The Mechanical Calf

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CHAPTER 5

THE MECHANICAL CALF: ON THE MAKING OF A MULTISPECIES MACHINE

Richie Nimmo

Introduction

The bodily production of milk is a defining characteristic of mammals, central to mammalian processes of reproduction, nurturance, and growth. All female mammals nurse their young with milk secreted from the mammary glands. In this sense milk is as “natural” a substance as one can imagine, being inextricably interwoven into the ontogenetic life process intrinsic to mammalian biocorporeality. But the milk consumed in vast quantities by adult humans in modern societies is not human milk but cow’s milk; it is a product of systematic human intervention into the reproductive cycle of another species, and thus both expresses and mediates a specific human–animal relationship. Moreover, since the middle of the twentieth century an increasing proportion of dairy milk consumed in the West has been produced not on small farms but in large agro-food enterprises on an industrial scale, using techniques of rationalized mass production increasingly permeated by science and technology. It is then distributed, exchanged, and marketed not just as a physical substance with a use-value, and also as an exchange-value or commodity enmeshed in capitalist economic relations. In these ways, the milk that is mass produced and consumed in late-modern societies is not simply a natural substance, but is something enmeshed in a deeply heterogeneous assemblage interweaving humans and animals, reproduction and production, bodies and technologies, organisms and commodities, states and markets, “culture” and “nature.” This chapter seeks to return the liveliness and agency of cows to accounts of the dairy industry by attending to the *relational* entanglements of cows with the processes of their milking.

The history of the dairy industry in the twentieth century can be grasped as a story of radically increasing complexity in networks of milk production and consumption, made possible by changing technologies along with shifting forms of socio-material organization, encompassing railways, refrigeration, tuberculin testing, pasteurization, bottling, municipalization, and subsidization, all of which enabled milk as material substance and exchange-value to flow and circulate through expanding networks stretching like capillaries across an ever-wider territory (Nimmo 2010; Atkins 2010). In the last decades of the nineteenth century milk production in the industrialized nations was in much the same state as it had been a hundred years earlier; it was still a localized cottage industry in which most people necessarily obtained their milk from cows kept in local farms or cowsheds no more than a few miles away. Indeed, people were keen to

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consume their milk while it was “warm from the cow” as this was taken to be a sign of its authenticity and the absence of adulteration, which was widespread (Nimmo 2011a: 69). The transformation that took place during the next hundred years could not have been more dramatic, involving the emergence of an integrated national—and subsequently international—system of standardized production, distribution, and mass marketing, in which milk underwent a process of heating, cooling, homogenization, refrigeration, and frequently transportation over hundreds of miles, in its passage between cow and consumer.

As scholars in human–animal studies would undoubtedly point out, no account of the dairy industry can be satisfactory if it fails to recognize that at the center of this increasingly complex assemblage are the cows themselves. Indeed, there are well-established critical accounts of the impact of agricultural industrialization and intensification upon the animals involved, drawing in particular upon Marxist and feminist theoretical frameworks (Benton 1993; Gaard 1993; Adams and Donovan 1995; Noske 1997). Though these critical paradigms were initially developed with exclusive reference to human social relations, many of their principle concepts can and have been fruitfully applied to human–animal relations in the context of animal agriculture, and are capable of making important contributions to a critical social account of the modernization of milk production and consumption. Marxist approaches foreground the incorporation of nonhuman animals into the industrial labor process at point of production and their role in the circuits of capitalist valorization, exploring the connections between the commodification of human labor and the parallel processes of exploitation of nonhuman animals in the extraction of surplus value (Dickens 1996; Perlo 2002). The Marxian concepts of alienation and species-being have been reworked and extended to nonhuman animals in order to furnish a critical vocabulary for thinking the intersection of capitalism and animal exploitation (Benton 1993; Noske 1997; Dickens 2003). A recent analysis, for example, sought to apply theories of alienation and species-being to the situation of cows in dairy production, focusing in particular upon “grazing-robotic systems” of automated or “voluntary” milking, which claim to render cows “free” to determine for themselves—within certain limits—both the timing and frequency of daily milking (Stuart, Schewe, and Gunderson 2013). Theoretical currents emerging from the rich spectrum of feminist approaches have brought to bear trenchant critiques of processes of objectification that are simultaneously material, epistemic, and semiotic, and which intersect and cross-valorize gendered human and human–animal relations (Adams and Donovan 1995; Birke 1994; Plumwood 1993). In Carol Adams’ ([1990] 2010; 1994) seminal work on “the sexual politics of meat” for example, women in a patriarchal and carnivorous culture are dehumanized and objectified by being animalized, while animals are simultaneously feminized and quite literally objectified in the meat industry; this in turn normalizes the sexual objectification and consumption of women, in a structure of mutually reinforcing processes of symbolic and corporeal violence (Adams this volume). It does not require a huge leap to imagine how this “feminist-vegetarian critical theory” could be transformed into a feminist-vegan critical theory that could readily be mobilized in a critique of milk and dairy products; in which

light the systematic extraction and consumption of cow's milk might be grasped as at one and the same time a form of gendered animal exploitation and a process of objectification of female corporeal and reproductive capacities (Arvidsson this volume).

