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Proxies

The Cultural Work of Standing In

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2 HOW TO CLEAN A KILOGRAM: STANDARDS, DATA HYGIENE, AND THE THEATER OF OBJECTIVITY

THE CONVERSATION ROOM

It is October 22, 2018, and I am sitting in the Conversation Room at the Royal Institution of Great Britain (RI). The RI is a venerated site of public science education made famous through the exhibition of new discoveries and technologies, including Michael Faraday's demonstrations of electromagnetism, Guglielmo Marconi's demonstrations of wireless communication, and Nikola Tesla's spectacular demonstrations of alternating current. In the late nineteenth and early twentieth centuries, public events at the RI were often written up in the press, and represented the site of an idealized middle-class audience, as Carolyn Marvin describes.[1] For over two hundred years, the RI has served as the place where theoretical and scientific insights can become consumable events, and where the public can see how those insights will affect everyday life. It's a theater for sharing emergent scientific ideas with a privileged audience. Tonight, I am here to see Michael de Podesta, an experimental physicist and employee of the National Physical Laboratory (NPL).[2] He is scheduled to give a talk called "The Measure of Science: Redefining the Kilogram."

As the crowd quiets, de Podesta begins with a simple statement on the nature of measurement: "Measurement is an incredible idea; it's a very, very simple idea," he says.[3] There are roughly a hundred people in the Conversation Room. I am here because, for the past six years, I've been studying the management of the metric system and the methods that scientists and

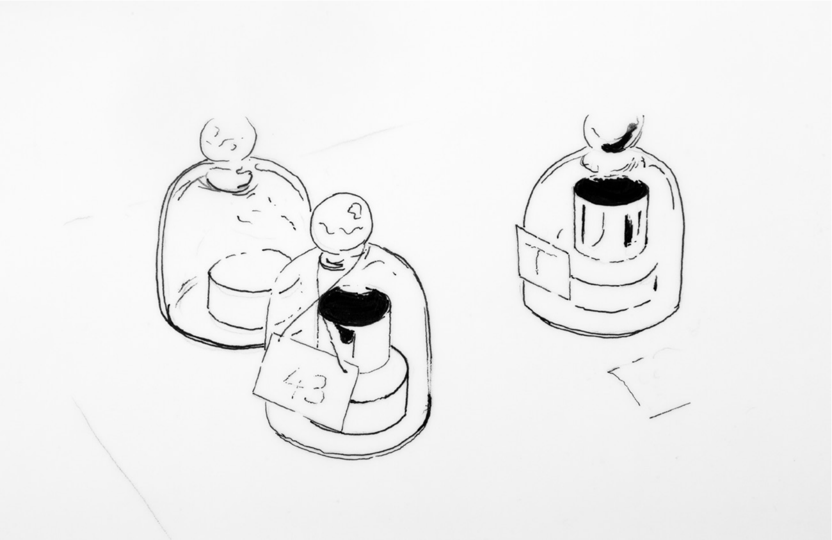

Figure 2.1
Clean, official kilograms under bell jars. Image: R. R. Mulvin.

technicians have developed for maintaining standard kilograms as proxies for the idea of "mass" (figure 2.1). The title of de Podesta's talk refers to the fact that the definition of "mass" is about to change. Mass has been based on one physical artifact—the International Prototype Kilogram (IPK)—but now it will shift to a definition based on a numerical constant. Right now, I don't really think that measurement is very simple. But it's a rare opportunity to see the changing definition of a standard, and the deliberate end-of-life planning of a proxy—one that has persisted for an inordinate 130 years.[4]

Then de Podesta continues:

> Measurement is just this thing where you notice things; you notice that one thing's bigger than another. And, after a while, you stop just noticing one thing's bigger than another, and you do something like you pick up a standard stick and you say, "This is the one I'm going to use to measure whether that plant's bigger than that one": you put it against one and you measure it; and you put it against the other and you measure it. People have being doing this since time immemorial.[5]

And there it is: at the heart of de Podesta's simplification of measurement is a proxy—in this case, a standard stick—that becomes a fixed point through which comparison is made possible and systematic. For de Podesta, and the metrological community more generally, having a communal standard is foundational to the very idea of measurement. When pressed for the pithiest of definitions for what measurement is, de Podesta says, "What is measurement? I've thought rather long and hard, and I've come up with this two-word definition: *quantitative comparison*. Or *quantitative comparison (of an unknown quantity with a standard)*."[6] The shared standards that de Podesta describes—those common benchmarks—are some of the oldest and most pervasive of proxies: stand-ins for ideas like "length" or "mass" that are fixed points, ready-at-hand, and against which other things can be compared.

