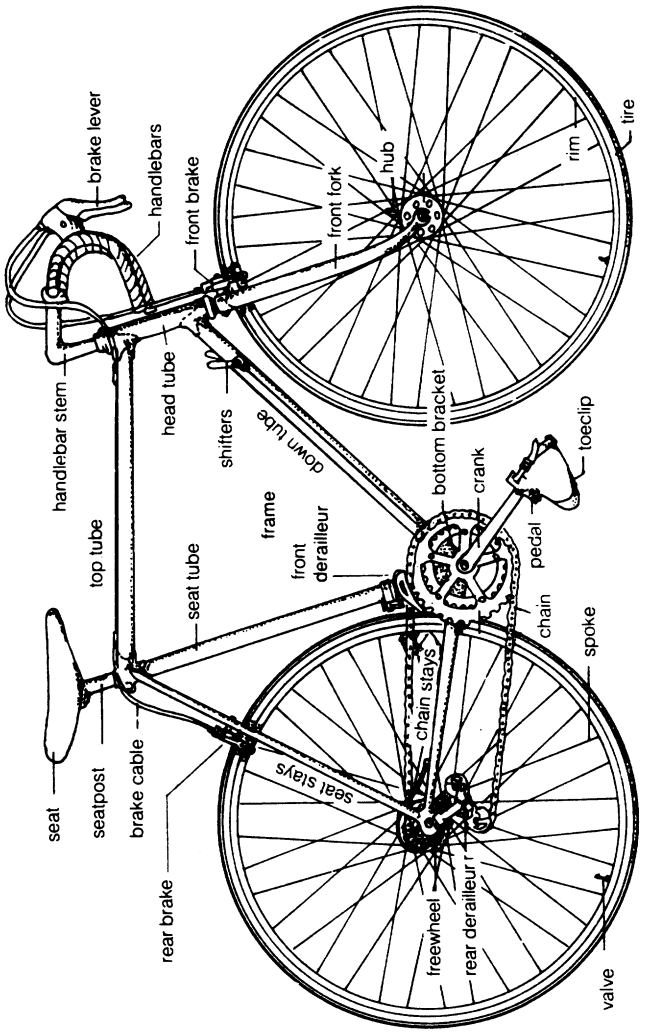


FIGURE 1
The Safety Bicycle

Source: Van der Plas, op. cit. note 30, 24.

publication of Pinch and Bijker's paper, further constructivist studies of technology have appeared;[3] but these works, too, have focused primarily on the internal workings of technologies, while generally offering a scant and oversimplistic account of society.

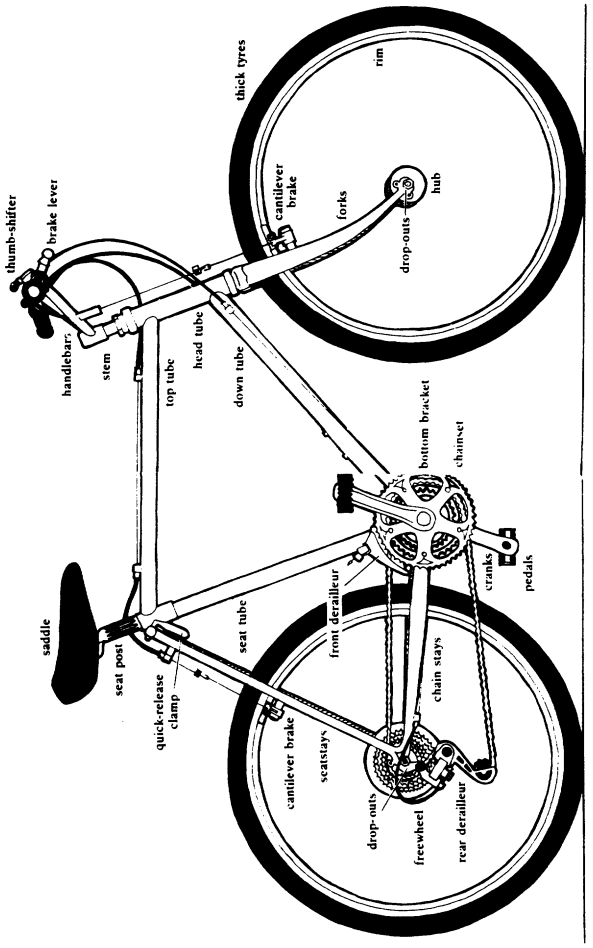
In this Discussion Paper, I intend to use the technology of mountain bikes as a way of looking at how this imbalance might be redressed, by problematizing Pinch and Bijker's concepts of stabilization and 'relevant social groups', and by questioning SCOT's adequacy in addressing the conflicts among social groups that it sees as generating technological development. I will also present a macro-social account of the wider context of mountain bikes, namely postmodernity, and thereby hope to throw open the modernity/postmodernity debate for science and technology studies.

The Social Construction of Technology (SCOT)

Pinch & Bijker's exposition of SCOT sees 'the developmental process of a technological artefact [as] an alternation of variation and selection' among designs.[4] In the case of the bicycle in the late nineteenth century, many different artefacts coexisted at this time. All of them, though, held equal claim to the name of 'bicycle'. The question for SCOT is how this technology became stabilized – that is, how one of the various artefacts on offer came to be perceived as 'the bicycle', whilst the other options were abandoned. Pinch & Bijker try to answer this question by importing into SCOT some of the concepts of EPOR. SCOT thus follows EPOR in using three stages of analysis: 'interpretive flexibility', where the analyst aims to demonstrate that there are multiple interpretations of what an artefact is; 'stabilization', by which the social mechanisms that bring about closure of this multiplicity are identified; and 'the wider context', linking these closure mechanisms to their 'wider social-cultural milieu'.[5]

For Pinch & Bijker, the key to this social process of technological development is 'relevant social groups' (RSGs). Through identifying the meanings that various RSGs attach to particular designs, it is possible to trace the conflicts of interest among RSGs that have led to the rise of some, and the fall of other, designs.[6] As an example, Pinch & Bijker write that penny farthing, or Ordinary, bicycles were for young male cyclists 'macho machines' which symbolized virility and speed. In contrast, for women and elderly men they were dangerous.[7] Even a single artefact, then, can be seen as two or more

FIGURE 2
The Mountain Bike



Source: Kelly & Crane, op. cit. note 18, 6–7.

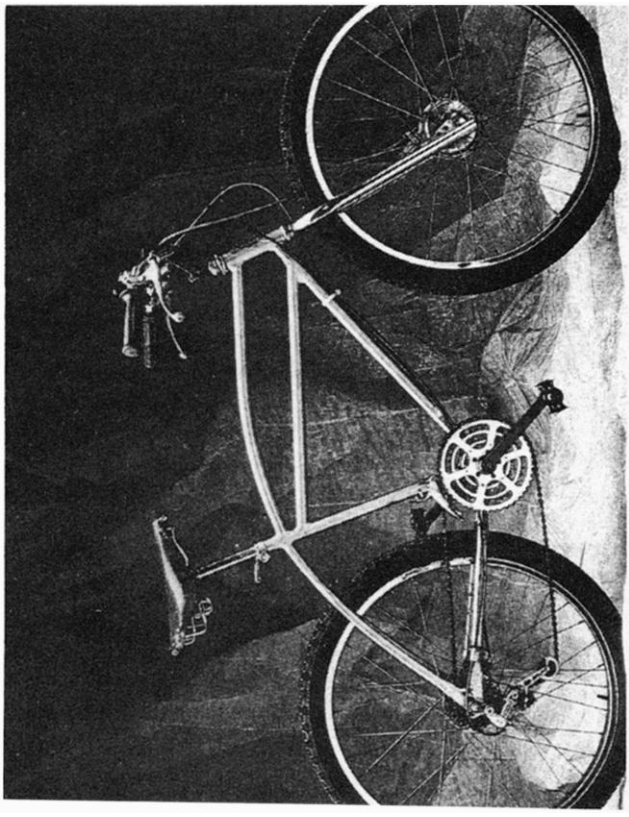
different artefacts at the level of the meanings constructed for it by its potential users.

Stabilization of a technology is what happens when all the problems attached to an artefact by various RSGs are overcome. The characteristics of this artefact then come to be 'taken for granted' as the essential 'ingredients' of the technology. For the safety bicycle, these features, after a nineteen-year process, come to be low wheels, rear chain drive, diamond frame and air tyres.[8] According to Pinch & Bijker, three RSGs that were crucial to this stabilization were women, elderly men and racing cyclists. Low wheels and air tyres solved the safety problem attached by women and elderly men to high-wheeled, iron-tyred bicycles, whilst air tyres solved the speed problem that racers otherwise attached to low-wheeled bicycles. This artefact thus solved the problems of all three RSGs, and is essentially still the standard form of racing and touring bikes today (see Figure 1).

An important part of the SCOT programme is the claim that '[o]nce the relevant social groups have been identified, they are described in more detail'; we are told, for example, that 'the social group of cyclists riding the high-wheeled Ordinary consisted of young men of means and nerve', followed by a list of likely occupations.[9] For Pinch & Bijker, this description belongs within the first stage of SCOT's analysis, enlarging on the interpretive flexibility of an artefact.