A criticism that can be leveled at these kinds of critical approaches however is that they can tend to presuppose and affirm an essential or given animal subjectivity, which can be problematic for scholars of human–animal relations influenced by poststructuralism. Indeed, much of the analytical and rhetorical force of Marxist and feminist critiques lies in their confluence with animal rights philosophies in calling for nonhuman animals to be accorded subject-status or personhood in opposition to the multiple and systematic objectifications to which they are subjected within industrial agriculture (Nimmo 2015b, cf. this volume). But, as Lewis Holloway observes in his analysis of robotic milking systems:

Especially in relation to farming, the question of what such a subjectivity might be is in most instances underexamined. Instead, most writers ... have tended to essentialize the subjectivity of farmed animals in ways which negate the potential for them to become, to be co-constituted as they are entrained within various sets of socioeconomic, ecological, spatial, and technological relationships.

Holloway 2007: 1041

Drawing upon Foucauldian poststructuralist understandings of subjectivity as produced by technologies of power within disciplinary and bio-political assemblages, Holloway examines the case of robotic and information technologies in automated dairy farming systems in order to explore “the ways in which particular bovine subjectivities are produced in and through the specific sets of technospatial configurations associated with robotic milking technologies” (Holloway 2007: 1041). In this way, Foucauldian analysis purports to go beyond the politico-ethical affirmation of subjectivity in order to trace the bio-political constitution and reconstitution of animals in relation to particular technoscientific assemblages in animal agriculture (Holloway and Morris 2007; Holloway, Bear, and Wilkinson 2014).

So, existing critical social perspectives on human–animal relations in animal agriculture explore, variously: the commodification and alienation of animals within capitalist production processes; the feminization and objectification of animals within patriarchal and anthropocentric social and cultural structures; and the bio-political production of animal subjectivities through the disciplining of animal bodies within techno-political apparatuses. Although there are important differences and tensions between these, they might be seen as offering broadly complementary contributions to a critical understanding of the human–animal relations bound up with late-modern industrial-capitalist agriculture (Novek 2005). The aim here is not to displace these approaches, but rather to explore what else emerges if one adopts some different starting points and emphases, in part by taking a more historical perspective which does not directly tackle the contemporary dairy assemblage in all of its sociotechnical complexity, but instead traces its early emergence and conditions of possibility. This chapter therefore focuses on a critical sociotechnical juncture which preceded and

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enabled the subsequent permeation of technoscience into dairy production that culminated in the automated robotic milking systems examined by both Stuart and Holloway; namely, the long-frustrated and belated emergence of the first mechanical milking machines with which to replace hand-milking. To do so it draws upon a range of primary archive sources consisting of documents produced by dairy farmers, clean milk and sanitary inspectors, milk machine engineers, and various contemporary assessors of these devices, in dairy farming and agricultural journals as well as some occasional pamphlets. The approach taken here also relies less upon structural or poststructuralist explanation as modes of critical engagement, and more upon relational-materialist description drawing upon ontological sensibilities engendered by theoretical currents from actor-network theory (Latour 1993; 2005; Michael 2000; Nimmo 2011b; 2016) and new materialism (Bennett 2010; Coole and Frost 2010). This means examining more agnostically how the cow's body is entangled with other fields of relations and forces, tracing the frictions and resonances that arise from such encounters, and exploring how these are precariously stabilized. Finally, the analysis tries to avoid the reduction of technology to a tool or instrument of anthropocentric or speciesist oppression, of patriarchal domination, of capitalist exploitation, or of bio-political subjectification, and instead describes specific technologies as socio-material devices that mediate the relations of humans, nonhumans, organisms, substances, and forces with which they are entangled.

The knottiest problem

This is the one implement of which dairy farmers at the present time stand most in need. A milking machine is, however, one of the knottiest problems which inventive genius has yet to solve.

Sheldon 1878: 53

Attempts to develop mechanical devices with which to milk cows began as early as the 1860s. The concatenation of various factors—some historical and situational, others rooted in the very materiality of dairy farming—created a demand for an efficient and practical milking machine which persisted throughout the latter half of the nineteenth century. Paramount was the desire to replace or diminish the labor of hand-milking, in part due to changing labor relations in agriculture resulting in an increasing difficulty in obtaining laborers willing to work for the very low rates of pay on offer, and partly because of the nature of the work itself (Morton 1878: 667; Courtney 1900: 466). Milking cows by hand is laborious, repetitive, physically demanding, and manually skilled work, requiring a degree of embodied technique that in Europe was largely the purview of women until the introduction of technological help. In order to promote optimal milk yields this work must be performed at uniform intervals during unsociable hours and with clockwork regularity, under what may well be perceived as unpleasant or uncomfortable conditions (Erf 1906: 61). Moreover, in response to an emerging awareness of the likely contribution of unclean, infected, or contaminated milk to high