Finally, he reached his thesis:

> The key to our understanding the world around us is the fact that we can measure. And so the key thing I'd like you to realize is: the only way we know anything about the world is by measuring things. And it's measurement that makes science scientific; it is not mathematics.[7]

How did a presentation in the Conversation Room about kilograms lead to a statement about "the only way we know anything"? We live in an era of unprecedented quantification and comparison. New standards abound to measure and classify people, behaviors, and phenomena. Some of this is engineered for profit, and some for the control of populations—the long hangover of the so-called average man—but all of it relies on the "very simple idea" that things can be compared if there is a shared benchmark. This is an ideological way of seeing the world as revealed through comparison. And whether or not we accept this view as legitimate, we have to reckon with the traction it attains and the manifold ways that benchmarks structure and distort our lives.

Fast-forward a few months: in May 2019, the definition of mass in the metric system was officially revised, and the IPK was replaced with a new standard—a standard that stipulates a recipe for creating or calculating a kilogram under strict conditions, based on the value of the Planck constant.[8] The IPK was replaced by a calculated value meant to provide a new, more stable base for the measurement of mass. But the convoluted replacement process occurred despite the fact that the original system was working just fine. As Terry Quinn, the former head of the International Bureau of Weights and Measures, argues, “There is no evidence of there ever having been a problem with mass measurement or measurement of any other physical quantity whose unit depends on the kilogram that could be attributed to defects in the system.”[9]

Prior to this redefinition, the metric system’s definition of mass was equivalent to the mass of the IPK—a cylindrical piece of platinum-iridium held in a vault in the suburbs of Paris. By basing the measurement standard of mass on a literal piece of metal, both the standard and the object were defined only with reference to themselves. This meant that without external checks, strict protocols were required to keep the kilogram as static as possible. To do this, the IPK needed to be compared with other, sibling kilograms—*but only after washing and cleaning*. In other words, the common standard that Michael de Podesta identified as foundational to the idea of measurement, relied on the human, manual, and embodied practice of hygiene. This was a curious and ad hoc process that reveals the haphazard, often fluky ways that proxies persist because they have been deemed fixed points.[10]

This chapter examines the IPK through the rituals that made it a viable fixed point. The IPK was born via ritual and returned to ritual forms of maintenance throughout its existence. Ritual, in this instance, is a way of distinguishing some objects as sacred, and it is best understood as a way of construing a protocol or an act so as to invest it with importance and meaning.[11] To understand the ritual labor of making and maintaining proxies, I trace two converging trajectories. The first considers *data hygiene* as a set of techniques and practices for keeping knowledge and information systems orderly. With particular focus on the ways that order is attained through embodied and manual protocols, data hygiene provides a heuristic for seeing the pervasive cultural labor that exists in the maintenance of knowledge infrastructures. The second trajectory follows the study of standards as specific examples of knowledge infrastructures by building on existing studies of standards as sociopolitical artifacts and “recipes for reality.”[12]

Bringing these two together, this chapter uses the IPK to illustrate some common features of proxies, as well as the protocols and rituals of maintenance and repair that make standards possible. Proxies are both porous (they absorb their surroundings) and sticky (they pick up pieces and leave traces of wherever they travel), leaving them marked by their institutional management and the communities of use where they circulate. To play off of another use of "fixed point" and to follow Ludwig Wittgenstein: "The axis of reference of our examination must be rotated, but around the *fixed point* of our real need."[13] If we let cultural labor and the politics of embodied performance be our fixed points as we examine the IPK, then we can situate the attempts to mitigate its porousness and stickiness as attempts to render the visible invisible and the detectable undetectable—to erase, in other words, the markings of its history, its emplacement, and its use.

DATA HYGIENE

Everyone has purity rituals: some people wash their hands in sinks, others douse themselves in alcohol-based hand sanitizer, we purge with fire, or we cleanse our bodies with specialized diets. In every case, dirt is shunned through learned, practiced, and embodied techniques.[14] "Dirt is essentially disorder," Mary Douglas writes. "If we shun dirt, it is not because of craven fear, still less dread of holy terror. Nor do our ideas about disease account for the range of our behavior in cleaning or avoiding dirt. Dirt offends against order."[15] Treating dirt as a category instead of as a natural thing allows us to see the social practices behind hygienics, including the fluid and changing boundaries of what constitutes dirt. It also allows us to view and analyze the technologies, protocols, and rituals that bring the category of dirt into being.

