Symposium on the History of Technology: Past, Present, and Future
Massachusetts Institute of Technology
Program in Science, Technology, and Society (STS)
June 7-8, 2024 (Session 3)

How Things Work and Why It Matters – or, Why Poring Over Automotive Wiring Diagrams from the 1970s Isn't Actually a Colossal Waste of Time

David Lucsko

[illustrations follow text]

Thank you, Deborah, and thank you, Roe, for putting this together and Judy for doing all of the logistics as we've all said. Historians of technology like me have long endeavored to distance themselves from antiquarianism or internalism, what we sometimes pejoratively call hardware studies. So although we still focus on particular technologies in our work, we no longer study technology for its own sake. Instead we do contextual work. We downplay the significance of our black boxes themselves in favor of sophisticated analyses of the cultural, political, and economic circumstances of their development and use.

Now, we all know that the inner workings of certain technologies do in fact matter, right? -- that the material reality of gears and plastics and transistors do often have a say, as we put it. But it's been a long time since these sorts of things have played decisive roles in most of our studies.

So people, institutions, ideologies, cultural and social norms, these are the things that ultimately matter, right? But that does beg some troubling existential questions, one in particular. What does it actually mean to be a historian of technology? If people, institutions, ideologies, and the like are what really matter, then what is it that differentiates our work from that of our colleagues who are not historians of technology but whose studies ultimately hinge on the same litany of explanations?

And I find myself asking these questions in no small part because many of my colleagues at Auburn University work on projects centered on particular technologies, but only a handful of them actually identify as historians of technology per se. And so I sometimes find myself wondering: were Leo Marx and David Noble right? Do we really need the history of technology as an organized field?

Now, my answer is yes, and for a whole host of reasons, but today I'm going to focus on just one, and that is technology itself. Now again, none of us wants to be seen as a rivet counter, but I think that if we power past our fears about focusing on the technology too much, and if we nudge our chosen technologies just a bit closer to center stage in our work, then I think our studies stand to benefit.

And to try to make this case today I'm going to do two things. First, I'm going to begin with what is admittedly a very sweeping and unfair tour through the historiography where I'm going to touch on just a handful of studies published over the long durée in which I think fine grain analyses of particular technologies have paid off handsomely big picture–wise. And then I'm going to zoom in briefly on my own work, past and present, to give you all a sense of the sorts of things that I've tried to learn over the years from the things themselves.

So where to begin? I want to start with Arnold Pacey and his classic work on medieval cathedrals.[1] Now, I first encountered this when I was an undergraduate at Georgia Tech. And it's a work that I still assign to freshmen at Auburn today because it's a work that forces students who have been brought up under the assumption that all technological change is a result of economic rationality -- it forces them to confront other causes for technological change, in this case, namely, idealism.

It forces them to consider the role that idealism played in the construction of those places of worship with walls that rose to the heavens, right? So in Pacey's work there's an important big picture lesson sort of at the heart of things. But what grabbed me when I first read that book so many years ago now, and what continues to grab my students today, is the way that Pacey carefully walks us through the technological challenges that building those soaring walls posed, as well as the solutions that the craftsmen involved came up with.

Now, Arnold Pacey certainly could have made a case for idealism as a cause of technological change without doing any of this, but I think that precisely because he takes us through specific problems, like thrust forces, and through specific solutions to those problems, like flying buttresses, I think as a result of that, he ends up making a much stronger case for the power of idealism to actually shift the technological state of the art (fig. 1).

Again, a very unfair survey of the literature here. I'm reminded as well of David Hounshell's work on interchangeability in the mid- to late 19^{th} Century.[2] It still stands out to me as a classic example of the utility of really paying attention to the things themselves. And I think most of us in this room will remember one of the things that he did in, I think it was his second appendix, right, where he documented how he was at the Smithsonian and took apart various Singer sewing machines from the 1860s and 1870s and was able to test their fit and finish and their tolerances.

And as a result of this work, Hounshell was able to confirm empirically that Singers from the 1860s and 1870s were in fact not interchangeable, which is pretty cool work (fig. 2). But more importantly, in the body of the text of his work itself, working from archival records, he carefully walked us through the spread of interchangeable production from the federal arsenals that Roe Smith studied through the sewing machine, bicycle, and automotive businesses.

And he did so how? By paying careful attention to the techniques and to the machinery deployed in those different industries, culminating in my favorite part of the book, a detailed look at why the Ford Motor Company had so much trouble shifting from production of the Model T to the Model A at the end of the 1920s.

Now, Henry Ford himself, curmudgeon that he was, had a lot to do with that problem. But what Hounshell demonstrates is precisely how and why the many thousands of machine tools at the River Rouge plant mattered in that episode as well.

In a broadly similar manner, there's of course Tom Hughes's monumental work on the development of electrical systems[3] -- a work that stands out for me, at least, for its careful explanations of exactly how specific components -- things like induction motors -- how these things actually worked (fig. 3). And also his careful explanations of exactly how large-scale electric distribution networks function, all of which in turn helps his readers grasp the concept of technological systems and why they matter.

Likewise, Bob Post's work on the origin and evolution of drag racing builds its case for the importance of technological enthusiasm as a cause of technological change, in part by carefully engaging with the technology of drag racing itself.[4] He pays attention to superchargers and to special brews of potent fuels. He pays attention to clutches and camshafts and roll bars and aerodynamic forces (fig. 4). And it's no wonder that his book *High Performance* has done exceptionally well, both among professional historians and among drag racers themselves, because the book speaks their language.

And I bring up Post's book here in particular because the fact that his book speaks their language means that Bob Post's broader arguments have actually reached a broader audience. And as I know, most in this room will recognize that this is no mean feat, right?

Now a handful of others leapt to mind as I was putting this talk together. In particular, there's Karen Freeze's study of open-end spinning technology in Cold War–era Czechoslovakia.[5] This was an article in *T&C*. And in this article, Karen first walks us through the operation of the old technology, a ring spinning machine. And then she carefully walks us through the operation of the new Czechoslovak-developed open-end spinning machine (fig. 5). And she does this in order to help her readers understand exactly why the open-end approach took the textile trade by storm on both sides of the iron curtain and became a rare example of east-to-west technology transfer during the Cold War.

Now, I have a little inside baseball for you here on this. I was on the editorial team at *T&C* when Karen Freeze's article was in production. And I remember that for some reason, the page layout guy at Hopkins was having a heck of a time reproducing the line-art drawings that are at sort of the heart of Karen Freeze's study. They kept coming out quashed. And I remember how justifiably panicked Karen was about this. "The pictures aren't coming out right. They're wrong. They're wrong."

And we worked like heck to get this to come together. And I understood how distraught she was about this, because she knew, as I did, that those images had to pop just right so that readers could really understand how that ring spinner worked and how that open-end spinner worked so that they could grasp why, again *why* that new technology took the textile trade by storm. The technology itself mattered.

A couple of others quickly before I get to my own work. There's Whitney Laemmli's close analysis of ballet shoes,[6] another *T&C* article, an analysis in which material differences between the ballet slippers that were worn through the early 20th Century and the point shoes that have been worn since helped to account for differences in how ballerinas trained, how they danced, and even the physical characteristics of their bodies (fig. 6). And you get this by carefully studying the shoes and how they interact with one's body.

And finally, there's Heidi Hausse's work on early modern mechanical hands[7] -- prostheses, prosthetic limbs. In her work, Hausse carefully studies the material composition, the workmanship, and the mechanical design of a number of surviving examples of these early modern prosthetic limbs (fig. 7). And doing so, carefully reading the surviving limbs, leads her to two important interventions.

First, it led her to the conclusion that these early prostheses were almost certainly never used to hold a sword in battle, which is what people have long assumed about them, that people lost their arms in battle and they got a prosthetic iron hand so that they could forge on. Not really true.

But second, and I think more importantly, Hausse has been able to reconstruct precisely how these artificial limbs were made, and by whom. And I don't mean specific people here, but I mean she's able to identify the networks of craftsmen from different guilds whose specialties came together at different times and places and in different combinations to develop this new kind of prosthetic aid. And you get that by studying the technology itself very closely.

Now as for my own work, I will try to be at least somewhat brief. For my dissertation, I studied hot-rodding, the hobby and business of modifying ordinary cars to squeeze out more power. And to do so properly, I discovered pretty quickly that I had to learn exactly how things like manifolds and camshafts and carburetors work. And I had to do that in order to really understand how and why hot-rodders did the things that they did and why they were successful or not successful.

A little more inside baseball here on this front: my very first SHOT meeting was in San Jose back in 2001. Right when the planes started flying after 9/11 they convened that meeting. And I was presenting at that SHOT conference a paper on how hot-rodders in the 1970s found ways to continue to improve the performance of their cars without elevating tail pipe emissions and therefore running afoul of authorities like the California Air Resources Board or the federal EPA.