rates of infant mortality, tuberculosis, and outbreaks of various diseases such as scarlet fever, dairy farming was gradually becoming more conscious of the importance of sanitation in all aspects of milk production, and those carrying out hand-milking—a majority of whom were women—began to be accused by a growing cadre of male health inspectors and sanitary experts of such practices as routinely milking with unclean, unwashed, or soiled hands, allowing dirt and dung to fall into the milk, carrying out milking while suffering from illness, and so on (Little 1881: 653; Orr 1919: 30). While sanitary concerns about dairying were not unjustified, the emphasis on milkers' practices was no doubt fueled to a certain extent by gender-inflected class contempt, and it is notable in the historical documents that for every acknowledgment of the labor and skill involved in hand-milking there are more comments concerning the routine lack of cleanliness said to be pervasive among milkers (Heineman 1919: 433–4, 438–9; Orr 1919: 30–2). This perception and this discourse fed the demand for a machine with which to obviate or reduce the need for such labor.

The demand for a mechanical device for milking cows was not satisfied with any degree of success for several decades, and it was only in the 1900s that a genuinely practicable milking machine became commercially available (Hamby 2014). In the interim a variety of designs were trialed, with bold claims routinely made for their effectiveness and efficiency, but all were ultimately found to be unworkable, counterproductive, or impractical in some crucial respect. The main obstacles included the difficulty of producing a machine that would milk cows at least as quickly but also as thoroughly as a skilled hand-milker, ensuring that no milk was left in the udder as this would soon induce the cow to produce less (Carrington 1877: 11–12; Sheldon 1878: 52). At the same time the machine had to be constructed in a manner that meant it was relatively easy and quick to clean, otherwise the labor and time involved in cleaning the machine would soon either outweigh the labor saved in milking or encourage inadequate or irregular cleaning thereby undermining the sanitary advantages claimed for mechanical milkers (Orr 1919: 32). A workable machine also had to be practically usable in the context of the normal conditions of most existing dairy farms, in the space available in the average cowshed, and with the sources of power available to most farmers, as well as easily and routinely operable by farm laborers without requiring specialist knowledge, special skill, or a detailed grasp of the engineering principles behind the machine (Erf 1906: 54). These were all significant challenges to the development of an effective and workable device, and numerous otherwise promising designs fell at the hurdle of one or more of these requirements. More daunting than any of these, however, was the problem of how to accomplish the necessary inter-mediation between animal and machine at the point of material connection between living udder and technical apparatus, which for decades seemed to present almost insuperable difficulties.

The problem was initially understood in strikingly functional and mechanistic terms, as a question of how to empty the udder of its milk as quickly and easily as possible, with curiously little reference being made to either the embodied practice of hand-milking or the actual suckling of calves (Henderson 1890; Courtney 1900; Erf 1906). Indeed, the cow as a living being appears to be almost absent from the thinking of the designers of

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the earliest milking machines, who seem to approach the udder as no more than a rather awkward container of a substance which needed to be removed. This instrumental approach is manifest in the earliest attempts at mechanical milking devices, most of which utilized some form of "milk tube" design, involving the insertion of a narrow tube or catheter into the teat, forcing open the sphincter muscle so that the milk would flow out of the udder and through the tube into a container. This was adapted from the earlier method of inserting straws into the udder, which was occasionally practiced as least as early as the first decades of the nineteenth century. The first milk tube device was made commercially available in 1878:

It consisted of a teat tube or tubes, having a number of small openings along its side through which the milk entered, and a flaring end for increasing the flow of the milk without unduly stretching the teat. An embracing band held the lower ends of the flexible tubes together and a flexible supporter sustained the weight of the nozzle tubes and their contained milk.

Erf 1906: 3–4

Numerous minor variations on this design emerged during the 1880s, but all operated on the same principle and thus were subject to the same fundamental flaw; though initially capable of emptying the udder more rapidly than was possible by hand-milking, by wholly neglecting the biology of cows and the physiology of the udder and teats in their design, milk tube devices soon led to damage to these organs and a subsequent diminution of milk (Van Vleck 1998). The cause was either physical injury resulting from repeatedly forcing a foreign object into the teat or the introduction of infection into the udder by the same means, and in many cases a combination of the two. It was eventually recognized that milk tubes could not be made effective by any modification of the basic principle, with further attempts to develop such devices being all but abandoned by 1900. Yet it seems extraordinary that they were ever considered, let alone put into practice; they are materializations of a highly reductive conception of the cow as an object and the udder as simply a milk-container, with apparently little thought being given to the species-being of the animal and its reproductive and ontogenetic life process, within which cow, udder, teat, and calf are inextricably intertwined organic elements, which can only be properly understood in relation to each other. Hence, the calf, having already been made physically absent in order to facilitate the appropriation of its mother's milk, was equally absent from the thinking of the engineers, who failed to see their task as a matter of how best to approximate the action of a calf suckling, but instead saw it in narrowly technical terms, as a question of how best to remove a fluid from its container.