Such elaboration of RSGs also, however, provides an important link to the third stage, the technology's wider context. Pinch & Bijker implicitly recognize this in their brief account of the third stage, which they see as being provided directly by the RSGs: 'the sociocultural and political situation of a social group shapes its norms and values, which in turn influence the meaning given to an artefact'.[10] A 'thick' enough description of an RSG in the first stage would, then, automatically provide the wider social context of the RSG, of the artefact itself and of the social mechanisms that shaped it. Unfortunately, Pinch & Bijker don't provide this thick description.[11] They identify three RSGs whose interests have decided the shape of bicycles for almost a hundred years. It is important to understand why it was that these particular groups, rather than others that Pinch & Bijker refer to, were the relevant ones. Although women and elderly men made up over half the adult population, we are told nothing about the social make-up of these groups, how large a proportion of them were cyclists, from which social classes they came, and so on. By failing to provide this information, Pinch & Bijker undermine their claim that SCOT will give 'more detail' about RSGs.

FIGURE 3
Gary Fisher's Original 5-Speed Drum Brake Clunker, c.1974



Source: Kelly & Crane, op. cit. note 10, 33. Reproduced with permission from Gary Fisher (UK) Ltd.

This omission is understandable, given the programmatic nature of Pinch & Bijker's paper. Underlying it, however, is a failure to recognize that if the wider context of a technology rests on its RSGs, then these too must be seen as socially constructed. It is not enough to take categories such as 'women' and 'elderly men' as unproblematic. The same applies to the relations among RSGs, which Pinch & Bijker's account suggests were not completely harmonious. The conflicts that exist between different social groups are another key to understanding the social processes that lead to stabilization.

'More detail', then, is crucial for demonstrating the processes by which RSGs as well as technology are constructed. Otherwise, both remain decontextualized, with the consequence, as Stewart Russell points out, that all social groups are regarded as having equal power and status in society, and consequently equal access to and control over technology.[12] No distinction can then be made between, for example, 'women' and 'young men of means', although these two groups clearly have different power and status.

I would argue, consequently, that the distinction made in SCOT, between the first two stages of a technology and the third, is a false distinction. Rather, the social context of a technology, identified through the RSGs, is pertinent to both the first and second stages of SCOT. In order to understand the full extent to which an artefact can be seen as a 'sociotechnical ensemble',[13] it is necessary to look not just at the internal dynamics of the technology, but to look at the same time beyond this to the wider social world in which they are located.

Mountain Bikes: The Social Construction of Clunkers

The case of mountain bikes provides a pertinent opportunity to develop this critique of SCOT.[14] While retaining for the most part the features of the safety bicycle, mountain bikes challenge the idea that this design is necessarily stable. Mountain bike design is constantly changing. My objective in this paper is to show that the changes in their design bear a close relation to changes in Western society at large, and thus to illustrate the need for closer attention to the third stage than is usually given in SCOT.

Mountain bikes differ from the safety bicycles that Pinch & Bijker discuss on a number of counts.[15] They have smaller wheels and fatter tyres, flat handlebars, gear shifters on the handlebars rather than on the frame, and a higher bottom bracket. They have cantilever brakes,

and at least fifteen gears. Mountain bikes have 'slacker' frame angles and a longer wheelbase than road bikes (Figure 2). For a mountain bike to withstand regular use off-road, it should also, according to mountain bike buyers' guides, weigh less than 32lb, be made of lightweight materials,[16] and use a set of components (the 'groupset', comprising brakes, gears, hubs, bottom bracket and other moving parts) of a minimum quality (that is, the Shimano '200GS' groupset).[17] Such a bicycle from the 1992 brochures would cost at least £250.

Mountain bikes were 'invented' during the mid- to late 1970s. They originated in Marin County, northern California. During the early 1970s, a small group of people began to build bicycles for racing down Mount Tamalpais. These bikes, known as 'clunkers', were constructed from frames and components that happened to be lying around in people's backyards. In particular, this 'clunker group' of riders used the frames of Schwinn Excelsior bikes, built between the 1930s and the 1950s.[18] The Schwinn Excelsior was a children's bike designed to look like a car, with a wide frame and tyres, large handlebars and a broad saddle. Later models even had imitation petrol tanks and lights moulded into the mudguards. These bikes became the quintessential 'news-boy' bike in America.[19] In the 1970s, there were still plenty of old Schwinn frames around, and the clunker group realized that they were sturdy enough to withstand rough handling on the mountainside.

After a period of experimenting with various components, the Schwinn frames began to be treated to 'the standard Marin County conversion'.[20] This entailed adding modern components such as 'derailleur gearing systems . . . front and rear drum brakes, motorcycle brake levers, wide motocross handlebars, handlebar-mounted shift levers, and the biggest knobbly bicycle tyres available mounted on heavy . . . steel rims' (see Figure 3).[21] This resulted in bikes that could survive what is now an infamous ride in mountain bike folklore, the Repack run, a steep drop on the slopes of Mount Tamalpais, losing 1300 feet in less than two miles. Riders would be taken up the mountain in a truck, and would then race down it on their clunkers. The ride was named 'Repack' because it is claimed that by the time a rider reached the bottom, all the grease in the original back-pedalling coaster-brakes would have 'turned to smoke', and the hub would need to be repacked with fresh grease.[22]

Clunkers exemplify the idea that the design of an artefact draws on the cultural resources available to its designer.[23] The old Schwinn

bikes were a cultural resource available to the clunker group, on two levels. First, they were a physical resource lying around in people's yards, waiting to be used. Just as important, though, was the meaning attached to Schwinn bikes by Americans who grew up in the mid-twentieth century. The following quotation is from an American cycling magazine article celebrating the tenth anniversary of mountain bikes:

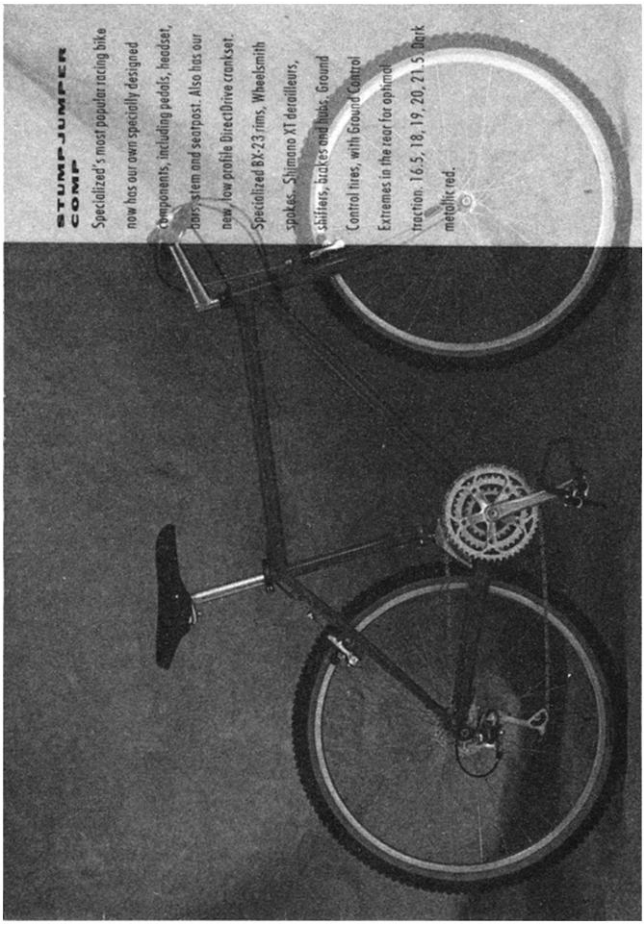
> 'I grew up with an old Schwinn two-speed', recalls Lou Gonzalez, who promotes the subsport of Mountain Bike Polo. 'We used to ride around on these forest trails in Illinois at breakneck speed, trying to kill each other. The first time I got a mountain bike on singletrack it reminded me of my youth. It brought back that special time when you didn't have a care in the world'.[24]

The cultural determination of mountain bikes, then, is able to override technological considerations. What mountain bikes evoke is for many riders more important than technical factors. The clunker group was, then, a relevant social group which constructed a meaning for Schwinns, and consequently clunkers, that centred on nostalgia.

Mass production of mountain bikes began after 1977, when members of the clunker group began to build their own custom frames to improve on the Schwinn design. Joe Breeze is generally credited as having built the first mountain bike. Tom Ritchey expanded on Breeze's design, and set up a company called MountainBikes with Gary Fisher and Charles Kelly. This was the first commercial production of mountain bikes, in 1979.[25] The earliest cycle industry interest came from Schwinn themselves, aware that the clunker group was ordering a large number of their spare parts. Schwinn produced an unsuccessful mountain bike,[26] the Clunker Five. It wasn't, however, until 1982 that mountain bikes took off commercially. In 1981, Specialized had produced the Stumpjumper, the first mass-produced mountain bike, manufactured in Japan and based on Ritchey's design. The Stumpjumper is still part of Specialized's range (see Figure 4). More importantly, by late 1982, the component manufacturers Shimano and SunTour introduced groupsets for mountain bikes; in Kelly's words,

> [t]he availability of component groups was the last stage of assembling the infrastructure necessary for mass production, and from that time forward mountain bike production swung into high gear, maintaining for several years the highest growth curve in the bicycle industry. For better or worse, mountain bikes were no longer a garage industry.[27]

FIGURE 4
Specialized 'Stumpjumper'



Source: Specialized 1992 Brochure. Reproduced with permission from Specialized Bicycle Components (UK) Ltd.