And I remember that in the Q&A to that panel, one of the people in the audience stood up and was very upset and flatly declared that this was not possible, this was untrue. "You *can't* have more performance without affecting tailpipe emissions," etcetera, etcetera. And I listened to the question and I sort of sat there and thought about it. I knew that the person was wrong, right? I had seen the technical papers from the EPA which studied hot-rodders and emissions levels, and I understood how things like intake manifolds and ignition systems interacted with pollution devices like vacuum ignition retards and exhaust gas recirculation.

So I knew this guy was wrong, but what struck me as he asked this question was, aha! I hadn't made my case. And I hadn't made my case precisely because I hadn't gone into the fine grain technical details of what hot-rodders do and how their work interacted with emissions control devices. Lesson learned. So as I finished up my dissertation and then as I worked on my first book, I made damn sure that I laid those sorts of things out much more clearly (fig. 8).[8]

Now these days, I am working on what I consider to be my fun book, a book about the American car culture during the 1970s. Side note: this was the most important decade in the history of the automobile, but that's another story for another day. Anyway, one of the chapters in this book revisits the seatbelt interlock debacle of 1974. And for those in the room who don't remember this or have never heard of it, really briefly, for just over a year, from late 1973 to late 1974, virtually every new car sold in the United States market was equipped with a system that was designed to compel seatbelt use, right, compel seatbelt use by preventing the car's engine from starting unless the driver and front passenger buckled up first, right?

Now this was a sequential system, which meant that if you didn't want to use your seatbelt, you couldn't just buckle the beat once, tuck it under the seat and forget about it, right? You couldn't do it that way. Instead, every time you wanted to start the engine, you had to sit down first, then buckle up. Then you could turn the key (fig. 9), okay? Now the theory here was pretty solid. At a time when lots of Americans weren't using their seatbelts, the theory here was pretty solid: Buckle up or you can't drive.

But in practice, this was one of the most hated technologies ever rolled out. If it malfunctioned, which was common, you were stranded. If you were in your garage and you just needed to back your car up one foot to access something at the front, you had to buckle up and close the door and everything first. If you put a package on the front seat next to you, you had to buckle the package up first. If you had a purse, and you put it in the middle seat, you could start the engine, but a buzzer would go off continuously until you buckled up the middle seat. People hated this thing.

And amid a surge of constituent fury, Congress voted in late 1974 both to ban the interlock from new cars and, importantly, to legalize the already widespread practice of disabling it. Now, a handful of scholars have touched on the interlock episode as part of the larger story of auto safety in the 1970s. There's Lee Vinsel, Jamie Wetmore, and Renée Blackburn from MIT in her recent dissertation here.[9]

But a lot of questions remain unaddressed, particularly regarding the material reality and lived experience of this episode, namely, in looking at it, I want to know how exactly did these systems work? What was it like to use them? What kinds of things went wrong with them? How could they be repaired? What kind of inspections happened at the state and local level? And of course the kicker, how exactly could these systems be disabled?

Now, if we were talking about pretty much anything else, an easy place to go – not easy in the sense that it's easy to do -- but a straightforward place to go would be material culture. You'd assemble a sample of surviving examples of 1974 model year cars, and you would study them and figure out how these systems work. But in this case, you can't do that, and that's because nearly every model-year 1974 car is long gone. And among the few that remain, you are not going to find a functioning interlock because almost all of them were disabled five decades ago.

In my experience, about the only evidence you're likely to find, the only physical evidence you're likely to find, is a mass of botched wiring under the dashboard and front seats. So instead we have to try to reconstruct what these systems looked like and how they worked using written sources. And we're in luck here. There are a lot of sources. There's patents. There's technical papers (fig. 10). There's evidence from federal agencies. There's newspaper and magazine coverage (fig. 11). And of course there's things like automobile repair manuals (fig. 12).

And I've been working with these sources for a while now, and by poring over the wiring diagrams from the technical papers and the repair manuals, I've put together exactly how these systems worked. Reverse engineered, basically -- well, not reverse engineered but figured it out from the wiring diagrams. The basics differed brand to brand, but they were pretty similar across the board.

You had pressure sensing contacts in the front seats. You had switches in the seatbelts, a buzzer and a light on the dashboard (fig. 13). You also had a little button under the hood near the engine so that a mechanic could start the car once without having to get in and buckle up, so they could observe what was happening as they started the car up (fig. 14).

And importantly, you also had what was called the interlock module, which was a metaphorical black box containing a printed circuit board and sequenced transistors that enforced the system's logic (fig. 15). And I don't have time -- somewhat ironically given my ultimate point here, I don't have time to go into the fine grain detail here today. Believe me, I would love to.

Let me just sum this up by saying in a nutshell that what happened is a sensor in each seat would send current to the logic module if somebody sat in that seat. And then that module would allow the car to start if and only if it *then* received current from the seatbelt buckle which told it that that person had actually buckled up after they sat down. So if the right sequence of butts hitting seats and buckling up happened, the car would start. If it didn't, it wouldn't. I'd love to talk about this at greater length, but what you're wondering now, surely, is why does any of this matter?

Three things. First, because nearly all of these systems have vanished without much of a material trace, reconstructing their form and function by studying things like wiring diagrams puts us one step closer to understanding what the average mechanic and the average motorist encountered back in 1974. It puts you a little bit closer to the lived experience of the interlock episode.

Second and related, the various means of disabling, disconnecting these systems that pop up in period magazine and newspaper coverage, they're good on their own, but they really only make sense if you also understand how the systems worked and what the kinds of components you were going to encounter under the dash and under the seats looked like.

Third, maybe most importantly, there's the components themselves, especially that interlock module, because at a time when logic modules of any sort were still exceedingly rare in automotive applications, here in 1974, we have all of the car makers -- foreign and domestic -- taking a pretty big leap of technological faith and deploying rather sophisticated logic modules across the board on millions of vehicles.

And in retrospect, this would prove to be an important pivot point in the computerization of the automobile. But you'd never know it if you didn't understand something about how and why the interlock system worked the way that it did. I know I'm perilously low on time, but the buzzer hasn't rung yet, so who knows?

Let me wrap up by saying two more things. First, my main point here today has been to try and demonstrate or at least suggest by looking at some of the literature and some of my own work that close technological analysis, studying the things themselves, doesn't have to come at the expense of a richly contextual history of technology. And I think in a lot of cases, doing that kind of close reading of the technology itself can actually be the key to unlocking that broader context. Sometimes it's really important.

Second, I also want to argue that even when it doesn't really matter for our studies exactly how a given technology works, I think it behooves us to try to find out anyway, because doing so is, after all, an important part of what sets us apart as historians of technology. And in my experience, it often pays off in the classroom, too. Roe Smith knows this, right? Every year he gets special dispensation from the City of Cambridge and somehow from MIT security to bring a Harpers Ferry rifle to campus to show his students. And he does this why? So that they can see for themselves the intricate precision of an interchangeable firearm.

And I know from my own experience, the questions I get in the classroom, they tend not to be big-picture questions. Those are the things I want the students to work toward, but what I get are questions like how does a two-stroke motor work? Why does an airplane lift, right? What was it that Faraday discovered? Those are the questions that I get. And so knowing a little bit about those things has helped me in the classroom as well.

So let's not fear the things themselves. I know we all love them. I saw all of yall's faces at the museum last night as we saw the objects. So let's not fear them. Let's learn from them.

illustrations follow

[1] Arnold Pacey, "The Cathedral Builders: European Technical Achievement between 1100 and 1280," chap. 1 in *The Maze of Ingenuity: Ideas and Idealism in the Development of Technology*, 2nd ed. (Cambridge, Mass.: MIT Press, 1992 [1974]), pp. 1–28.
[2] David Hounshell, *From the American System to Mass Production, 1800–1932: The Development of Manufacturing Technology in the United States* (Baltimore: Johns Hopkins University Press, 1984).
[3] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore: Johns Hopkins University Press, 1983).
[4] Robert C. Post, *High Performance: The Culture and Technology of Drag Racing, 1950–1990* (Baltimore: Johns Hopkins University Press, 1994).
[5] Karen Johnson Freeze, "Innovation and Technology Transfer during the Cold War: The Case of the Open-End Spinning Machine from Communist Czechoslovakia," *Technology and Culture* 48 (April 2007): 249–285.
[6] Whitney Laemmli, "A Case in Pointe: Romance and Regimentation at the New York City Ballet," *Technology and Culture* 56 (January 2015): 1–27.
[7] Heidi Hausse, *The Malleable Body: Surgeons, Artisans, and Amputees in Early Modern Germany* (Manchester, U.K.: Manchester University Press, 2023).
[8] David N. Lucsko, "Manufacturing Muscle: The Hot Rod Industry and the American Fascination with Speed, 1915–1984" (Ph.D. diss., Massachusetts Institute of Technology, 2005), and *The Business of Speed: The Hot Rod Industry in America, 1915–1990* (Baltimore: Johns Hopkins University Press, 2008). I continued to do the same in my second book, *Junkyards, Gearheads, and Rust: Salvaging the Automotive Past* (Baltimore: Johns Hopkins University Press, 2016).
[9] Jameson M. Wetmore, "Delegating to the Automobile: Experimenting with Automotive Restraints in the 1970s," *Technology and Culture* 56 (April 2015): 440–463; Lee Vinsel, *Moving Violations: Automobiles, Experts, and Regulations in the United States* (Baltimore: Johns Hopkins University Press, 2019), esp. 245–247; Renée Blackburn, "Highway Madness!: Politics and Citizen Participation in Postwar US Traffic Safety Technology and Policy" (Ph.D. diss., Massachusetts Institute of Technology, 2017).

springing from the walls and curving across between them, gave the whole building a more unified appearance. However, the problem of building such a vault over any space as wide as the nave of Durham Cathedral was something that had not been attempted in medieval Europe before about 1075. Then, in France and the Rhineland, a number of churches were given simple vaulted ceilings that offered a variety of tentative solutions to the problem. Almost all these vaults were conceived as continuous stone shells forming a smoothly curved ceiling to the church. The innovation at Durham consisted in subdividing the vault into small areas by means of stone ribs. These ribs were really arches, crossing the church both transversely and diagonally; and in order that they should all reach up to the same height, the transverse arches rose sharply to a point, whereas the diagonal ones were semicircular (see figures 2 and 3). This stage in the development of Durham was not reached until the 1120s. But even then, pointed arches were almost unknown except in a few Cistercian abbey churches, although later in the twelfth century they became the most characteristic feature of "Gothic" architecture.