If dirt-as-category includes all forms of disorder that need to be cleansed, then it is also consistent with the norms and rituals that pervade in information and knowledge systems for maintaining "clean data," where data scrubbing and cleaning are both "accepted and unexceptional."[16] Anyone working with collections of data, whether large or small, will recognize the importance of maintaining a clean data set. Cleaning in this case involves the removal of extraneous, erroneous, or inconvenient elements from a database to create usable and verifiable data. In financial operations, for instance, data scrubbing or data cleansing might be as simple as rendering the data in the same unit (e.g., gold, silver, or a national currency). This practice of bringing disparate data points into relation, finding common units, and scrubbing unwanted information (to remove disorder) is a manual and repetitive process.[17]

In a database, a valid data set "must look pristine at the end of its processing."[18] To enable comparison and commensuration, certain features of data must be brought into focus (polished), while others are scrubbed clean away. Dirty or unclean data are not bad in and of themselves, but they do represent a threat to the coherence and usability of a data set, technology, or system, where eliminating dirt "is not negative movement, but a positive effort to organize the environment."[19] Data hygiene, then, is a way of describing the cultural work of articulation and disarticulation that bring data into accordance with their intended function by keeping "dirt" at bay.

Laundering

In the early 1970s, anyone following the Watergate scandal could add a new term to their lexicon when they learned that money could be "laundered." Specifically, they learned that President Richard Nixon's former commerce secretary, Maurice Stans, in his new role as finance chairman of the Committee to Reelect the President (CRP for short, CREEP for fun), had laundered illegal campaign donations through a Mexico City bank—donations that eventually went, among other places, to bribe the Watergate burglars and to buy First Lady Pat Nixon a pair of diamond-studded earrings.[20] The term "money laundering" did not appear in a major American newspaper until 1972, and throughout the Watergate scandal it usually appeared in scare quotes. In *All the President's Men* Bob Woodward and Carl Bernstein describe how Martin Dardis, the chief investigator for the state attorney's office in Dade County, Florida, linked the flow of money from a Mexican bank to Nixon's campaign for reelection. "It's called 'laundering,'" Dardis said. "You set up a money chain that makes it impossible to trace the source. The Mafia does it all the time."[21] Dardis was right about what had occurred with the president, and his apparent familiarity with the term "laundering" indicates that both the practice and term predated the scandal, although they had yet to penetrate common parlance.

Why would the Mafia, or a finance committee, want to launder money?[22] In each case, the aim is to clean money (as data) of the traces left by suspect and illegal sources; currency may be fungible, but the records of money's exchange are not. The traces left by money as an exchange medium can form their own record of what Lana Swartz calls a "transactional community": the set of relations that are produced by, through, and around transactions.[23] In the case of ill-gotten or ill-spent money, laundering is an attempt to camouflage this community. We can imagine money launderers like Stans—who kept the records of Nixon's laundered money—bent over their ledgers, deciding what bare minimum of data was necessary to keep for their own records and what needed to be effaced to conceal their transactional community. This is also a laborious memory practice of deciding what sufficient and plausible set of traces could conceal an illegitimate or dubious past.[24] We might also imagine ourselves staring at a spreadsheet of grades, ethnographic research, or bibliographic metadata to carry out the time-consuming practice cleaning data, pecking away at the DELETE and TAB and ENTER keys until order has been restored.

Voiding

In the simplest understanding, hygiene is a necessary and laborious part of making data commensurable and usable. But this assumes that we know and agree on what constitutes the extraneous or erroneous information that needs cleansing. "There is no such thing as absolute dirt," Douglas writes; "it exists in the eye of the beholder."[25] Take, for example, the US Supreme Court's 2018 ruling on the maintenance program for Ohio's voter lists (*Husted v. A. Philip Randolph Institute*). At issue was the purging of voter lists that was done ahead of the November 2016 elections. Registered voters in Ohio who had not voted for six years and who had not returned a postcard that they were sent were removed from the eligible voters' list.[26] Ohio was not alone; across the United States, many jurisdictions were eliminating voters from their rolls in similar ways. The states purging voters claim that such data hygiene is necessary to prevent voter fraud, though it appears to be a naked attempt to suppress votes by sowing confusion at the polls and excluding otherwise eligible voters from participation.