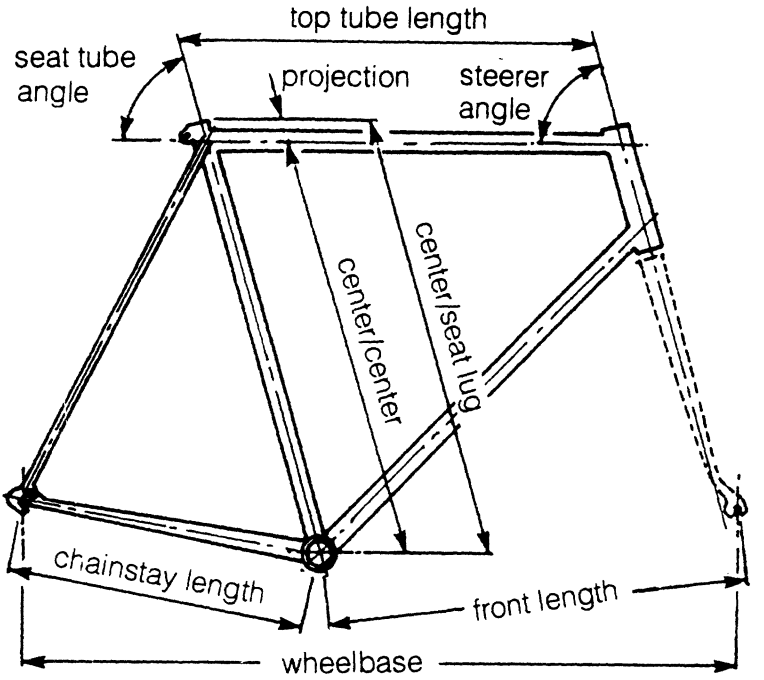
Controversy and Closure: Frame Geometries

A key focus of the sociology of scientific knowledge is the study of scientific controversies.[28] Pinch & Bijker's paper carries this approach over into technology studies, by focusing on controversies in bicycle design in the late nineteenth century. One hundred years later, the development of mountain bikes has again opened up controversies over the design of bicycle technology which had to a large degree been closed since the early twentieth century. Mountain bikes are, therefore, a useful technology with which to follow up, and to scrutinize, the SCOT approach.

I want to apply SCOT to a technological controversy in mountain bike design, that of frame geometries. This concerns the angles and lengths of the tubes that make up a bicycle frame. Small variations in these are seen to make a significant difference to the performance of a bike. A 'diamond frame' safety bicycle generally consists of four tubes – the head tube, the seat tube, the top tube, and the down tube – plus the seat stays and chain stays that make up the 'rear triangle'. The crucial elements of the mountain bike frame geometry controversy are the angles of the seat tube and head tube, the length of the chainstays, and the wheelbase, which is the total distance between the front and rear drop-outs (Figure 5).

The early custom designers of mountain bikes in California simply duplicated the geometry of the Schwinn clunker frames. These had a long wheelbase of about 44 inches, long chainstays of 18.5 inches, and 'slack' (that is, low) head and seat tube angles: 68° for the head tube, 70° for the seat tube.[29] In comparison, a typical racing bike might have chainstays of 16–17 inches, a wheelbase of 38 inches, and steep angles of 73–74° for both head and seat tubes.[30] What the Schwinn geometry meant practically was that the 'California style' mountain bikes were good for racing fast downhill, but difficult to ride uphill.[31] A slack seat tube angle means that the saddle, and consequently most of the rider's weight, is further back on the bike, over the rear wheel. The seat tube is further to the rear of the bike, meaning that the chain stays need to be longer, to give clearance for the back wheel's fat tyres. The slack head tube angle pushes the front wheel further out in front of the bike. Riding fast downhill with these angles is easy. If the angles were steeper, the rider would be further forward, and the front wheel would be under, rather than in front of, the bike, giving a risk of the rider being thrown over the handlebars.

FIGURE 5
Major Frame Dimensions and Angles



Source: Van der Plas, op. cit. note 30, 63.

On the other hand, uphill riding is more difficult. The lack of forward weight might lead the front wheel to lift off from the ground. It also makes it difficult to manoeuvre the front wheel around obstacles while going uphill. Uphill riding, then, needs steeper angles and consequently a shorter wheelbase than the California-style mountain bike. Kelly writes that as soon as this design appeared on the market, other designers quickly began to produce steeper-angled versions. One example is the 'Seattle style'. This design arose to cope with the terrain of the American Northwest. Riders there were going through logging country and often riding over small logs. They therefore needed better control over their bikes than the Californian riders.[32]

We already have then, in the very early days of mountain bikes, two relevant social groups: downhill riders and logging country riders. The California-style mountain bike held different meanings for each group. For the clunker group, the downhill riders, it was a bike well-suited to their purposes – they themselves had developed it, through

trial and error over some years. For logging country riders, on the other hand, this technology was impractical, and variations of the design were developed to cater to their needs.

Each year's new models during the mid- to late 1980s featured gradual modifications to the frame geometry of mountain bikes, which eventually stabilized by about 1989 at around 73–74° for the seat angle, 71° for the head angle, up to 17 inch chainstays, and a 41–42 inch wheelbase.[33] This is considerably steeper and shorter than the original California-style bikes, but still longer than a typical racer, with a slacker head angle, though the same seat angle. The explanation is that the current frame geometry is more versatile, allowing riders to go both uphill *and*, with a little extra skill, downhill.

At first glance, it appears that the interpretive flexibility of mountain bike frame geometry stabilized in a straightforward manner. The final artefact favours the meanings held by the largest group of riders, those who ride mountain bikes in a variety of settings, rather than the meanings of specialist riders such as the two RSGs suggested above. The question of frame geometry has not, however, been fully resolved, even though these particular angles and dimensions are now relatively stable. A further dimension to the controversy can be seen in the 1992 brochures of some manufacturers. Many models of both mountain and road bikes now feature 'proportional geometry'. That is, the same model will have a different geometry for each frame size. Ridgeback's 1992 brochure explains proportional geometry in this way:

> Larger riders require a shallower seat angle to maintain correct 'knee over pedal' riding position and use a steeper head angle for sharper handling. Smaller riders need a steeper seat tube combined with a shallower head angle to achieve the same optimum pedalling efficiency.

Scott's 1992 brochure takes a similar but more complex approach, starting from the principle that '[n]o frame design works for every range of use, and no geometry is correct for all sizes'. Instead of proportional geometry, Scott uses 'Pro-Spec' geometry, standing for 'Proper Fit for Specific Use'. Pro-Spec aims to 'match every biker's profile', including a 'Superslope' geometry that 'perfectly fits the specific demands of the female anatomy'. In effect, Pro-Spec means that not only do the different sizes of a specific model have different angles, but each different model across the Scott range has its own set of geometries, suited to the uses for which the particular bike was designed. This latter feature can be seen also in the Schwinn 1992

brochure. Each of the different series in the Schwinn off-road range has a different geometry: mountain bikes for 'racing' have an 'aggressive 71/73° team geometry'; 'sport geometry' is 70/73°; 'all-terrain' bikes have a 70/72° 'recreational geometry'; whilst 'cross' bike angles are 72/73°.[34]

Proportional geometry isn't exclusive to those companies that have labelled it as such in their brochures. The Dawes 1992 brochure, for example, makes no mention, in its detailed account of how Dawes frames are built, of the fact that proportional geometry is used throughout the range. Nevertheless, proportional geometry represents a redefinition of the terms of the frame geometry controversy that appears to have gained acceptance throughout the cycle industry. I have been told by a mountain bike designer and writer that 'the angles of the frame are actually nothing to do with the performance of the bike'. They are, rather, important solely in relation to the size of the rider. The original terms of the controversy, that different angles affect performance in different settings, have, then, been entirely dismissed.

This phenomenon is an example of one of the social processes that Pinch & Bijker identify as bringing about stabilization: 'closure by redefinition of the problem'. The example Pinch & Bijker give concerns the rubber air tyre, invented by Dunlop in 1887 as a way of solving the 'problem' of vibration. Vibration was a problem only for one RSG, however, the riders of low-wheeled bicyles. It wasn't until rubber air tyres were found to greatly increase speed in cycle racing that resistance from other RSGs was overcome. For racing cyclists, the existence of the technology defined a new problem that didn't exist for them previously.