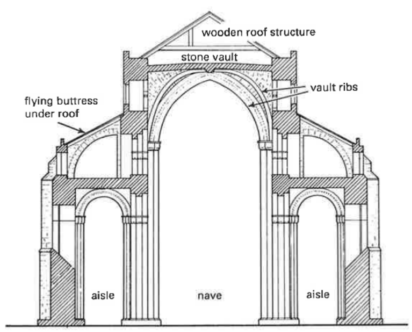


Figure 2
Durham Cathedral: cross-section of the nave. The cathedral was begun in 1093; the nave was built c.1104–30.

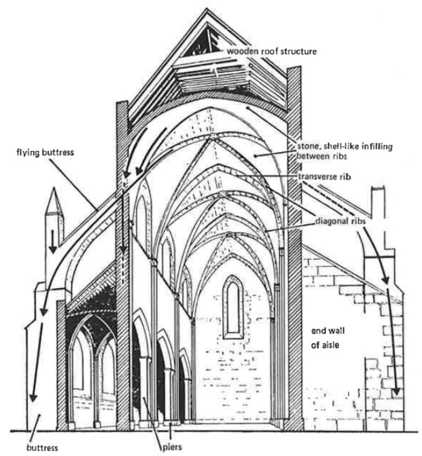
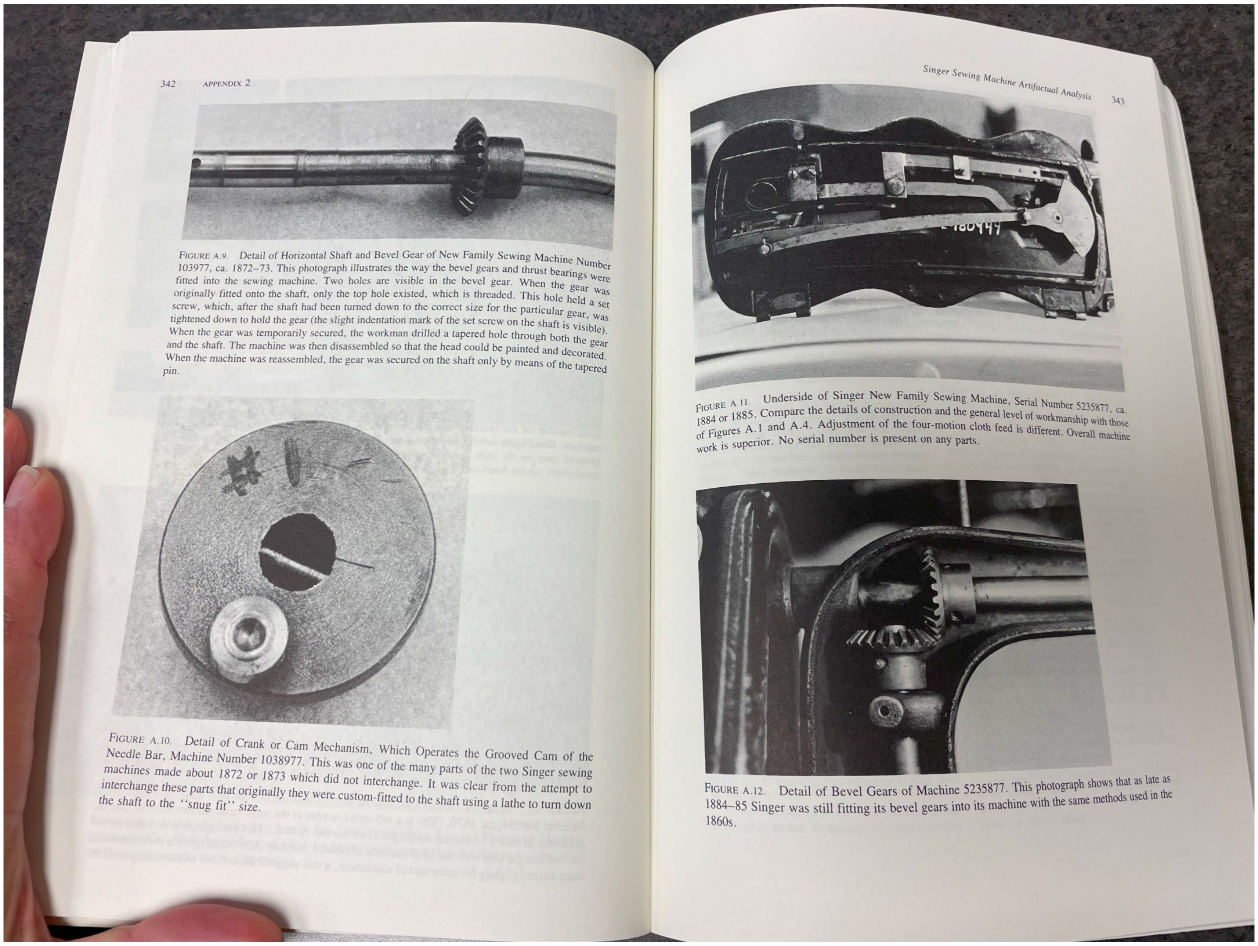


Figure 3
The principle of the rib vault: arrows and dashed lines show how thrusts (forces) from the ribs are carried partly by the flying buttresses.

The ribs in the Durham vaults had both a technical and an aesthetic function. Thus they made possible a stronger structure, which was also lighter in weight, and at the same time, because the ribs were built first and the rest of the vault was filled in later, they made the whole thing easier to construct, involving the use of less centering and scaffolding. The aesthetic improvement obtained by using the rib vault was that its surface, patterned with ribs, could be made to match the piers and walls more closely; stone shafts attached to the piers ran from floor level to the vault, and the ribs were made to continue their vertical line into its curving shape.

The introduction of rib vaults at Durham gave rise to one major structural problem. The forces resulting from the weight of the vaults could not simply be supported by the piers and

Fig. 1 -- Two pages from Pacey's chapter on cathedrals, in *The Maze of Ingenuity*. Here Pacey illustrates the principal features of the Durham Cathedral, highlighting how its structure solved the various technical problems associated with building its towering walls that seem to reach to the heavens.



342 APPENDIX 2

FIGURE A.9. Detail of Horizontal Shaft and Bevel Gear of New Family Sewing Machine Number 103977, ca. 1872–73. This photograph illustrates the way the bevel gears and thrust bearings were fitted into the sewing machine. Two holes are visible in the bevel gear. When the gear was originally fitted onto the shaft, only the top hole existed, which is threaded. This hole held a set screw, which, after the shaft had been turned down to the correct size for the particular gear, was tightened down to hold the gear (the slight indentation mark of the set screw on the shaft is visible). When the gear was temporarily secured, the workman drilled a tapered hole through both the gear and the shaft. The machine was then disassembled so that the head could be painted and decorated. When the machine was reassembled, the gear was secured on the shaft only by means of the tapered pin.