The technique has clear origins in the interpretive flexibility of existing laws, identified and exploited by conservative activists. In 2014, the Heritage Foundation, a conservative think tank, published a fearmongering report titled *A Primer on "Motor Voter": Corrupted Voter Rolls and the Justice Department's Selective Failure to Enforce Federal Mandates.*[27] The primer, written by a lawyer at the Virginia-based Election Law Center, instructs potential activists on how to exploit the 1993 National Voter Registration Act (NVRA), or "Motor Voter Law," to reduce their voter lists. The techniques rely on a selective reading of the NVRA's mandate. The primer states, "The third goal of the law was to impose a minimal obligation on states and local election officials to maintain *clean* voter rolls through the implementation of a *list maintenance program.*"[28] This was a politicized interpretation of what constitutes a "clean" voter roll, which has allowed some states to remove less frequent voters, as opposed to only those who have died or moved away. The Supreme Court ruled 5–4 in favor of Ohio's list maintenance program, upholding the state's interpretation of what could constitute a clean voter roll and paving the way for future voter-suppression techniques.

At the forefront of voter suppression in the United States is an opportunistic interpretation of what constitutes "dirt" in a data set, as well as conflicting norms over hygienic protocols for maintaining clean data. Evident in this case is the fact that the meaning of extraneous data is a contested area; there is a political stake in categorizing list items, and political actors develop highly choreographed rituals to justify these categorizations. The ruling in *Husted* confirmed the legitimacy of a scripted performance of citizenship, in which an unreturned postcard combined with a pattern of nonparticipation could transform a person's name into a political commodity, where deletion became a gain for some and a loss for others—though, we should stipulate, the easy deletion of anyone's name is a loss for everyone with a vested interest in supporting access to electoral democracy.

Sanitizing

In the development of contemporary information professions, as Michelle Murphy writes, office buildings were "machines designed to encourage the buzz of 'information' work inside and to produce a clean, orderly corporate world sealed off from both the polluted outdoors and the dangerous factory floor."[29] Likewise, in the early twentieth century, filing cabinets were promoted and adopted as technologies for compressing documents, managing an overwhelming amount of paperwork, and responding to the corresponding demands for the storage and retrieval of information.[30] Vertical filing cabinets sat on floors, but manufacturers would offer "sanitary legs" that could hold the cabinets several inches above the ground, permitting a cleaner to sweep under them.[31] In the case of the office, then, there are nested understandings of cleanliness that cannot be easily separated: the information in the office needs to be processed to be clean—well organized, easy to recall, and free of extraneous data—but this is possible only if the environment is itself free of contamination.

In homes and sites of leisure, we are also surrounded by familiar hygienic protocols. And just as the office contains nested understandings of cleanliness, homes are also characterized by the interdependence of systems for maintaining order. Ruth Schwartz Cowan documents the changing character of housework as gendered labor and in doing so makes the case against the separation of any one task (e.g., cooking, cleaning, shopping, caring) from any other—since each will rely on the other.[32] In the case of data hygiene, we might focus on those practices that are exerted on domesticated media texts: acts of censoring, cropping, dubbing, bleeping, moderating, flagging, filtering, blocking, and deleting content that allow texts to cross the threshold between the public and the private. The Motion Picture Production Code, the Communications Decency Act (CDA), and social media content moderation policies are all top-down methods of trying to control media content and to enforce normative conceptions of acceptable representation in the public sphere.[33] To view these policies and regulations as practices of data hygiene is to understand them as techniques for managing the contested boundary between clean and dirty, as protocols for performing hygienic labor, and as ways of making a public media experience commensurable within prevailing and hegemonic standards of decency.

For media texts, Raiford Guins draws a distinction between cleaning and sanitizing. The term "sanitizing," according to Guins, refers to the ways that images, films, television programs, and music can be edited to produce, for instance, so-called family-friendly versions. Hearing a song on the radio with the curse words bleeped out is a sanitized version. But sanitizing leaves a censorial gap, Guins argues, and "cleaning" is a further act of repair that not only sanitizes the text but fills the gap left by the initial cut. A clean version of the same profane song would substitute new words to cover up the censorship, and the result would appear to be the original.[34] In both cases, hygienic practices are instrumental in making texts that can circulate according to differential norms of propriety. Sanitized films, as Guins points out, are often promoted as versions that audiences can supposedly trust. If dirt is equal to disorder and dirty content is untrustworthy, then hygiene becomes a way of bringing trustworthy content through an imagined boundary protecting the home.