How could the designers have been so blinkered, obtuse, and consequently brutal? It is telling in this respect that many of those who developed the early machines were engineers who saw an opportunity but had relatively little personal experience of dairy farming or milking cows (Henderson 1890: 645). This no doubt contributed to their tendency to approach the problem in abstract, engineering terms, with little reference to bovine corporeality. Indeed, insofar as the biological body of the cow appears to have

entered into their thinking at all, it was as a recalcitrant “nature” which could be—indeed had to be—*forced* by science to yield to the human will. Moreover, there was often friction between those developing the machines and those performing the everyday labor of hand-milking on working dairy farms, who frequently had to accommodate the engineers as they experimented with different designs and tested their efficacy (Henderson 1890: 645, 651). This is unsurprising given that the engineers ultimately aimed to render the milkers redundant, hence their presence would have exacerbated the already tense labor relations on dairy farms. It is also important to note that the engineers were overwhelmingly male while a large proportion of the hand-milkers were women, who, in contrast to the disembodied functional abstractions of those designing the machines, and by virtue of their everyday embodied experience, were more likely to have had a “hands-on” appreciation of the process of milking another female animal as an inter-corporeal interaction between biological beings.

A machine with organs

If the cow is viewed as a machine, it is evident that it will run more perfectly if all its parts are in good condition.

Hazard 1885: 472

As the experiments with milk tube devices were abandoned, machines utilizing different principles began to be developed. The first main alternative was pressure machines, which operated via mechanical compression of the teats by means of some configuration of rollers and pressure plates, in order to massage the teats and stimulate the secretion of milk into an attached tube. These were significant in marking the initial transition away from a wholly mechanistic approach and towards an attempt—albeit crude—to approximate the action of biological organisms, amounting to a sort of rudimentary bio-mimicry, though significantly it was still the hand motions of a human milker rather than the suckling of a calf that was the object of imitation for these devices. One of the earliest such machines, registered for patent in 1886, was described as follows:

It has . . . a main frame to which an auxiliary frame is attached and upon the latter is a pair of milking cylinders, each provided with a hinged shield, a detachable pressure plate, spout leading to the delivery trough, a series of yielding, automatically adjustable rolls which revolve within the milk cylinders. Adjustable base plates support the rolls which revolve within the milk cylinders. Adjustable base plates support the rolls. A suitable shaft, levers and gearing are provided for transmitting motion to the yielding rolls.

Erf 1906: 6

There were many variations on this pressure machine design, as successive attempts were made to devise more effective means of massaging the teats and udder, which would more

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closely approximate the subtle hand motions of a skilled milker. Whereas the earliest pressure machines were designed simply to reproduce the squeezing of the teat by applying pressure through mechanical rollers, later machines attempted to devise a means of recreating the combined squeezing and tugging motion used in hand-milking. But the challenge of mimicking a human hand, with all its joints, tendons and muscles, in the performance of a set of dexterous manipulations irreducible to a simple application of force, and long before the era of robotics, proved almost insurmountable. Thus, while pressure machines were undoubtedly more effective than milk tubes, and somewhat less damaging to the cow's body, they were nevertheless still highly inefficient in comparison with a proficient hand-milker, excessively complicated to operate in many cases, very difficult to keep clean in normal dairy farm conditions, and therefore unviable for regular use in most cases because in practice they did not significantly reduce the total labor involved.

The movement away from a thoroughly mechanistic approach and towards an increased focus on the imitation of organic principles marked by the emergence of pressure machines can be traced in the language used to describe them, which manifests an increase in the use of organic terms with which to name or describe the various parts of the apparatus and their interaction with the animal body. Thus one pressure machine is said to have "two inwardly connecting lips at the outer part connected by a pin" (Erf 1906: 6), while in another "Non-porous sacks have their mouths stretched over the tops of the cylinders," another "has a frame upon which are milking fingers, consisting of an angular body which may be pivoted at the forward end of the inner member" (Erf 1906: 6, 8), and yet another "consists of nipples which fit over the teats . . . attached by short necks to an elastic bulb" (Erf 1906: 16). Such language reveals that the machines were beginning to be seen in quasi-organic terms as efforts were made to adapt their principles of operation more closely to the body of the animal. Yet the cows themselves are still remarkably absent from many of the descriptions of the machines, almost as though they are but the natural element or raw material upon which the machine is designed to operate. This strangely absent presence is made suddenly visible in one case when it is punctured by the description of a particular machine:

No. 24, invented in 1901 . . . is a machine having a body upon which are spaced a teat-engaging apparatus, an udder-pressing device located on the body between the teat apparatus and projecting above the upper face of the same, yielding supporting means connected to the body of the machine in operative relation to the udder. Straps pass over the cow to support the machine. Coiled springs are placed in these straps to help retain the position. Leg-engaging arms extend back from the machine to prevent the cow from kicking.