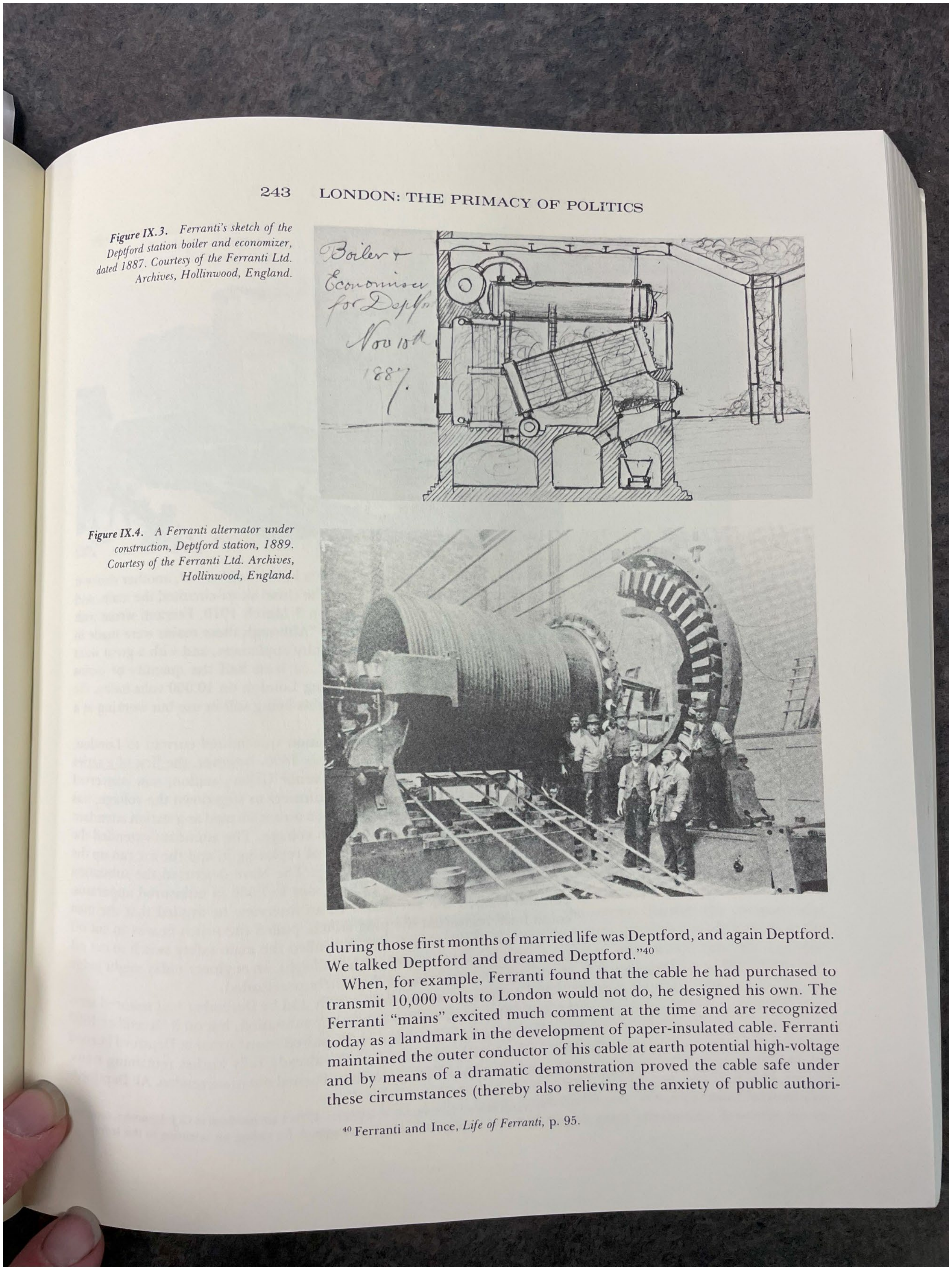
FIGURE A.10. Detail of Crank or Cam Mechanism, Which Operates the Grooved Cam of the Needle Bar, Machine Number 1038977. This was one of the many parts of the two Singer sewing machines made about 1872 or 1873 which did not interchange. It was clear from the attempt to interchange these parts that originally they were custom-fitted to the shaft using a lathe to turn down the shaft to the ‘‘snug fit’’ size.

Singer Sewing Machine Artifactual Analysis 343

FIGURE A.11. Underside of Singer New Family Sewing Machine, Serial Number 5235877, ca. 1884 or 1885. Compare the details of construction and the general level of workmanship with those of Figures A.1 and A.4. Adjustment of the four-motion cloth feed is different. Overall machine work is superior. No serial number is present on any parts.

FIGURE A.12. Detail of Bevel Gears of Machine 5235877. This photograph shows that as late as 1884–85 Singer was still fitting its bevel gears into its machine with the same methods used in the 1860s.

Fig. 2 -- Two pages from Appendix 2 of Hounshell's *From the American System to Mass Production*. In this appendix, Hounshell documents his experiments with several Singer sewing machines at the Smithsonian.



243 LONDON: THE PRIMACY OF POLITICS

Figure IX.3. Ferranti's sketch of the Deptford station boiler and economizer, dated 1887. Courtesy of the Ferranti Ltd. Archives, Hollinwood, England.

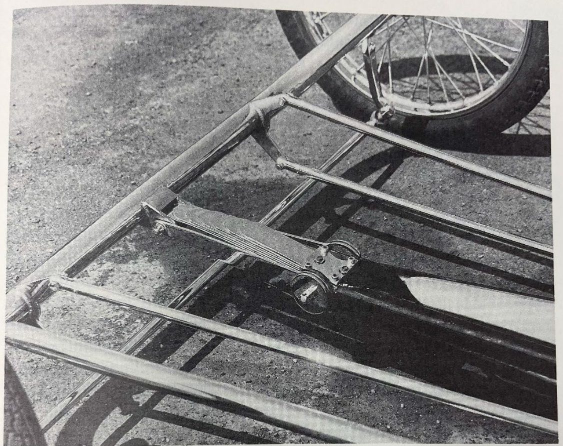
Figure IX.4. A Ferranti alternator under construction, Deptford station, 1889. Courtesy of the Ferranti Ltd. Archives, Hollinwood, England.

during those first months of married life was Deptford, and again Deptford. We talked Deptford and dreamed Deptford."[40]

When, for example, Ferranti found that the cable he had purchased to transmit 10,000 volts to London would not do, he designed his own. The Ferranti "mains" excited much comment at the time and are recognized today as a landmark in the development of paper-insulated cable. Ferranti maintained the outer conductor of his cable at earth potential high-voltage and by means of a dramatic demonstration proved the cable safe under these circumstances (thereby also relieving the anxiety of public authori-

[40] Ferranti and Ince, *Life of Ferranti*, p. 95.

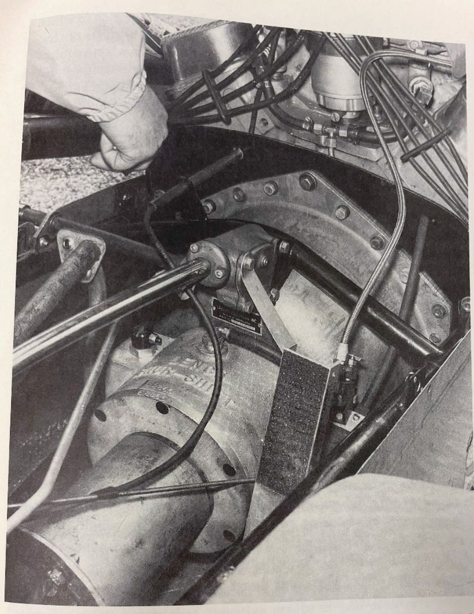
Fig. 3 -- A page from Hughes's *Networks of Power* in which he delves into the inner workings of electrical components.



The heliarc process was developed in the aircraft industry for welding chrome moly tubing in a cocoon of inert gas to prevent occlusions. Note the precision bead that Jim Davis has drawn where the spring mount and radius rods are attached to the axle. Every other chassis fabricator had turned to torsion bar front ends by the mid-1960s; Davis remained enthusiastic about using a quarter-elliptic spring. (Photograph by Jerry Mason)

substituting turbocharging for the standard positive-displacement blower, and even substituting tanks of compressed air. "I'm never happy with the norm," he said. "I always want a new deal."[52]

Intrigued with Miller's shortie, Snow ordered one of his own from Gene addy, a fellow Texan who built all his chassis. Unlike Miller, Snow had



A bellhousing from Joe Schubeck's Lakewood Industries, of the sort prevalent in the late 1960s. Photograph also shows a Lenco two-speed transmission, steering box, and a hydraulic throttle control. (Photograph by Leslie Lovett, courtesy National Hot Rod Assn.)

at Lions Drag Strip during the 1960s than at the Brickyard. Across the nation, but mostly in California, the toll continued to mount. Bruce Johnston. Bruce Woodcock. Boyd Pennington. Dub Irwin. Denny Milani. Gene ... John Crews. John Wilson.

Fig. 4 -- A couple of images from Post's *High Performance*. Throughout, Post pays close attention to the kinds of modifications, components, and tricks drag racers used to improve their dragsters' performance.