In the case of frame geometry, the problem to be solved originally was one of riding location and style. Proportional geometry has redefined this as a problem concerning riders' bodies, and their individual pedalling efficiency. Companies whose bikes are seen to solve this problem, by means of proportional geometry, have successfully constructed a market for their products, by constructing riders into RSGs such as 'larger riders', 'smaller riders', 'aggressive racing cyclists', 'recreational cyclists' and so on. As Mackay & Gillespie rightly argue, marketing is a particularly fruitful area for technology studies to pursue, providing in advertising rhetoric an overt aim of pushing stabilization in particular directions.[35]

The interaction that is evident here between design and marketing strategies is a good example of how entwined technology is with

society, a relationship that runs right through the question of stabilization. Regular shifts in the meaning of frame geometry suggest that the technology of mountain bikes will never stabilize definitively. Although specific features, such as the angle of a particular tube, may remain stable for a period of time, 'the mountain bike' is continually changing. As soon as one controversy is resolved, another appears.[36]

If SCOT is to account for the social construction of mountain bikes, it will need to explain this constant shifting in their design. This is not possible, however, from within the confines of the first and second stages of SCOT, since the explanation lies outside the technology itself, but rather in the culture of the cycling world, in the cycling media, and ultimately in the post-Fordist economic system to which the cycle industry belongs.[37] In order to contextualize mountain bikes, then, I want now to sketch the production practices of post-Fordism, which promote an incessant pursuit of technical innovation that opposes the concept of stabilization. The wider context of a technology is thus not separate from the first and second stages of SCOT, but something which informs both the range of artefacts that comprise its interpretive flexibility and the mechanisms for possible closure.

The Wider Context: Modernization, Postmodernity and Post-Fordism

Cyclists have been riding off-road, and altering the design of road bikes to do this, since the days of Pinch & Bijker's controversies over wheel size and air tyres. One of the members of the clunker group itself, John Finley Scott, built a bike in 1953 which 'in nearly all respects resembled the generation of off-road bikes' raced at Repack.[38] Scott's 'woodsy bike' was constructed from a Schwinn World frame, and equipped with 'knobby tyres, derailleur gears, and upright handlebars'.[39] Neither this nor other off-road adaptations, however, were able to transform the world of cycling or the cycle industry in the way that mountain bikes have. It is important, therefore, to ask what is so special about mountain bikes that they, and not other off-road designs, have become so significant. Charles Kelly himself asks this question:

> As a participant in one of the more far-reaching developments in the field of bicycling, a development that is in its own way as significant as the introduction of the chain drive and the 'safety bicycle' to replace the high-wheeled boneshaker, I still speculate on whether a few of my friends and myself really did influence the

> world, or whether we were just the people who were standing there when the appropriate forces came together. All of us who participated in the seminal mountain bike period of the middle seventies are daily confronted with reminders of our vision and dreams in the form of the mass-produced mountain bike, and still we wonder whether we did anything or whether it just happened to us.[40]

To have any chance of answering such questions, it is necessary to push SCOT a good deal beyond Pinch & Bijker's framework. In order to understand the social construction of a technology, it is important first to understand the social construction of its relevant social groups. Pinch & Bijker's concentration on the micro-level of the technology itself stops short of this, and their inattention to the wider context leaves them open to the accusation of technological determinism.[41]

The 'wider context' that provides the social construction of mountain bikes and their RSGs seems to be postmodernity. The state of the cycle industry both before and since the arrival of mountain bikes can be explained well by David Harvey's extensive account of postmodern economics.[42] On a cultural level, also, the themes associated with mountain bikes match many of the key notions of postmodernism.[43] My argument, then, is that mountain bikes are a technological artefact of postmodern society.

'Postmodernity' is a concept that is contested across various academic fields, including sociology, anthropology, geography, philosophy and psychology. I don't want in this paper to engage in the debate over whether or not postmodernity really exists, or whether it is just a phase of late modernity.[44] I want, rather, simply to present 'the postmodern thesis' as something that may prove useful to technology studies. What follows, therefore, is not a discussion of postmodernity, but a sketch of its main features, accepting as given the assumptions, concepts and cultural phenomena commonly associated with it.

Harvey argues that it was specific moments of capitalist modernization, resulting in major social and cultural upheavals, that brought about the cultural phenomena of modernism and postmodernism (architecture, art, film and so on).[45] He identifies three major periods when economic crisis caused cultural upheaval: first, the late 1840s, when an economic depression in Britain swept across Europe, resulting in the revolutions of 1848, and in the birth of modernism; second, the immediate post-World War I period, which is generally seen as the main era of modernist art, literature and architecture; and third, the crisis in Fordist economics of 1968 to 1973, which for Harvey was the catalyst of postmodernity.[46]

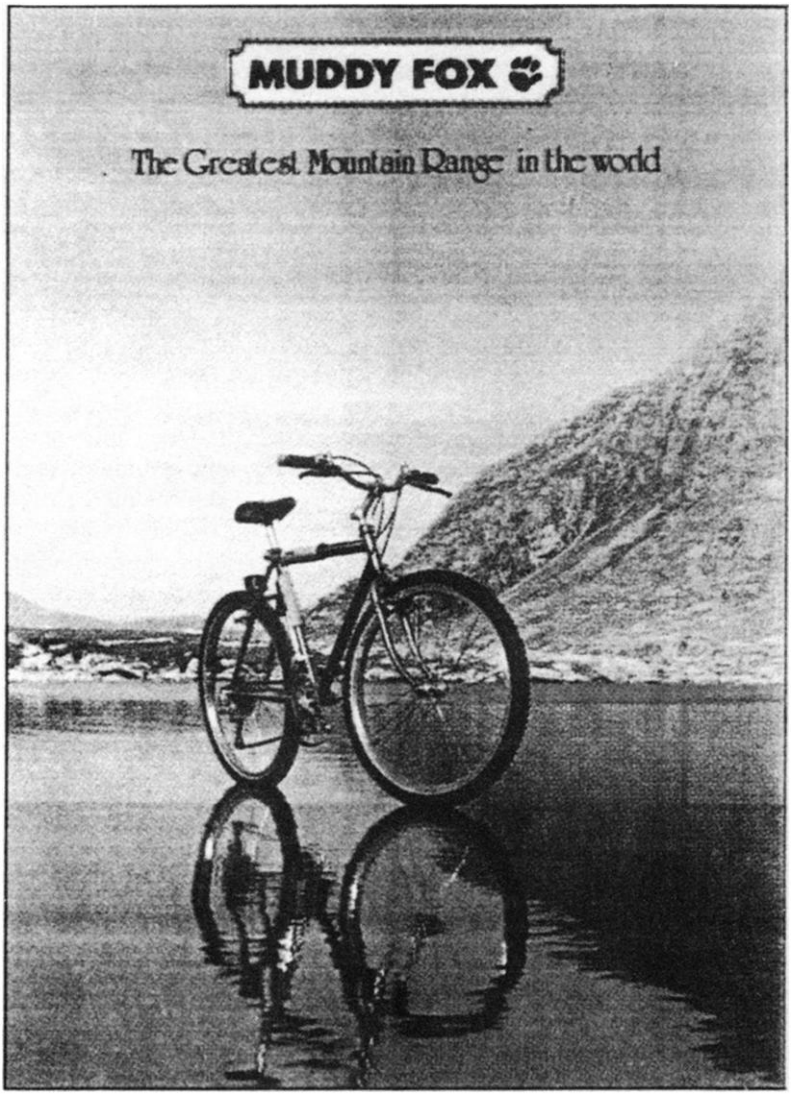
The cycle of modernization/economic crisis/cultural crisis derives, for Harvey, from the 'three basic features of any capitalist mode of production' that were identified by Marx. These features are that capitalism is 'growth-oriented', that this growth 'rests on the exploitation of living labour in production', and that capitalism is 'necessarily technologically and organizationally dynamic', requiring competitive innovation in both areas. The combination of these three features embodies contradictions that render capitalism 'crisis-prone', with a tendency towards 'periodic phases of over-accumulation' of capital, of labour and of goods.[47]

What distinguishes as special the overaccumulation in each of the periods Harvey identifies is that in each case it has led to major crises in the economy, which have then spread through all elements of society. The extreme nature of these particular crises is related on each occasion to 'a radical readjustment in the sense of time and space in economic, political and cultural life.[48] The 'time–space compression' brought about by many of the innovations of these periods, making geographical and temporal distances increasingly insignificant, frequently results in a sense of fragmentation and instability. The result each time has been a 'crisis of representation' that is manifest in the cultural artefacts of the period – in the paintings, the literature, the films and so on.[49]

The crises of the 1840s were linked to the rapid international spread of industrial capitalism, reflected in the international nature of the 1848 revolutions. Since then, Western culture has seen great innovations in transport and communications technologies, which have had the effect of making the world seem to shrink.[50] This is, in fact, part of the social context of the controversies around the safety bicycle that Pinch & Bijker discuss. Similar changes have come about in the postmodern period, starting with the collapse of Fordist economic organization in the 1970s. Harvey describes this era as 'an intense phase of time–space compression that has had a disorienting and disruptive impact upon political-economic practices, the balance of class power, as well as upon cultural and social life'.[51]

Postmodernity in economics is intricately tied up with flexible accumulation in the production process and in labour relations. Fordism, typified by the business practices of Henry Ford, is characterized by features such as the mass production and consumption of homogeneous, standardized goods, and the centralization of production and of state controls. In contrast, post-Fordist production, or flexible specialization, features small batch production, responsive

FIGURE 6
'Wilderness'



Source: Muddy Fox Brochure, mid-1980s. Reproduced with permission of Muddy Fox (UK) Ltd.

to individualized consumption demands. Production is spatially dispersed, while state control is flexible and decentralized.[52]