Erf 1906: 12

The final sentence in particular is striking; in its casual reference—almost as an afterthought—to the machine's "leg-engaging arms," the cow dramatically reappears, reminding us that she has been there all along, and not just as an object upon which or around which various bits of machinery are arrayed, but as a living being with an agency

that is irreducible to the functions of her reproductive organs, indeed as a creature capable of some form of resistance. At the same time an increasingly organic terminology is used in reference to the machines, which are spoken of as “bodies” with “arms,” “fingers,” “lips” and “mouths,” paralleling and merging with the language used to describe the cows. The result is a strange hybrid vocabulary wherein animal and machine appear to be entangled, with proliferating references to such bovine-cyborg entities as “leg-engaging arms,” “udder-pressing devices,” “teat-engaging apparatus,” and “teat-compressing rollers” (Erf 1906). It may be objected that this is less a case of animal-machine hybridity than of discipline and biopower acting upon the animal body by means of the machine. But what I want to emphasize—because it is less easily seen—is the extent to which the machines were also acted upon by the animal, in the sense that they were profoundly shaped by its stubborn and recalcitrant biocorporeality. This is particularly discernible in the emergence and development of a third type of milking machine, based on a new principle of operation, which became the template for all subsequent milk machines for the next sixty years, namely the suction machine.

Where milk tube devices had simply penetrated the udder in order to obtain the milk, and pressure devices had operated by squeezing, massaging, and pulling the teat in an attempted simulation of hand-milking, the invention of suction devices marked a realization that the suckling calf offered the best model of how the udder and teats were “designed” to work. To comprehend how it was that this was not immediately and universally recognized, it must be borne in mind that the motivating aim of the designers from the outset was to replace or reduce the labor and cost of hand-milking, which was increasingly perceived as a key problem holding back dairy production (Sheldon 1878: 53; Murray 1879: 156). Hence, the state of labor relations on dairy farms very much framed and underpinned their efforts, and they were not thinking primarily about cows. Another important factor would have been the prevailing gender and class relations of the time, particularly in dairy farming and in the nascent field of dairy technology, and it is significant in this connection that the earliest recorded suction machine was designed and constructed by a woman, Anna Baldwin of Newark, New Jersey. It consisted of “a case or band to fit over the udder, connecting tubes and bands to fit on the teats in combination with a tube and suction pump” (Erf 1906: 14). Remarkably simple in comparison to the often complex pressure machines, with their elaborate configurations of plates, pads, grips, and rollers, the machine’s significance lay in its use of suction to draw milk from the teat. This had been presaged by the progressively closer attention of those designing successive pressure machines to the “mechanics” of the udder and teats, but the shift to suction was nevertheless a radical step because it marked the first attempt to directly simulate a suckling calf rather than the hand of a human milker.

Of udders and air pumps

It would be quite easy to prove by reference to the facts of physiology, that the animal organism is a delicate and complicated piece of mechanism, and that the

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attempt to rectify any errors in its structure or functions is likely to result in disaster, unless the effort is made by someone who is familiar with all the details of the machinery.

Brown 1884: 246

Suction machines worked by using an air pump to create a vacuum, or localized area of lower pressure, to produce a suction effect, thereby mimicking the mouth of the suckling calf. This—it was finally observed—stimulated the secretion of milk not by pressure as such but by creating suction around the teat. In contrast to pressure machines, which had tended to be hand-operated, many suction machines were designed to harness inorganic power sources and most required access to a nearby diesel generator or steam-powered engine in order to provide the motor force for the vacuum pump (Courtney 1900: 466–7; Erf 1906: 40). These were not yet readily available on all farms and could create hazards if used in the proximity of straw or hay, so there was some discussion of the practicalities of using a “tread power,” which was a mechanical treadmill used to convert the pulling force of a tethered bull or horse into a rotary motion that could be used to drive simple machines (Erf 1906: 46). Tread powers were becoming obsolete by the time that milk machines were emerging, so there would have been few cases of this arrangement being put into practice, but it is nonetheless fascinating—albeit disturbing—to contemplate the configuration of relations and translations of forces involved in the prospect of a bull walking upon a machine in order to convert its muscle power into a rotary force with which to drive another machine designed to create a vacuum in order to suck milk from the teats of a cow to feed to human beings. Perhaps the most significant advantage of the move to inorganic power sources though, was that it created the possibility of several cows being able to be milked simultaneously using a single machine, thus dramatically increasing the efficiency of the milking process by reducing the labor required; potentially, a single operator could milk half a dozen or more cows in the time it would otherwise take to hand-milk just one (Henderson 1890: 650). The economic advantages were obvious and the early suction machines were received with some excitement in anticipation of an imminent revolution in milk production. Reality proved rather more complex however, and in practice these designs were still confronted with significant problems.