TECHNOLOGY AND CULTURE

APRIL
2007
VOL. 48

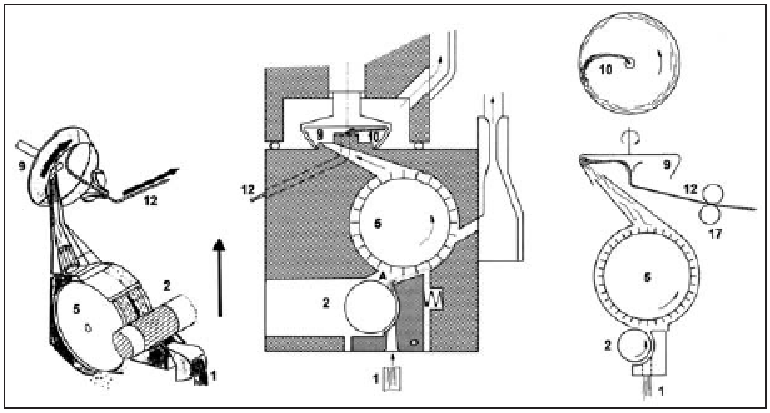


FIG. 5 Open-end (rotor) spinning unit: (1) sliver, directly from the can; (2) feed roller; (5) opening roller; (9) rotor; (10) free end of the yarn; (12) newly formed yarn; and (17) withdrawal rollers. Today, OE rotors impart twist at over 100,000 rpm; in 1967, the BD 200's rotor speed was 30,000 rpm. (Adapted from W. Klein, *New Spinning Systems* [Manchester, 1993].)

Early in 1963 Novotný visited Khrushchev, launching intense and urgent discussions about how to organize such a partnership. VÚB had set a target date of 1968 for a working machine that embodied "new spinning principles," but the Soviets wanted it in 1967, for the fiftieth anniversary of the October Revolution. The pressure was on: "We had to make a five-year plan in three days, and we did it," recalled Ripka. Finally, on 11 April 1963, the Soviet Union and Czechoslovakia signed an agreement to establish what became known in English as the International Center for Open-End Spinning in Ústí nad Orlicí.[39]

39. Ripka (18 June 1984, Ústí). The commission consisted of representatives from government and industrial agencies; those from VÚB included Rohlena, Maršíček, and Hýbl. The report shows Czech concern with legal and administrative issues ("Zápis z porady komise pro zřízení československo-sovětského výzkumného pracoviště pro kontinuelní bezvřetenové předení konané dne 22.1.1963 ve Výzkumném ústavu bavlnářském v Ústí n. Orl."), SOAZ VÚB, k 47; for the fifty-seven long articles constituting the proposal, see SOAZ VÚB, k 626. Dr. František Vlasák, minister-president of the State Commission for Technology, noted the difficulty of the negotiations preceding the agreement to establish the International Research Center ("Informace o stavu vývoje, zabezpečení výroby a prodeje licence bezvřetenových dopřádacích strojů"), SOAZ VÚB, k 625, 6; see also SOAZ VÚB, k 102. Participants and observers credited Rohlena with astutely exploiting the ČSSR's relationship to the Soviet Union, agreeing that "without the Soviet Union, this project would have been delayed 10 years." This center represented the first of several bilateral and multilateral agreements within the CMEA countries in textile research; see "Protokol z 11.4.1963 o spolupráci mezi SSSR a ČSSR," SOAZ VÚB k 627. Generally speaking, each CMEA country specialized in a particular type of machinery, the most sophisticated machines being made in the ČSSR (headquarters of the tex-

264

Fig. 5 -- A page from Freeze's *T&C* article on Czechoslovak open-end spinning machines. The image at the top is the one that kept coming out "squashed" during the production process at *T&C*.

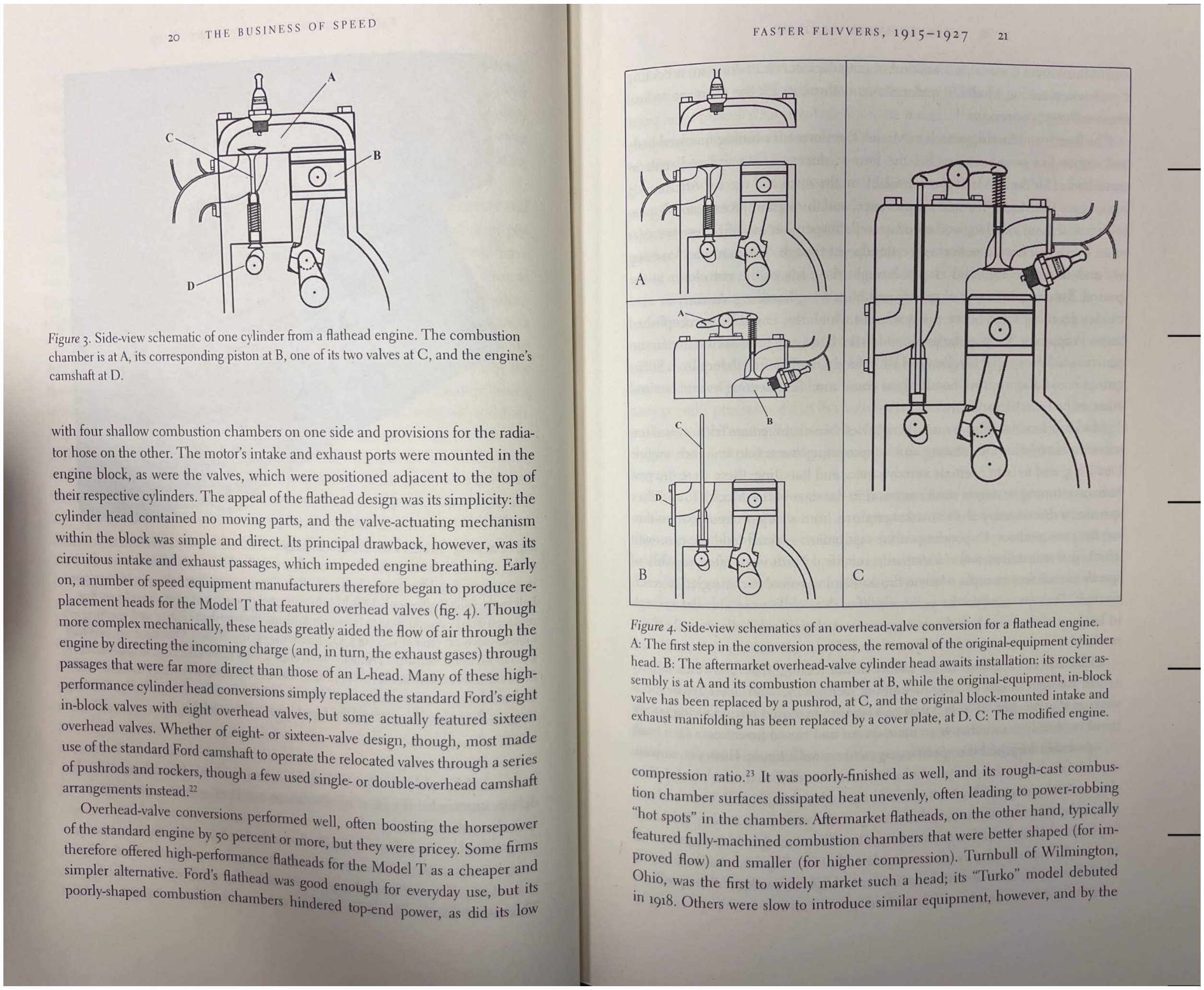
LAEMMLI | **Technology at the New York City Ballet**

FIG. 1 (Top) Pointe shoe worn by Marie Taglioni ca.1842. The shoe is unblocked, and the only additional support is provided by darning beneath the shoe's toes and up its sides. (Source: Cyril W. Beaumont Bequest, Victoria and Albert Museum. © Victoria and Albert Museum, London.) (Bottom) Marie Taglioni as a weightless sylphide. Lithograph by Alexandre Lacauchie, ca.1832. (Source: Henry Beard Print Collection, Victoria and Albert Museum. © Victoria and Albert Museum, London.)

7

Fig. 6 -- A page from Laemmli's *T&C* article on ballet shoes in which careful analysis of the shoes themselves plays an important role in her study.

Fig. 7 -- At top is the Kassel Hand, one of many early modern mechanical limbs in Hausse's study. At bottom is a shot of the internal mechanism of the Kassel Hand. Careful analysis of this and other hands' internal workings led Hausse to some important conclusions regarding the design and purpose of these hands, and their makers.