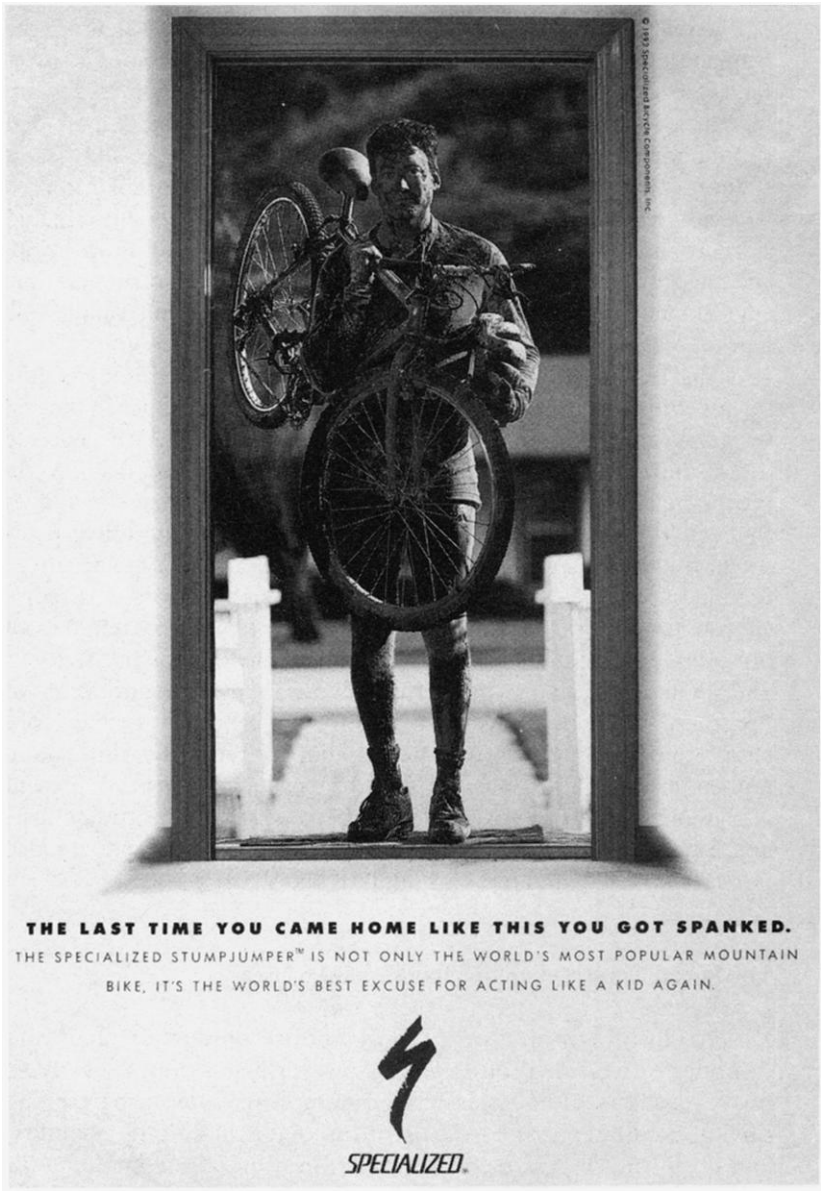
Flexible accumulation thus works with, rather than against, the fragmentation caused by modernization. The production of an artefact can be spread across entire continents, whilst workforces are increasingly made up of casual and part-time staff. This fragmented production has come about in response to the depressed world economy that forms the backdrop of post-Fordism. Competition is a necessity for business survival. Production needs to be sensitive and responsive to new opportunities and markets. Product innovation, cheap locations, short production runs and a fast turnover time enable companies to cater for 'highly specialized and small-scale market niches'.[53]

A fast turnover in production needs to be matched by a fast turnover in consumption; hence the increasing importance in the last twenty years of advertising and fashion, of attempts to generate desire and need among consumers.[54] Advertising and fashion are intrinsic elements of the postmodern. In postmodernity, the images that sell commodities have themselves become commodified; postmodern culture is 'the culture of the image or the simulacrum'.[55] Simulacra frequently operate at the level of nostalgia. Fredric Jameson argues that nostalgia films, and contemporary remakes of old films, exemplify postmodernism. These films, made in the 1980s and 1990s, but set in the 1950s, operate 'a new connotation of "pastness" and pseudohistorical depth'.[56] In other words, they construct the past in their own terms, but at the same time claim authenticity. Jameson terms this feature 'pastiche', a feature present also in other facets of postmodern culture – art, architecture, music, and especially urban design. I would argue that these features also inform the design and use of mountain bikes.

The Social Construction of Mountain Bike Users

Despite the fragmentation of post-Fordist production and consumption, advertising for its products nevertheless draws heavily on images such as the nuclear family, nature, scientific progress and (male) scientific expertise – that is, on discourses of stability. Stability, and nostalgia for it, are clearly evident in promotional material for mountain bikes. References to wilderness and to youth are common themes in mountain bike advertisements (see Figures 6 and 7). At the

FIGURE 7
'Youth'



Source: 1992 Press advertisement. Reproduced with permission of SBC (UK) Ltd.

same time, however, there is also a strong focus on technological progress and efficiency (see Figure 8). Mountain biking discourse is imbued with a dialectic of 'fashion and function', which is perhaps embodied in the growing green consciousness among cyclists – preserving the planet goes hand-in-hand with a concern for health and fitness.

These themes locate mountain bike users with the contradictory terms of what Berger, Berger & Kellner call the 'de-modernizing impulse',[57] a resistance to modernization which is nevertheless at the same time a product of it. A typical example of this impulse is the search for wilderness areas uncontaminated by modernization. This is perhaps the most important theme in mountain biking discourse, and was the initial motivation of the clunker group who, according to one writer, were 'a pack of hardcore hippie bike bums' who had moved from San Francisco into rural Marin County 'to live less frenetic, more laid-back lives'.[58] It is still a prevalent theme, with articles and advertisements drawing on notions of pioneers, frontiers and a relationship to nature which seeks at the same time both to escape to it as a haven from the city, but also to conquer it using the very technology that drives the desire to escape. Richard Ballantine writes that '[i]n any activity, there is always an edge of adventure, always a place where people are wild and free'. In mountain biking, this edge is 'a line of discovery and testing new limits'.[59] The names of mountain bikes often reflect this theme – Summit, Amazon, The Edge, Off Limits.[60]

Nostalgia, too, is a major mountain biking theme, as shown in the American mountain biker's quotation above, and in Figure 7: the market for mountain bikes is by no means restricted to children. By using old Schwinn frames, the construction of the original clunkers was strongly nostalgic, as well as being practical. They also embodied Jameson's notion of pastiche. They were a collage, a 'juxtaposition of diverse and seemingly incongruous elements'.[61] They were 1970s remakes of a 1950s artefact. It is thus the cultural meanings attached to mountain bikes by their riders that have meant that mountain bikes, rather than earlier off-road adaptations, are socially a success. This cultural resonance has in turn provided the market to make mountain bikes an economic success.

Alongside these de-modernizing themes, however, mountain bikes are also heavily infused with the very opposite – the advanced technology which lies at the forefront of mountain bike innovation and which is central to modernity. While mountain bikers share with

FIGURE 8
'Technological Sophistication'

Source: Press advertisement, 1991–92. Reproduced with permission of Muddy Fox (UK) Ltd.

de-modernizers a desire to escape civilization, they do so in a highly technological fashion. This has led to conflicts with other groups that share mountain bikers' rejection of the modernization of the city, notably ramblers in national parks.[62] The latter's objections to mountain bikes appear often to have more to do with visual and aesthetic damage than with actual physical damage to the environment. It is not a belief that mountain bike tyres could do more damage to footpaths than horses' hooves or walking boots could, but the incongruity of 'a modern contrivance' in a wilderness area, that produces 'a deep sense of hatred' at the sight of wheel tracks on the fells.[63]

It is ironic, then, that most mountain bikes are used primarily on city streets rather than on wilderness trails. This reflects yet another closure by the redefinition of the problem. Just as rubber air tyres generated and then solved the problem of speed for racing cyclists, so do mountain bikes solve a problem not previously perceived by city cyclists – that although they had been riding in cities for a century, the sturdiness of mountain bikes provides a new, and supposedly better, means of negotiating over-congested and badly-repaired city streets. By bringing the tensions between the modern and the counter-modern, between technology and the wilderness, on to city streets, a central arena of postmodernism,[64] mountain bikes are as crucial an element of the postmodern urban landscape as is architecture. Consequently, mountain bikers must be seen as a relevant social group that has been constructed by the same forces of modernization and postmodernity as the bikes themselves. To make this more clear, I want now to explore the social construction of another RSG, the cycle industry.

The Social Construction of the Cycle Industry

The seamless web that centres around mountain bikes – the different parts of the bikes, the bikes themselves, their history and mythology, their inventors, their users, the various elements of the cycle industry – maps on to Harvey's account of postmodernity to an astonishing degree. Changes in the cycle industry during the 1980s appear to fit closely the ideal–typical shift from Fordism to post-Fordism, and the catalyst for this shift appears to have been the appearance of mountain bikes.