One such problem arose from the fact that even as the potential efficiency gains of simultaneous milking began to be glimpsed, the progress of sanitary reforms in the dairy industry was gathering pace, particularly in response to the linking of unclean or contaminated milk to high rates of infant mortality, tuberculosis, and diseases such as scarlet fever which in some cases were believed to have been transmitted through infected milk. By the 1890s a concerted effort to transform the sanitary conditions of dairy production was under way, pursued by an ad hoc ensemble of sanitary inspectors, medical officers of health, and those dairying and agricultural associations that increasingly recognized the potential economic benefits of cleaner milk (Sheldon 1909: 27; Orr 1919: 21). This involved a sustained information and educational campaign along with the organization of systems of regular testing, both of cows for tuberculosis and other

diseases, and of samples of milk for bacterial content or other infection, as well as for proportions of fat and protein, which were taken to indicate the “quality” of the milk and by extension its authenticity or adulteration. At the same time, the practice of recording milk yields systematically over time in order to create a more objective basis for decisions on such matters as feeding and breeding was being ever more strongly encouraged and widely practiced, as dairy production gradually became more rationalized and more permeated by scientific knowledge-practices (Lawson 1913; Macintosh 1921). Taken together these trends provided several reasons for retaining the individual connection between milker, cow, and milk in the milking process: so that the important opportunity to perform a routine visual inspection to detect signs of ill-health in specific cows would not disappear from the milking process; so that the milk tested for quality, contamination, and infection could be traced back when necessary to particular cows, and so that the changing milk yields of individual cows could be accurately recorded over time and compared with others in the herd. These considerations countervailed the economic rationale for a transition to multiple simultaneous milking (Erf 1906: 66). Hence, after a short period in which suction machine designs tried to maximize the number of cows that could be milked at once (Sheldon 1878: 53), this began to be abandoned as a principal criterion for an ideal machine, and later designs were more focused once again on the most enduring problem of all, which was the bio-material interface between teat and technology.

The problem in essence was that of how to mediate between the variability and complexity of a living body and the uniformity and standardization of a machine. Unlike the constituent parts of the various milking machines that were trialed throughout the later nineteenth century, the udders and teats of cows did not conform to regular or uniform sizes, shapes, proportions, or positions, but—rather like milk itself (Nimmo 2010; Atkins 2010)—were subject to infinite natural variation. Thus, a device that fitted one teat relatively well would fit another more or less badly and would require constant supervision in order to prevent it from repeatedly slipping off and potentially falling onto the typically dirty floor below, thereby introducing contaminants into the milk (Sheldon 1878: 53). After some early attempts to use metal teat devices it was soon determined that rubber was the most suitable material for the construction of teat-cups, since it allowed for a degree of bending and reshaping in order to fit differently shaped teat (Erf 1906: 16; Orr 1919: 31–2). The use of rubber created another problem however, because it tended to harbor bacteria and was difficult to clean effectively given the need to avoid high temperatures or strong detergents which would damage it. Indeed claims made for the early machines by their inventors almost invariably included bold assertions about the sanitary advantages and ease of cleaning of their machines, followed tellingly by warnings that all rubber parts such as teat-cups and tubing must be washed regularly and thoroughly, albeit only ever with cold or tepid water (Orr 1919: 32).

Later machines included a wide range of variously sized teat-cups that would better approximate the diverse shapes and sizes of real teats and udders, and the use of suction helped to create a firmer seal and keep the cups on the teats, but even this only

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mitigated the problem, and the tendency for the teat-cups to fall off during milking persisted (Orr 1919: 31–2). The problem was essentially a spatial one, rooted in the difficulty of translation between the cow's living corporeality and the inorganic materiality of the machine, as very different kinds of spatial modalities. Rubber combined with suction provided an ad hoc and imperfect solution, a necessarily approximate and messy translation between organism and machine. But entangled with this spatial dilemma was the equally difficult problem of how to mediate between the temporal mode of being of the animal, characterized by cyclical rhythms, and the more linear temporality of the machine. This did not become visible as a distinct problem until suction machines with varying teat cup sizes had begun to render the spatial problem less overwhelming; once it became apparent however the temporal problem seemed to be so fundamental as to threaten to derail the operating principle of suction machines completely.

A mechanical calf

In the first suction machines a pump was used to create a vacuum that was transferred via tubes to rubber teat-cups, where it acted to exert a continuous and even suction by maintaining a constant difference in air pressure between a localized area inside the rim of the teat cup and the surrounding air. By this method, it was quickly found that cows could usually be milked considerably more quickly than by even the most skilled hand-milkers, and this was initially remarked upon as a real advantage of suction-type devices:

Thus, while in the case of the natural method of extracting the milk the vacuum is suspended every time the animal swallows, with Mr Murchland's machine the action of the vacuum is maintained all through the operation, and from 8 to 10 minutes serve with the majority of the animals to empty the udder of its contents.

Henderson 1890: 651

In this arrangement the intermittent action of the suckling calf is set aside, and replaced by continuous suction ... The milking was done more rapidly by this method than by the machine which provided intermittent suction ... As to what effect the prolonged use of this continuous suction might have on the natural powers of a cow to retain her milk, these trials could give no indication.

Courtney 1900: 468

It was soon discovered however that the repeated use of suction machines led consistently to problems in the udder, characterized by bloating and bruising of increasing severity, followed by a subsequent sharp decline in milk production. It was assumed that the problem was one of excessive suction applied to the teat, and experiments were conducted in order to determine the optimal vacuum force required to drain the udder of milk without causing damage over time with repeated use (Erf 1906: 65); but these efforts were effective only in extending the number of occasions on which a machine could be used

before the characteristic udder problems inevitably surfaced. It was belatedly realized that the problem was suction itself, or rather the application of continuous suction to the teat, which not only encouraged the rapid secretion of milk but also caused the pooling of blood and fluids inside the lower part of the udder, leading to a build up of pressure and resulting in the swelling and bruising (McDonald and Lapenta 2016; Erf 1906: 63).