20 THE BUSINESS OF SPEED

Figure 3. Side-view schematic of one cylinder from a flathead engine. The combustion chamber is at A, its corresponding piston at B, one of its two valves at C, and the engine's camshaft at D.

with four shallow combustion chambers on one side and provisions for the radiator hose on the other. The motor's intake and exhaust ports were mounted in the engine block, as were the valves, which were positioned adjacent to the top of their respective cylinders. The appeal of the flathead design was its simplicity: the cylinder head contained no moving parts, and the valve-actuating mechanism within the block was simple and direct. Its principal drawback, however, was its circuitous intake and exhaust passages, which impeded engine breathing. Early on, a number of speed equipment manufacturers therefore began to produce replacement heads for the Model T that featured overhead valves (fig. 4). Though more complex mechanically, these heads greatly aided the flow of air through the engine by directing the incoming charge (and, in turn, the exhaust gases) through passages that were far more direct than those of an L-head. Many of these high-performance cylinder head conversions simply replaced the standard Ford's eight in-block valves with eight overhead valves, but some actually featured sixteen overhead valves. Whether of eight- or sixteen-valve design, though, most made use of the standard Ford camshaft to operate the relocated valves through a series of pushrods and rockers, though a few used single- or double-overhead camshaft arrangements instead.[22]

Overhead-valve conversions performed well, often boosting the horsepower of the standard engine by 50 percent or more, but they were pricey. Some firms therefore offered high-performance flatheads for the Model T as a cheaper and simpler alternative. Ford's flathead was good enough for everyday use, but its poorly-shaped combustion chambers hindered top-end power, as did its low

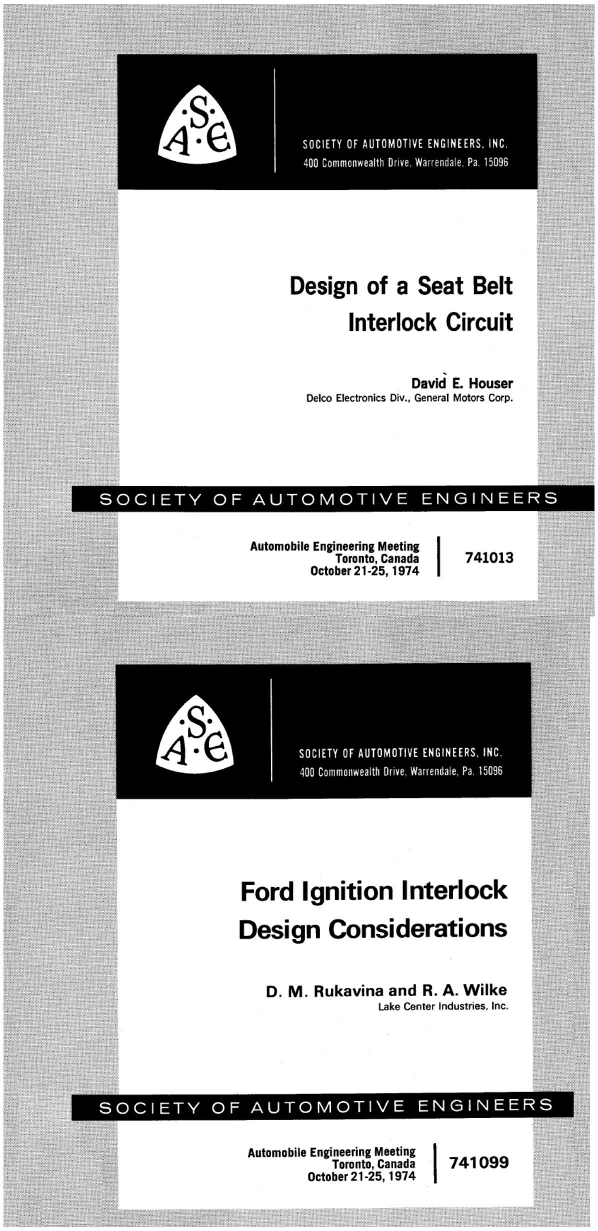
FASTER FLIVVERS, 1915–1927 21

Figure 4. Side-view schematics of an overhead-valve conversion for a flathead engine. A: The first step in the conversion process, the removal of the original-equipment cylinder head. B: The aftermarket overhead-valve cylinder head awaits installation: its rocker assembly is at A and its combustion chamber at B, while the original-equipment, in-block valve has been replaced by a pushrod, at C, and the original block-mounted intake and exhaust manifolding has been replaced by a cover plate, at D. C: The modified engine.

compression ratio.[23] It was poorly-finished as well, and its rough-cast combustion chamber surfaces dissipated heat unevenly, often leading to power-robbing "hot spots" in the chambers. Aftermarket flatheads, on the other hand, typically featured fully-machined combustion chambers that were better shaped (for improved flow) and smaller (for higher compression). Turnbull of Wilmington, Ohio, was the first to widely market such a head; its "Turko" model debuted in 1918. Others were slow to introduce similar equipment, however, and by the

Fig. 8 -- Two pages from my first book, *The Business of Speed*. Here I'm detailing precisely how aftermarket overhead-valve conversions for flathead motors worked.

Fig. 9 -- A bit of material culture from 1974 that has miraculously survived for 5 decades: this is a sticker VW placed on the steering wheels of its 1974 models for the US market to guide new owners in the procedure for starting their interlock-equipped cars. These stickers were meant to be removed after sale, but for some reason this one survived. It is one of only two parts of this particular car's interlock system that remains intact (for the other, see figure 14).



SOCIETY OF AUTOMOTIVE ENGINEERS, INC.
400 Commonwealth Drive, Warrendale, Pa. 15096

Design of a Seat Belt Interlock Circuit

David E. Houser
Delco Electronics Div., General Motors Corp.

SOCIETY OF AUTOMOTIVE ENGINEERS

Automobile Engineering Meeting
Toronto, Canada
October 21-25, 1974

741013

SOCIETY OF AUTOMOTIVE ENGINEERS, INC.
400 Commonwealth Drive, Warrendale, Pa. 15096

Ford Ignition Interlock Design Considerations

D. M. Rukavina and R. A. Wilke
Lake Center Industries, Inc.

SOCIETY OF AUTOMOTIVE ENGINEERS

Automobile Engineering Meeting
Toronto, Canada
October 21-25, 1974

741099

Fig. 10 -- The covers of two SAE (Society of Automotive Engineers) technical papers on the seat-belt interlock from 1974. There are dozens of papers like these in the SAE's collections.

Detroit Report

BY
JOSEPH M. CALLAHAN
EDITOR

Starter-Interlock To Bow

With the debut of the starter-belt interlock this fall, Washington takes another monumental step in its efforts to save the lives of American motorists.

It's a gargantuan step that will cost car buyers over $500 million a year ($50 each, without profit).

Whether the starter-interlock is the best automotive passenger restraint will be determined in the next couple of years by the percentage of additional motorists who begin using lap and shoulder belts.

Motor Vehicle Safety Standard 208, which requires the interlock, reflects the government determination to prevent motorists from defeating the system, as millions of drivers have apparently defeated the 1972-73 buzzer-flasher systems by tieing them off, or permanently disabling them in other ways.

For example, the interlock will have a logic system to force drivers to go through a three-step routine everytime they start the car. This will be (1) sit on the seat, (2) put on the combination lap-shoulder belt and (3) turn the ignition key.

If the driver doesn't go through this routine every time, the automobile simply won't start. In addition, all front-seat passengers must sit down and don their belts, or the car won't start, either. The outboard passenger also will have a combination lap-shoulder belt. Both outboard belt systems will have inertia reels in the car roof and retractors on the floor. Inertia reels will permit the shoulder belts to rest lightly on the occupants' shoulders, only snubbing up tightly during a rapid deceleration.

Importantly, if either the driver or the front passengers remove their belts, the engine will not stop. That's why this device is properly called a starter-interlock, rather than an ignition-interlock. However, the removal of any front belts will cause the buzzer-flashers to begin continuous operation.

Of course, when the bureaucrats begin tinkering with the habits of people and cars in the real world, strange problems sometimes materialize. For example, what about the husband who wants to rush his expecting wife to a hospital without trussing her up in a lap and shoulder belt.

For this and other emergencies where no belts are wanted by the driver, an override button is provided someplace in the automobile that will deactivate the system for one start only. General Motors has elected to locate this button on the engine side of the firewall. The motorists in this case will have to lift up his hood and press the button.

And what if the engine stalls, possibly on a railroad track? Because this is a starter-interlock with a logic system, the driver would have to quickly remove his belts, jump out of the car, jump back into the car, put the belts back on then re-start the car.

GM, the only maker to show its system thus far, will avoid producing this Charlie Chaplin movie by installing a "neutral safety switch." This will allow the driver to re-start his engine as often as necessary as long as he doesn't leave his seat.

In addition, GM's system will permit a "mechanic's start" which will allow a person to open the door, kick the gas pedal a few times and then reach over to start the engine without sitting on the seat. However, if he shifts into a forward gear on this start, the buzzer-flasher comes on.

Countless other complications will develop and GM statisticians predict that at least 150,000 engine failures will be caused by the interlock in the first year.

But Washington's determination to save lives on the highway is escalating. First, it was mandatory belt installation; then buzzer-flasher reminders, and now the starter-belt interlock. Future mandated devices, including the inflatable air bag, might be more costly and less efficient.

Los Angeles Times
6—Part II THURSDAY MORNING, AUGUST 2, 1973

Dilemma Over the Beef Freeze

Walter Ulbricht: Dreams and Fears

New Problems With Seat Belts

Pricking of Puffery

"What About Chappaquiddick?"

Letters to The Times

'Ehrlichman's Chilling Testimony'

Fig. 11 -- Magazines, trade journals, and newspapers covered the seat-belt interlock in depth from 1971 well into 1975. I plucked these at random from my collection: at left is a page from *Automotive Industries* in April of 1973, and at right is the editorial page of the *Los Angeles Times* from August 2, 1973 (the bit on the interlock is at bottom left on the editorial page).