The British cycle industry was at its peak during the 1950s. In 1955, over 3½ million bicycles were produced, of which almost a third were sold at home. From the 1960s, domestic production began to decrease more or less steadily until the mid-1980s. By 1970, significant imports began to appear in Britain, mainly from the far East, and domestic sales of bikes increased slowly during the 1970s and early 1980s. Between 1985 and 1990, however, although domestic production rose by only 30,000 (from 1,244,000 – the lowest figure since the 1950s – to 1,275,000), imports into Britain increased by more than three times (from 540,000 to 1,771,000) and domestic sales almost doubled (from 1,514,000 to 2,800,000).[65] These changes, both the increased sales and the transfer of production from home to abroad, are directly attributable to mountain bikes. In 1988, mountain bikes accounted for only 15% of British cycle sales; by 1990, this was up to 50–60%.[66] Mountain bikes have, then, been the major driving force in the recent regeneration of the cycle industry.

Mountain bikes have also been central to shifts in the industry from Fordist production to post-Fordism and flexible specialization. Preliminary research into changes in the cycle industry since the 1970s indicates similarities with changes in the culture industries.[67] The example of Penguin Books in publishing seems to offer a relevant model for Raleigh, the dominant British cycle manufacturer: both are long-established companies mass producing 'quality' products. Penguin was rare among publishers in coming early to Fordism, having 'a distinctive "company culture" ', with most aspects of production carried out in-house.[68] With the general shift in publishing towards post-Fordism, Penguin remains untypical in that it has opted instead for a 'neo-Fordist' approach, allowing an element of flexibility within the company, but retaining also a strong degree of integration.[69]

A brief glance at the organizational structure and approach of Raleigh, the leading British cycle manufacturer, suggests a parallel with Penguin. Raleigh's success rests on continual expansion since its founding in 1888, through a combination of business strategies typical of Fordist methods. These strategies have centred around 'far-sighted, imaginative thinking and hard work'.[70] Raleigh has throughout its history been close to major innovations in bicycle design, such as hub gears, small-wheeled 'shopping' bicycles and the 'high-rise' bicycle craze for which Raleigh developed the Chopper in 1969. The company's long-term view is especially evident in its planning during times of recession, with factory expansion and automation leading to lower prices. Keen attention to export

markets, diversification into motorized vehicles, and buying up troubled competitors have also been major parts of Raleigh's strategy.[71] Its Fordist approach to production is underlined by a visit during the 1920s made by its chairman, Sir Harold Bowden, to Henry Ford, 'to learn about his production techniques'.[72] These were put into practice immediately following the Great Depression.

In 1960, Raleigh Industries merged with the TI (Tube Investments) Group, becoming 'the world's largest producers of personal two-wheeled transport'.[73] In 1987, TI's cycle companies, the whole Raleigh 'family', were bought by Derby International, a company which is now 'the largest cycle manufacturer outside Asia', yet which has 'no offices or central staff'.[74] In 1989, Derby International/Raleigh held almost 50% of the overall British cycle market, although by 1992 this was down to around 30%.[75]

Like Penguin, Raleigh's production remains, for the most part, 'in-house'. Raleigh is a highly centralized organization, one of the few British cycle companies with its own design team, building as well as marketing its own bikes. It has, then, retained its Fordist approach into the 1990s. At the same time, there *are* hints that its organization is shifting towards something like neo-Fordism. Raleigh came late to mountain bikes, and consequently lacked credibility among the specialist, as opposed to the mass, market. Its response to this loss of credibility was the establishment during the 1980s of a well-funded Special Products Division which demonstrates Raleigh's recognition of the need to respond to market demand for flexible specialization. Furthermore, early in 1992, it was reported that Raleigh had signed a deal with a British designer of mountain bike accessories to act as an outside design consultant.[76]

Such examples, and the lack of corporate presence of Derby International, indicate that Raleigh is moving closer towards exhibiting 'the tension that has always prevailed within capitalism between monopoly and competition, between centralization and decentralization of economic power'. This tension manifests itself as an increased organization of capital by means of 'dispersal, geographical mobility, and flexible responses'.[77] Derby International own, as well as Raleigh, cycle companies and factories in Germany, France, Holland, the USA, Canada, Nigeria and South Africa.[78] In Britain, the company owns at least five brand names.[79]

Raleigh's speed at responding flexibly to the changing market, as well as to its old-fashioned image, has rewarded the company with a new-found reputation for top quality innovations at the higher price

end of mountain bikes.[80] Utilizing aerospace bonding techniques and innovative frame materials such as titanium, this Division has successfully countered Raleigh's image problem, de-emphasizing the Raleigh logo in favour of the new Dyna-Tech brand name.

Raleigh's moves towards neo-Fordism are untypical of most mountain bike companies, since few have existed long enough to have ever been Fordist. Rather, the typical mountain bike company is an exemplar of post-Fordist methods. It is generally only the older established companies that build bikes in Britain, using British-made Reynolds tubing. Aside from Raleigh, these include Townsend and its subsidiaries British Eagle and Coventry Eagle, Dawes, and the Elswick-Falcon brands which include Holdsworth, Falcon and Claud Butler. Very few newer companies have factories in Britain, especially not those that specialize in mountain bikes. Zinn is an exception to this, as is Saracen, but the latter in fact imports 'raw' Taiwanese framesets, which are only finished, painted and assembled in Britain.[81] Most mountain bike companies, rather than *building* bikes, 'source' them via a Taiwanese trading company.[82] Companies will specify their requirements to the trading company, who then submit a design, including tube lengths and frame angles. The trading company will then obtain the necessary tubing and components from the various factories in Taiwan. At the most extreme, a British company might never see a bike until the final product arrives at the warehouse to be sold.

Mountain bike production is, then, disintegrated and geographically dispersed. In the words of one mountain bike designer, it is 'remote control manufacturing'. Manufacturers are 'often little more than marketing companies with just an office and a phone'.[83] Muddy Fox, the company that popularized mountain bikes in Britain, is archetypal of this approach. Through the 1980s, Muddy Fox focused on high-profile marketing rather than design, which it left to its Japanese and, later, Taiwanese trading companies. Its early success lay less in the quality of its bikes than in its strategic marketing to a specific lifestyle.[84] Its most popular bike, the Courier, was 'a victory for sourcing and pricing' rather than design.[85] What sold the Courier were 'colour, style and status', exploiting the changing social trends of the 1980s.[86]

The tailoring of production to the needs of specialist market niches is a prominent feature of mountain bike manufacture, and the development of mountain bikes over the last ten years demonstrates the proliferation of more and more specialized markets for what

superficially is just one technology. Production for specialized markets problematizes the SCOT notion of stabilization, because the nature of capitalist innovation and accumulation works *against* stabilization.

Stabilization in mountain bikes *has* occurred, at a certain level. The features that distinguish mountain bikes from road bikes that I listed above continue to hold true.[87] However, closer investigation of the technological details shows constant shiftings in the design of frames and components which mean that since their inception, mountain bikes have been moving further and further away from being a stable artefact. They are in a constant and irresolvable state of interpretive flexibility. From this perspective, the original clunkers were the only versions of mountain bikes whose design was relatively stable.

This situation is the reverse of that described by Pinch & Bijker, where technological developments served to eliminate the problems experienced by RSGs, until all appear to have become happy with the same artefact. In contrast, since mass production of mountain bikes began, the technology has diversified with the appearance of each new RSG, so that now there is no longer just one 'mountain bike'; rather, there is a different artefact for each RSG, and there appears to be no prospect, need or desire for the stability Pinch & Bijker describe. Transformations in Western society since the late nineteenth century are such that it is now possible, and even necessary, to have a limitless variety of bicycles, and of mountain bikes, available. Greater numbers of people can now afford bicycles, which are more and more used for leisure rather than transportation. As uses for bicycles diversify, so the number of RSGs increases, with each new RSG demanding a different technological artefact, albeit still called a 'mountain bike'.

The social processes that Pinch & Bijker claim bring about stabilization, then, in fact lead to greater diversity. The redefinition of the problem that sees mountain bikes as ideal for city riding has not resulted in their design moving uniformly towards city use. Rather, companies generally now produce three or four different ranges of mountain bikes meeting the needs of the different RSGs: for their original rough stuff use; for racing; for city riding; and now, multi-purpose 'hybrid' or 'cross' bikes, combining features of both mountain and road bikes. Within these different ranges, specific models cater for more specialist requirements, as exemplified in Scott's Pro-Spec frame geometries described above.[88]

It may be that mountain bikes are actually still in a state of interpretive flexibility, and that with time, they *will* come to stabilize.

FIGURE 9
Brazed Lug

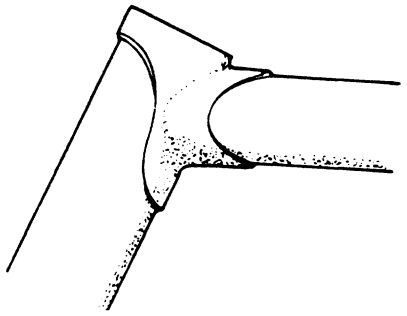
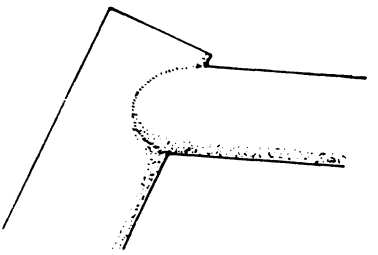


FIGURE 10
TIG Weld



Source: Both from Van der Plas, op. cit. note 30, 67.