This whole class of machines was based on the observation that a calf's mouth creates suction around a teat, but what had been overlooked was the importance of the fact that this is not continuous suction but intermittent, and far from this being an inefficiency that a milking machine might "set aside," a cow's udders and teats are evolved exclusively for intermittent suction, so that anything else will damage the tissues over time. Though a good deal of innovation had taken place in the transition from milk tubes to suction machines, with each step more closely mimicking the principles of organic life, whether the hand of a skilled human milker or the mouth of a suckling calf, continuous suction designs failed at the final hurdle because by attempting simply to suck the milk from the udder as efficiently as possible they ultimately reverted to the same crude instrumental rationality that had underpinned—and undermined—the early milk tube devices. The machines could not effectively mediate the interface between organism and machine because, while they were more spatially attuned to the udder than previous designs, they were still inimical to the distinctive temporal rhythms of the udder and involved the attempt to impose a linear, economic, and machine-like temporality upon the organism. Hence, despite the efforts of the designers of continuous suction machines to stress their efficiency and to render them less injurious, it was soon impossible to deny their damaging effects.

The first intermittent suction or "pulsator" machines emerged in 1895, with two similar designs patented that year, one by Alex Shiels of Glasgow, Scotland, and another by Modestus Cushman of Waterloo, Iowa. The Cushman machine consisted of "differentiated expansible vacuum chambers, milk pipes and a receptacle":

A rotary valve is placed at the bifurcation of the air pipe, which connects with the chambers; a similar one is at the junction of the air and milk pipes. The valves are connected by a rod whereby both are simultaneously operated for alternately opening and closing, communicating between the vacuum chambers, air pipes, milk pipes, and receptacle.

Erf 1906: 18

These machines represented the last major innovation in terms of fundamental operating principles, and all subsequent designs were essentially refinements and improvements on the "pulsator principle." The most significant of these refinements was a partial return to some of the ideas that had underpinned the earlier pressure machines, in that it sought to combine intermittent vacuum suction with "a pneumatic pulsating action varying inversely with the volume of the milk flow between the fixed minimum and fixed maximum of intensity" (Erf 1906: 27). Again, the intention was to more closely mimic the precise mouth actions of the suckling calf, which, it was observed, combined intermittent

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suction with a gentle tugging upon the teat, and it was felt that that this tugging probably had a role in properly stimulating the optimal secretion of milk. It was approximated through refining the application of intermittent suction so that it did not simply alternate between suction and no suction in an abrupt on/off binary action, akin to the explosions that power an engine, but instead cycled more fluidly through a build up and then decline of suction in a wave formation, causing properly-fitted teat-cups to intermittently “tug” at the teat as the pressure increased and then decreased with each pulsation.

Intermittent suction machines with some version of this refinement became known as “Thistle” machines, and these were the first milking machines widely regarded as practicable for regular use on working farms. They became the dominant design for milking machines throughout the early twentieth century, until they were eventually displaced by large-scale automated pipeline systems in the 1960s (McDonald and Lapenta 2016). Commercially available versions of “Thistle” machines were being marketed to dairy farmers in the United States under the name “Pine Tree Milkers” from 1900 and in Europe shortly after (Hamby 2014). Unlike the claims made by the designers of the earliest machines, which typically involved contrasting the putative efficiency of machines based on rational principles with the inefficiencies of nature, these later machines were presented not just as close imitations of the principles of nature, but as an improvement upon those principles which managed to put them into operation more perfectly than nature itself. “Surge” milking machines for example were the most commercially successful of the pulsation milkers, utilizing a design where the machine hung just under the udders during milking, which both significantly reduced the length of tubing that needed to be regularly cleaned and negated the problem of teat-cups falling onto the dirty floor if they became detached (Hamby 2014). As well as incorporating some design adaptations, Surge milkers were promoted with what at the time was a markedly sophisticated marketing strategy. In advertisements for Surge machines the brand name was often followed by the slogan “The Mechanical Calf,” emphasizing its closeness to nature; the machine operates so exactly like a real calf that in effect it *is* a calf, we are told, albeit an efficient and mechanical one.

The accompanying brand imagery consists of a cartoon depiction of a calf’s head sprouting from a metallic mechanical body with robotic legs, shown in the act of playfully kicking away an anthropomorphic milk pail labeled “hand milker,” as it winks conspiratorially at the viewer. A caption for “Pine Tree Milkers” reads “The cow’s like it, that’s why the farmer likes it—it *milks* better” (Hamby 2014). Thus the agency of the cow, far from being simply denied, is actually being invoked and enrolled in the discursive stabilization of this assemblage. Along with the tendency of some cows to reduce their milk production in response to machine milking, the act of a cow kicking away a milking machine in annoyance or discomfort was often remarked upon—albeit usually as an aside—in evaluations of the practicability of different machines, and is perhaps the most visible signifier of the cow’s agency and resistance (Courtney 1900: 470). That this very action was used—and its meaning cleverly reversed—in the marketing of milking machines is therefore very revealing of the discourse at work here: these machines are not only better for farmers than hand-milking, because they reduce the labor involved

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Figure 5.2 The Mechanical Calf, commercial image, 1929. Courtesy of GEA.