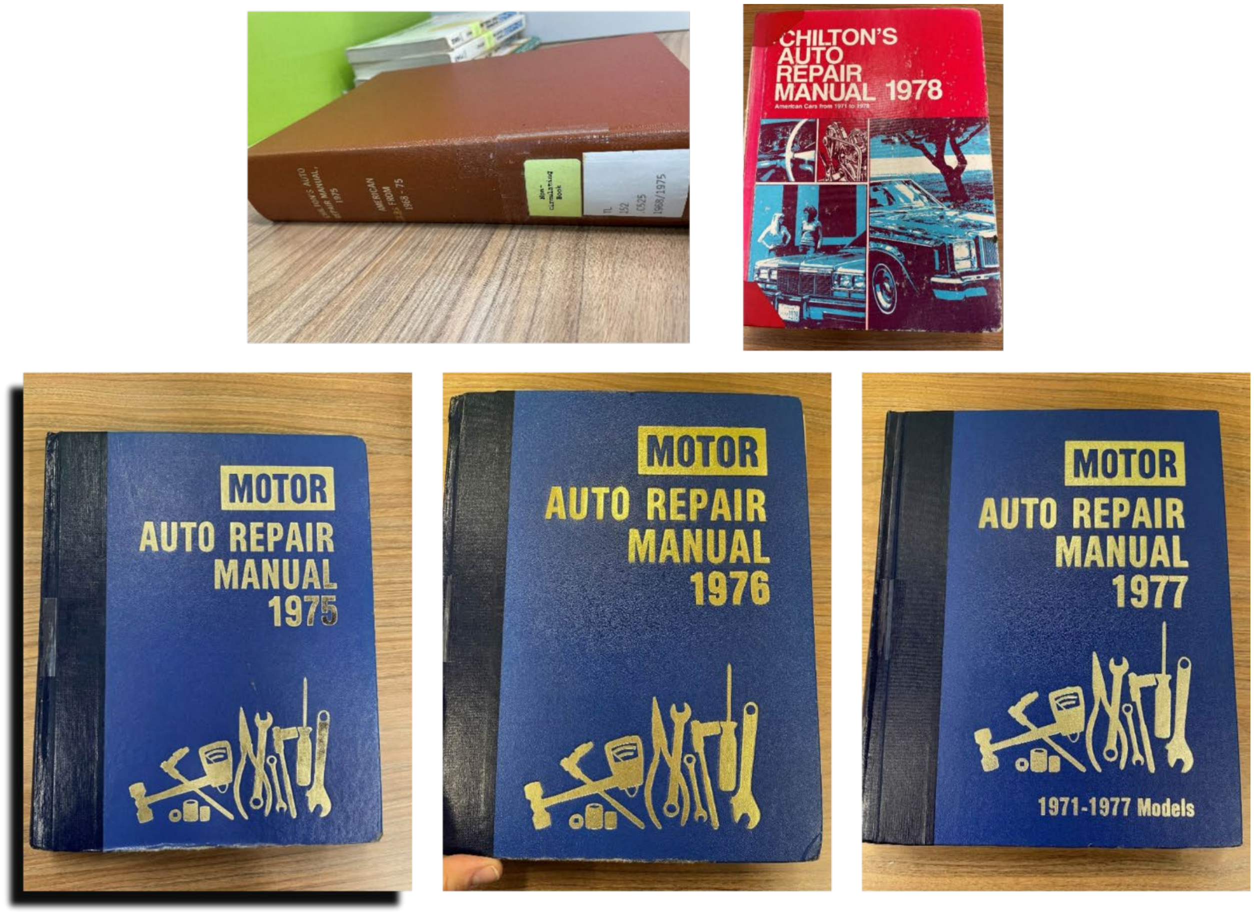
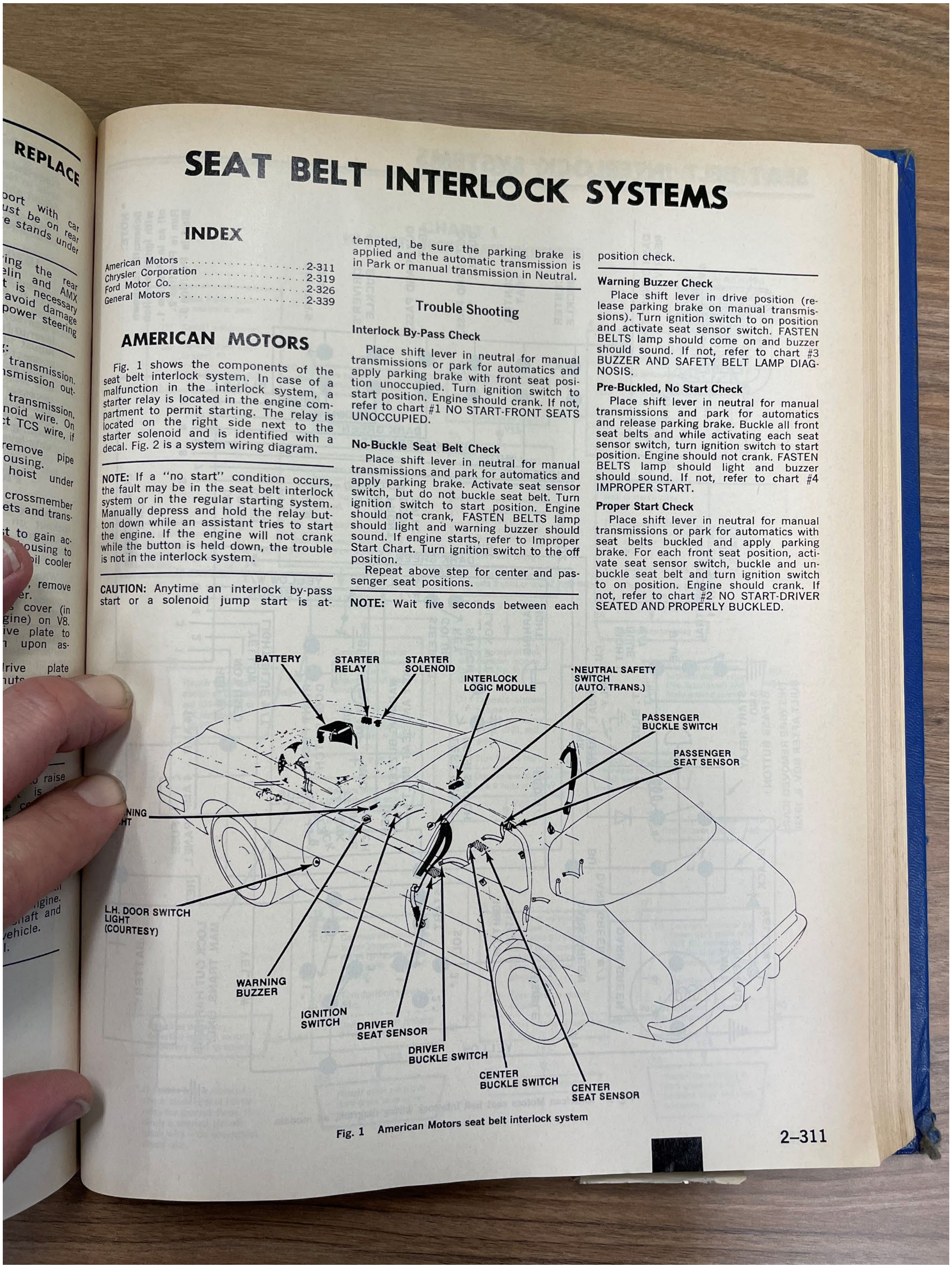


Fig. 12 -- A small sampling of automobile repair manuals from the mid-1970s, all of which covered the new seat-belt interlock systems at great length.



SEAT BELT INTERLOCK SYSTEMS

INDEX

AMERICAN MOTORS

Fig. 1 shows the components of the seat belt interlock system. In case of a malfunction in the interlock system, a starter relay is located in the engine compartment to permit starting. The relay is located on the right side next to the starter solenoid and is identified with a decal. Fig. 2 is a system wiring diagram.

NOTE: If a "no start" condition occurs, the fault may be in the seat belt interlock system or in the regular starting system. Manually depress and hold the relay button down while an assistant tries to start the engine. If the engine will not crank while the button is held down, the trouble is not in the interlock system.

CAUTION: Anytime an interlock by-pass start or a solenoid jump start is attempted, be sure the parking brake is applied and the automatic transmission is in Park or manual transmission in Neutral.

Trouble Shooting

Interlock By-Pass Check

Place shift lever in neutral for manual transmissions or park for automatics and apply parking brake with front seat position unoccupied. Turn ignition switch to start position. Engine should crank. If not, refer to chart #1 NO START-FRONT SEATS UNOCCUPIED.

No-Buckle Seat Belt Check

Place shift lever in neutral for manual transmissions and park for automatics and apply parking brake. Activate seat sensor switch, but do not buckle seat belt. Turn ignition switch to start position. Engine should not crank, FASTEN BELTS lamp should light and warning buzzer should sound. If engine starts, refer to Improper Start Chart. Turn ignition switch to the off position.

Repeat above step for center and passenger seat positions.

NOTE: Wait five seconds between each position check.