Hindsight would then allow an analysis of mountain bike development that more closely resembles Pinch & Bijker's account of safety bicycles. I cannot, of course, discount this possibility. The question of hindsight, however, must be balanced against understanding fully the detailed unfolding of a technological development. The events that comprised the 'invention' of the safety bicycle in the 1880s were still in dispute as late as 1900.[89] By the time Pinch & Bijker were writing in 1984, they seemed more clearly defined. My account of mountain bike development is, then, only one version of the story, which hindsight will no doubt come to modify. Greater distance from the events will always make an artefact look more stable. However, this will also black-box the technology, along with its RSGs and the relations among them. Hindsight has both advantages and disadvantages.

Technological (Cycle) Frames

To stick with the present versions of the story, transferring mountain bike production to the Far East has brought with it a shift in the 'technological frame' associated with bicycle manufacture, a shift that has been crucial in enabling the high degree of product differentiation among mountain bikes. Bijker defines a technological frame as 'a combination of current theories, tacit knowledge, engineering practice (such as design methods and criteria), specialized testing procedures, goals, and handling and using practice'.[90]

Proportional geometry, and the yearly shifts in frame angles until they stabilized, are not easily compatible with the traditional style of frame building in Britain. The tubes of British-made cycle frames tend to be brazed together at the ends, inside lugs (see Figure 9). The tubes are joined by melting between them a material, typically brass, with a lower melting point than the steel of the tubes. It is difficult with lugged frames to vary the angles, as lugs are mass-produced at a fixed angle. Only a large demand for a specific frame angle would justify the cost of changing the settings on the lug-casting equipment. It is no surprise, then, that the only mountain bikes built with lugs come from the long-established companies with their own factories, using traditional construction methods to produce large numbers of bikes: Raleigh, Dawes, Townsend, British Eagle, Claud Butler and the American company Trek.

In contrast, even the British-built Zinn mountain bikes are 'TIG-welded'. This is by far the most common joining method for mountain bikes, particularly since production moved predominantly to Taiwan. With TIG-welding, the tubes themselves are welded directly together, using a tungsten welding element to prevent corrosion, and a blanket of inert gas to prevent oxidization (see Figure 10).[91] This method allows a far more flexible approach to frame angles, enabling the industry to cater to more specialized demand. A further feature of the Taiwanese technological frame, the use of new technology, also contributes to this. Computerization has shortened the design process from a few days to a few minutes. It is no problem, therefore, for a factory to produce, relatively quickly, short runs of a large number of different designs.

The growing importance in mountain bike production of non-traditional technological frames is thus a central factor in the shift from Fordism to post-Fordism. It might even be generally the case, as it is here, that shifts in technological frames reflect broader cultural shifts. The shifts in Western culture towards postmodernity that are embodied in mountain bikes form the backdrop of a transformation in the cycle industry comprising not just an economic revival, but a significant shift in the structure of power relations within the industry.

Writers using SCOT are beginning to provide more elaboration of their RSGs. For example, Bijker explores the ways in which fluorescent lamps were socially shaped through the 'social interactions' among the RSG he describes – the Mazda companies that manufactured most of the lamps, other lamp manufacturers, the electricity

utilities, the light fixture manufacturers, customers and the government.[92] Bijker explicitly resists the use of RSGs as a means of 'imputing hidden interests to social groups',[93] but in doing so he also underplays the possibility that there exist not-so-hidden interests which can give rise to conflict among RSGs and affect the shaping of an artefact.

The example of mountain bikes shows that even where 'interests' aren't stated by the RSG concerned, these do not have to be imputed by the analyst. It is sufficient simply for other actors to perceive hidden interests for this to shape the meanings they construct for an artefact. British cycle production is no longer straightforwardly controlled by manufacturers in Britain. Control, along with production, has been fragmented among the manufacturers, the Taiwanese sourcing agents, and the component giant Shimano; the latter is in fact perceived by many as controlling the whole industry.[94] The dynamics of this changing relationship within the cycling world, and of the changing technological frame, are something that must inevitably remain beyond the grasp of SCOT as it currently stands.

Conclusion

Pinch & Bijker's original exposition of SCOT includes the objective of bringing together the micro-level of the technological content of artefacts with the macro-level of the wider society in which these are located.[95] Ironically, the SCOT framework obstructs this possibility by establishing an untenable distinction between the micro and the macro – that is, between a technology's interpretive flexibility and the mechanisms of its stabilization on the one hand, and its wider social context on the other.

With the case of mountain bikes, I have indicated a number of implications this approach has for our understanding of the social shaping of technology. First, by seeing the third stage as work for the future, SCOT's explanatory power remains too strongly rooted in the internal workings of technology; it doesn't explain the social aspects of technological development as richly as the technological aspects. Second, despite holding up relevant social groups as the agents of technological change, few studies give a detailed enough account of RSGs to justify this claim. It isn't sufficient simply to name 'women cyclists' and 'elderly male cyclists' as relevant groups: their relationship to the artefact must be elaborated more fully if their ability to

effect change is to be convincing. Third, the relationship of RSGs to each other must also be explained; if the wider context derives from the RSGs, then the relations among them are the social arena within which the technology is constructed.

Finally, the notion of stabilization in SCOT needs more attention. As a start, further research from within the 'new sociology of technology' perspective could be undertaken on the distinction between Fordism and post-Fordism, using artefacts other than bicycles. This would also be a way of assessing how valid it is to introduce concepts such as postmodernity from the field of cultural studies into technology studies. Once such problems have been addressed, it may then be possible more fully to articulate ways in which social relations are built into the very design of an artefact.

• NOTES

This paper grew out of discussions with the Mike Michael on various issues related to technology. I would like to thank Maria Thomas for regular help in shaping my thoughts and improving my writing, and Mike Michael, Brian Wynne, Jon Purkis, Peter Hughes, John Wakeford, Trevor Pinch, Peter Simmons, Stewart Russell, Scott Lash and four anonymous referees, for comments on earlier drafts of the paper. Thanks are also due to Hilton Holloway for insights into the workings of the cycle industry; Lisa Warburton of the Cyclists' Touring Club for help and information in finding material; Tom Cahill for the loan of mountain bike magazines; and Sam Dixon for his paper on mountain bikes.

1. Trevor J. Pinch and Wiebe E. Bijker, 'The Social Construction of Facts and Artefacts; or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other', *Social Studies of Science*, Vol. 14 (1984), 399–441.

2. H.M. Collins, 'An Empirical Relativist Programme in the Sociology of Scientific Knowledge', in Karin D. Knorr-Cetina and Michael Mulkay (eds), *Science Observed: Perspectives on the Social Study of Science* (London: Sage, 1983), 85–113.

3. For example, Wiebe Bijker, 'The Social Construction of Bakelite: Towards a Theory of Invention', in Bijker, Thomas P. Hughes and Trevor Pinch (eds), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press, 1987), 159–87; Bijker, 'The Social Construction of Fluorescent Lighting, or How an Artifact Was Invented in Its Diffusion Stage', in Bijker and John Law (eds), *Shaping Technology/Building Society* (Cambridge, MA: MIT Press, 1992), 75–102; Boelie Elzen, 'Two Ultracentrifuges: A Comparative Study of the Social Construction of Artefacts', *Social Studies of Science*, Vol. 16 (1986), 621–62; Thomas J. Misa, 'Controversy and Closure in Technological Change: Constructing "Steel" ', in Bijker & Law (eds), op. cit., 109–39.

4. Pinch & Bijker, op. cit. note 1, 411.
5. Ibid., 409.
6. Ibid., 416.
7. Ibid., 423.
8. Ibid., 416.
9. Ibid., 415.
10. Ibid., 428.
11. This is not a criticism that holds for subsequent work in SCOT. Bijker (1992) and Misa, op. cit. note 3, both describe their RSGs in some detail.
12. Stewart Russell, 'The Social Construction of Artefacts: A Response to Pinch and Bijker', *Social Studies of Science*, Vol. 16 (1986), 331–46.
13. John Law and Wiebe E. Bijker, 'Postscript: Technology, Stability and Social Theory', in Bijker & Law (eds), op. cit. note 3, 290–308.
14. The empirical material in this paper draws on unfinished fieldwork in the cycle industry. This includes interviews with mountain bike riders, designers and manufacturers, independent framebuilders, bicycle technologists and retailers, as well as company brochures, cycling and mountain biking magazines, and archive material on the Raleigh cycle company. Uncredited quotations are from my interview data.
15. Mountain bikes are also known as 'All-Terrain Bikes' (ATBs) and 'off-road bikes', as well as 'MTBs' (MounTain Bikes). Racing, touring and sports bikes are generally referred to by mountain bikers under the blanket term of road bikes.
16. Frame materials are one of the major areas of technical innovation in mountain bike design, lightness being considered a crucial feature. It is now common practice for new materials, often from the aerospace industry, to be tested by using them in bicycle frames. While steel remains the most common frame material, there are mountain bikes built of aluminium, magnesium, carbon-fibre, titanium, and most recently Metal Matrix Composites (MMCs).
17. Shimano groupsets referred to in this paper are from their 1992 range.
18. Charles Kelly, in Kelly and Nick Crane, *Richard's Mountain Bike Book* (London: Pan, 1990), 21.
19. Iain Lynn (ed.), *The Off-Road Bicycle Book* (Hawes, North Yorkshire: Leading Edge Press, 1989), 7.
20. Kelly, op. cit. note 18, 29.
21. Ibid., 21.
22. Ibid., 22.
23. Michael Mulkay, *Science and the Sociology of Knowledge* (London: George Allen & Unwin, 1979).
24. Quoted in Scott Martin, 'Mountain Biking Turns 10', *Bicycling*, Vol. 30, No. 9 (October/November 1989), 39–44, at 41.
25. Kelly, op. cit. note 18, 50–51.
26. Commercially and, from the clunker group's point of view, technologically, 'unsuccessful'.
27. Kelly, op. cit. note 18, 55.
28. H.M. Collins (ed.), *Knowledge and Controversy: Studies of Modern Natural Science*, Special Issue of *Social Studies of Science*, Vol. 11, No. 1 (February 1981), 3–158.
29. Kelly, op. cit. note 18, 90.
30. Rob Van der Plas, *Bicycle Technology: Understanding, Selecting and Maintaining the Modern Bicycle and its Components* (San Francisco, CA: Bicycle Books, 1991).