The Pine Tree Trade Mark

The cows like it, that's why the farmer likes it — it milks better

—the sign of better milking

PINE TREE MILKER

TRADE MARK REG. U.S. PAT. OFF.

The Cow's Adopted Child

SEE the Pine Tree Milker exhibit at the New York State Fair, Syracuse, N. Y., Sept. 8-13. We will have our usual location on Onondaga Ave.

See also Pine Tree Milker exhibits at New York County Fairs held at the following places:

Cuba	Sept. 8-12	Concord	Aug. 18-22	Lowville	Aug. 25-29	Oneonta	Sept. 18-22
Wellsville	Sept. Undecided	Lyons	Sept. 9-12	Ann	Sept. 9-11	Opportunity	Sept. 9-12
Richmond	Sept. Undecided	Watson	Sept. 3-5	De Ruyter	Aug. 12-15	Guadalupe	Aug. 19-22
Little Valley	Sept. 1-3	Malone	Sept. 18-19	Buckwater	Sept. 7-8	Franklin	Sept. 21-25
Moscow	Sept. Undecided	Ravena	Sept. 18-20	Fonda	Sept. 6-8	Catskill	Sept. 23-28
Albany	Sept. 20-22	Albany	Sept. 18-20	Middletown	Aug. 15-18	Orange	Sept. 9-12

Figure 5.3 Publicity for the Pine Tree Milker, exhibit at the New York State Fair c. 1919. Courtesy of GEA.

and increase the efficiency of the process, but they are also preferred by the cows themselves, because they more perfectly simulate the natural suckling of a calf. In this way, it is nature itself that is being sold to the farmer, albeit a nature mediated by technology and perfected by machines.

Conclusion

This chapter has drawn upon historical archive sources in order to examine a historical-sociotechnical moment that was pivotal for the subsequent industrialization and automation of milk production. It has traced how the development of mechanical devices for milking cows was a messy, uneven, and ad hoc process, full of contingencies, failures, and wrong turns. This is not consistent with any treatment of animal agricultural technologies as mere instruments of heteronomous political forces rooted in prior structural relations; instead technology emerges here as a contingent, contested, and agential moment in socio-material assemblages. It follows that the specifics of technological design as material practice should not be backgrounded or unduly simplified in order to serve a critical structural narrative. With this in mind, tracing the tortuous trajectory of milking machines empirically has unearthed a persistent tension between the extent to which the animal could be forced to adapt and yield, and to be reconstituted through the technology and in relation to the technology, and the extent to which the animal resisted subordination to the apparatus, instead forcing the technology to be adapted to her being. Thus, rather than situating the animal principally as a subject that is objectified, disciplined, and exploited by technology conceived as a political apparatus, what is striking in the case of milking machines is the degree to which the animal is resistant, and not principally through rudimentary acts of conscious resistance such as kicking away the apparatus, but as a being whose complex biocorporeality itself resists reduction to the materiality of the machine. In this way, this chapter has sought to contribute to restoring the liveliness and agency of cows that can be inadvertently exorcized in critical analyses of the dairy industry, by attending more agnostically to the relational entanglements of bovine biocorporeality with sociotechnical processes.

The body of the cow has its own nuanced spatio-material and temporal rhythms and modes of being that exceed reductive, linear and instrumental rationality, and which tend to thwart material devices rooted in these ways of knowing and measuring “nature.” Thus, the cow is never wholly objectified or disciplined by the machine, but rather—more symmetrically—becomes partially enrolled into an animal-machine-human hybrid in which each constitutive element mediates and conditions the others, but not without persistent material frictions, stresses, and moments of disjuncture, which at any moment could fracture the precarious assemblage. These frictions or interferences are not just bio-material but also bio-temporal; so it is not enough to examine disciplinary spaces and the politico-spatial dimensions of farming technologies, it is also necessary to attend to the ways in which specific temporal rhythms and modalities have both shaped and been reshaped by the human-technology-bovine

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nexus. What transpires from this kind of analysis is that cows are neither relatively passive objects of power, nor subjects constituted as such by the disciplinary and biopolitical technologies that act upon their “docile bodies”; rather, the cow is a bio-material being who shapes, constrains, and conditions the technologies that can act upon her even as she is subjected to those technologies. By exploring in this way the point of interface and mediation between animal body and technology that is at the heart of the industrial dairy assemblage, in a historical juncture wherein these relations were not yet stabilized and entrenched, this chapter has sought to strip away the layers of sociotechnical complexity and cast a new light on the relational materialities of animal, human, and machine.