Warning Buzzer Check

Place shift lever in drive position (release parking brake on manual transmissions). Turn ignition switch to on position and activate seat sensor switch. FASTEN BELTS lamp should come on and buzzer should sound. If not, refer to chart #3 BUZZER AND SAFETY BELT LAMP DIAGNOSIS.

Pre-Buckled, No Start Check

Place shift lever in neutral for manual transmissions and park for automatics and release parking brake. Buckle all front seat belts and while activating each seat sensor switch, turn ignition switch to start position. Engine should not crank. FASTEN BELTS lamp should light and buzzer should sound. If not, refer to chart #4 IMPROPER START.

Proper Start Check

Place shift lever in neutral for manual transmissions or park for automatics with seat belts buckled and apply parking brake. For each front seat position, activate seat sensor switch, buckle and unbuckle seat belt and turn ignition switch to on position. Engine should crank. If not, refer to chart #2 NO START-DRIVER SEATED AND PROPERLY BUCKLED.

Fig. 1 American Motors seat belt interlock system

2–311

Fig. 13 -- A page from the *Motor* auto repair manual for 1975 (printed in 1974), here providing an overview of AMC's seat-belt interlock system.

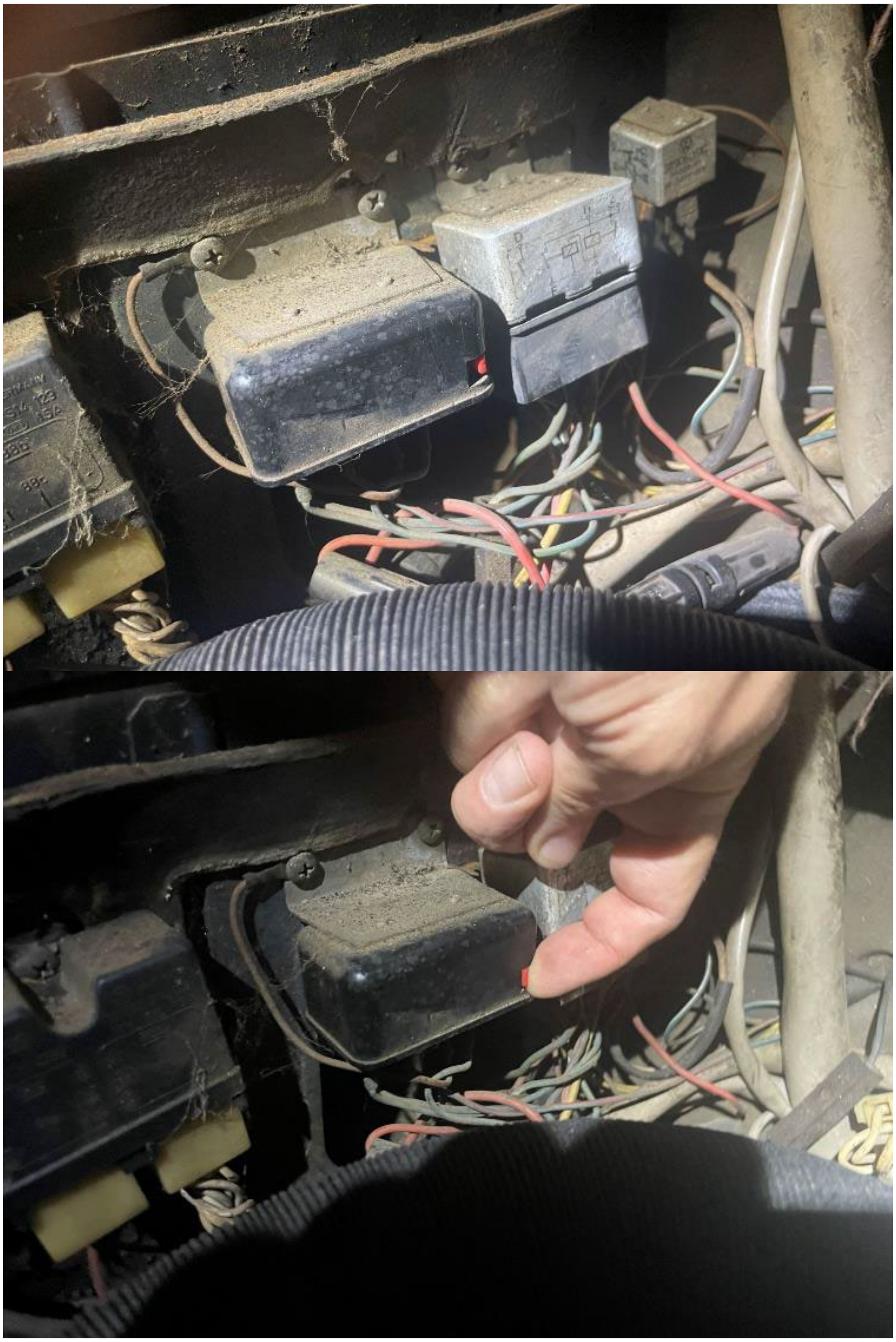


Fig. 14 -- This is the mechanic’s bypass switch from a 1974 VW 412. Unlike steering wheel stickers, under-dash wiring, and under-seat wiring, these switches often remained intact under the hoods of interlock-equipped cars, even when the system was disabled.

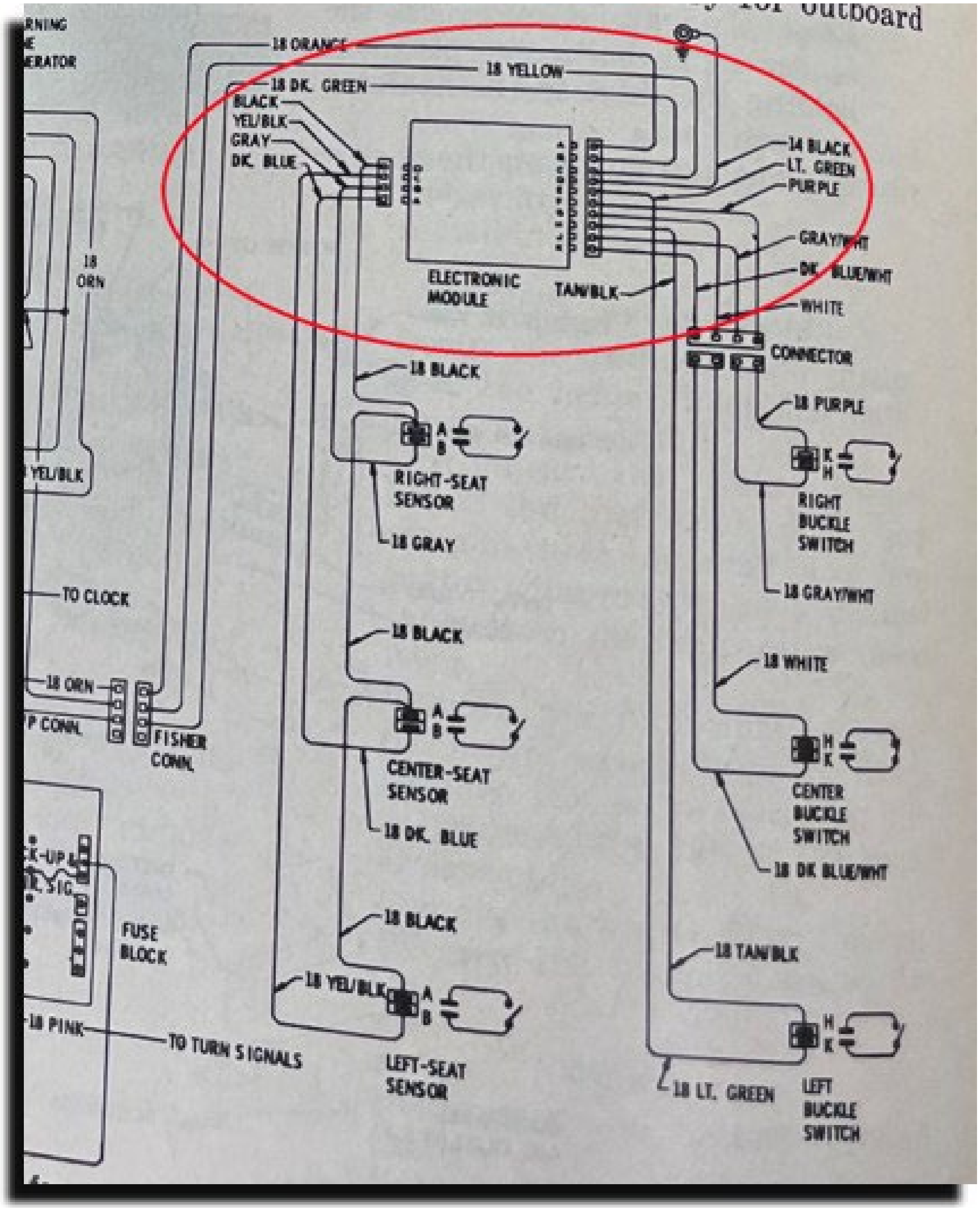


Fig. 15 -- Part of page C120 from Chilton's 1968–1975 auto repair manual. Here the interlock module for GM products is circled.