31. Kelly, op. cit. note 18, 90.
32. Ibid., 91.
33. Tom Bogdanowicz, 'Mountain Bikes – Set to Dominate Cycling', in Lynn (ed.), op. cit note 19, 104–10, at 104.
34. The first angle given is for the head tube, the second for the seat tube.
35. Hughie Mackay and Gareth Gillespie, 'Extending the Social Shaping of Technology: Ideology and Appropriation', *Social Studies of Science*, Vol. 22 (1992), 685–716. This point is also touched on by Pinch & Bijker, op. cit. note 1, and explored in more depth by Ruth Schwartz Cowan, 'The Industrial Revolution in the Home', in Donald MacKenzie and Judy Wajcman (eds), *The Social Shaping of Technology* (Milton Keynes, Bucks. & Philadelphia, PA: Open University Press, 1985), 181–201.
36. This constant shifting in the meaning of technological features recalls Derrida's notion of *différence*. Derrida argues that meaning is never fixed, but only temporary. The concept to which words such as 'mountain bike' are attached is constantly changing. See Jacques Derrida, *Writing and Difference* (London: Routledge & Kegan Paul, 1978).
37. It would be valid to argue that post-Fordist economics should be differentially applied to different types of industry. Except for questions of safety, the cycle industry in the West is left largely to the 'free market', unhindered by state intervention. The applicability of a post-Fordist analysis to other types of industry would need separate research; for example, state monopoly industries or industries whose products are affected by environmental regulations are subject to more constraints than simply 'free market' economics.
38. Kelly, op. cit. note 18, 27.
39. Ibid., 27, 60.
40. Ibid., 15.
41. Russell, op. cit. note 12, 337.
42. David Harvey, *The Condition of Postmodernity* (Oxford: Blackwell, 1989).
43. Ibid.; Fredric Jameson, *Postmodernism, or, the Cultural Logic of Late Capitalism* (London: Verso, 1991).
44. See Harvey, op. cit. note 42, for some of the issues involved in this debate, and Anthony Giddens, *The Consequences of Modernity* (Cambridge: Polity Press, 1991).
45. This Marxist perspective, assuming that the base determines the superstructure in the final analysis, begs the question of what it is that causes modernization in the first place. An alternative perspective can be found in Dan Shapiro, Nick Abercrombie, Scott Lash and Celia Lury, 'Flexible Specialisation in the Culture Industries', in Huib Ernste and Verena Meier (eds), *Regional Development and Contemporary Industrial Response: Extending Flexible Specialisation* (London: Belhaven, 1992), 179–94. Shapiro and his colleagues, writing about the culture industries, argue in contrast to Harvey that the 'expressive revolution' of the 1960s was a major source of changes in the record industry, that is, that 'an *economic* phenomenon . . . was arguably in large part a product of *cultural* causation'. It would, of course, be possible to argue indefinitely between these two positions, citing cultural and economic changes each in turn as having caused the other. That argument belongs elsewhere, though.
46. Harvey, op. cit. note 42, 260ff.
47. Ibid., 179–81.
48. Ibid., 260–61; Giddens, op. cit. note 44.
49. Harvey, op. cit. note 42, 260.
50. Ibid., 264.

51. Ibid., 284.
52. Ibid., 175–79, referring to Lash & Urry, and to Swyngedouw.
53. Ibid., 156.
54. Ibid., 285ff.
55. Jameson, op. cit. note 43, 5.
56. Ibid., 20.
57. Peter L. Berger, Brigitte Berger and Hansfried Kellner, *The Homeless Mind: Modernization and Consciousness* (Harmondsworth, Middx: Pelican, 1974), 178. This book pre-dates the advent of postmodernity. However, considering the common view that postmodernity is simply an intensification of modernity (e.g. Harvey, op. cit. note 42), it provides valuable insights into the changes in the construction of identity that result from modernization.
58. Richard Grant, 'Foreword' to Kelly & Crane, op. cit. note 18, 10.
59. Richard Ballantine, 'Pioneers Meet People-Pressure', *New Cyclist*, No. 17 (November/December 1991), 21.
60. The first two are made by Raleigh, the others by Dawes.
61. Harvey, op. cit. note 42, 338; the bike building methods of the clunker group also call to mind Lévi-Strauss's account of the 'bricoleur', who unlike the more disciplined engineer, works with 'whatever is at hand': see Claude Lévi-Strauss, *The Savage Mind* (London: Weidenfeld & Nicolson, 1972), 17. Mountain bikes are, then, a piece of 'bricolage'.
62. For the Lake District example, see John Wyatt (ed.), 'Report of the Adventure and Environmental Awareness Group Conference on Mountain Biking and the Environment' (Charlotte Mason College, Ambleside, 8 February 1992).
63. Joanne Colley, 'An Unnecessary Contrivance or a Versatile Leisure Machine?', *Westmorland Gazette* (21 February 1992), 11.
64. Harvey, op. cit. note 42.
65. Bicycle Association of Great Britain, 'Cycling – the Current Market' (1991), 6.
66. Ibid.
67. Shapiro et al., op. cit. note 45.
68. Ibid., 182.
69. Ibid.
70. Gregory Houston Bowden, *The Story of the Raleigh Cycle* (London: W.H. Allen, 1975), 104.
71. Ibid.
72. Ibid., 63.
73. Raleigh Industries, 'Raleigh Through the Years' (n.d.).
74. *Ethical Consumer*, No. 6 (February/March 1990), 19.
75. *Cycle Press*, No. 75 (January 1993), 5.
76. *Mountain Biking UK*, Vol. 5, No. 4 (April 1992), 32.
77. Harvey, op. cit. note 42, 159; a contrasting position can be found in Scott Lash and John Urry, *The End of Organized Capitalism* (Cambridge: Polity Press, 1987).
78. Nick Garnett, 'Flat Out in Pursuit of the Yellow Jersey', *Financial Times* (4 October 1989), 25.
79. *Ethical Consumer*, op. cit. note 74, 22.
80. 1992's suspension mountain bike, the Raleigh Activator, may have lost the company some of this reputation. The Activator is considered by few in the mountain biking world as a 'true' mountain bike.

81. This discussion excludes independent custom framebuilders, who generally use either Reynolds or the Italian Columbus tubing, but account for a very small part of the cycle market.

82. Until the mid-1980s, Japan rather than Taiwan dominated this side of the industry, and China is now beginning to make headway; see Kevin Rafferty, 'Bicycle Plant in Van of New Model Army', *Guardian* (15 August 1992), 32.

83. *Ethical Consumer*, op. cit. note 74, 18.

84. Jay Rayner, 'Of Lycra Cycling Shorts and the Wheels of Fashion', *Independent on Sunday* (15 March 1992), 22.

85. Hilton Holloway, *Bicycle* (June 1992), 16.

86. Rayner, op. cit. note 84.

87. As Trevor Pinch says, 'I know nothing about mountain bikes but I can tell one when I see one', personal communication.

88. As evidence that the earliest RSGs still exist, Pace Research, a producer of top-of-the-range mountain bikes and components, has produced a £4000 prototype bike designed solely for going downhill, although the mass market appeal of such a bike is now minimal: see Bob Allen, 'Dream Demon', *Mountain Biker International* (August 1992), 22–24.

89. Derek Roberts (ed.), 'The Invention of the Safety Bicycle, Correspondence in the Weekly Magazine *Cycling* from 1 September 1900 to 15 December 1900' (Mitcham, Surrey: privately published, 2nd edn, 1990).

90. Bijker (1987), op. cit. note 3, 168.

91. Van der Plas, op. cit. note 30, 56. 'TIG' stands for 'tungsten-inert-gas'.

92. Bijker (1992), op. cit. note 3.

93. Ibid., 77.

94. See, for example, 'Only Your Product Manager Knows for Sure', *Mountain Bike Action*, Vol. 6, No. 8 (August 1991), 94–108.

95. Pinch & Bijker, op. cit. note 1, 431.

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