In American laws and regulations that seek to control content through a threshold between decency and obscenity, children are often the presumed victims of unfettered access to any allegedly dirty content. If we take data hygiene as an umbrella term to refer to a range of hygienic practices meant to identify and manage data, information, and content, then the idea of "out of place" can mean anything from an inadvertent keystroke that infects a data set to a fleeting expletive on live television, to an image that must be vetted before it is posted to a public website. From the office to private media lives, hygiene is not a supplemental practice added to the management of information, media, and data. Instead, it is a constitutive condition for the emergence of information management, as well as the very architecture of private and professional space—internal, external, and the ventilation in between.

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Hygiene is a fundamental technique for delineating social boundaries and norms of orderliness; it is a way that a society constructs techniques for identifying some things as dirt, and the response to that dirt in the form of rituals and practices of cleanliness. But hygiene is also inescapably bound up in power. Hygiene protocols always target specific things, people, and behaviors. And they are carried out by specific bodies. In the United States, voter suppression takes place in a system of structural racism that, in concert with the state's carceral industries, excludes racialized, immiserated, and marginalized populations from the democratic process; databases are often constructed to limit gender identity to a binary value, even when user-facing interfaces present a variety of options;[35] content moderation, on social media platforms, is often specifically targeted at limiting the communication of marginalized and minority users and of sex workers, and is carried out by a precarious and outsourced workforce often denied the bare minimum of workplace safety and mental health protections;[36] custodial labor is disproportionally carried out by racialized and migrant workers; household labor is disproportionally carried out by women. And some users of information systems are considered to be dirtier than others.

As T. L. Cowan has suggested, "digital hygiene" can refer to the ways that we are called upon to maintain clean digital habitats. This might mean keeping an orderly file structure, or maintaining a professional presentation on social media. In either case, the metaphor always concerns the body.[37] Just as bodily hygiene, diet, and behavior have been used to shame individuals and to police bodies that are deemed a threat to public health, the compulsory demand that our digital environments be sanitary falls mostly upon the already-marginalized. Even when we look for exceptions to this rule, we find that hygiene is inescapably bound up in political negotiations over the power to handle information. As Daniela Agostinho and Nanna Bonde Thylstrup show, whistleblowers, leakers, and "truth-tellers" are always "entangled in gendered matrices of control that make possible some truth-telling subjects while foreclosing others."[38] All of this orients the study of data hygienics (1) as a social category for the policing of bodies and behaviors, (2) as relying on the embodied and infrastructural labor of a community of practitioners, and (3) as bound up in a political negotiation over who can handle and manage information in normatively valued ways.

As the remainder of this chapter returns to the role of standards in structuring lifeworlds, it will be tempting to see the protocols for maintaining the IPK as being unbound to the same political negotiations over hygiene protocols. But this couldn't be further from reality: not only is the metric system the foundation of a global infrastructure for the measurement and control of space and time—a European-based standard on which countless other standards rely—but the protocols for cleaning the kilogram demonstrate that, at the most fundamental level, standards and infrastructures are *always* tied into the manual and bodily practices of hygiene and cleanliness that make data socially valuable.

STANDARDS AND THE THEATER OF OBJECTIVITY

Standards are a dominant way of organizing the world. They distribute people, places, and things according to hierarchies, classifications, and categories, and they do so in ways that are putatively pragmatic. Standards are often treated as obdurate pieces of technology that spread over time and space with a force all their own. But in practice, the standardization process is contingent, as people craft standards in specific places and for practical or idealistic reasons, and they maintain them in makeshift ways according to local imperatives.[39]

Over the past several decades, scholars have increasingly turned to the role of standards on two contrasting scales: as technologies that condition everyday existence, and as technologies that span the globe, enabling systems of trade, circulation, and management.[40] But on each scale, standards are made to get things done—for some people, at some times. As we are constantly reminded, standards are also meant to disappear from view, to sink to the level of infrastructure, to go without notice, and to become second nature—they are meant to help us to forget.[41] As Elizabeth Cullen Dunn says, "A standard without an appropriate infrastructure cannot be put into force without major upheavals in the physical environment and the social organization of production."[42]

To employ standards requires an initial investment in a single decision about choosing fixed points.[43] These points are both arbitrary and precise:

even when based on supposedly invariant, natural phenomena, they are the product of human community, human measurement, and a collective agreement to accept them as fixed and communal.[44] For a familiar case of arbitrary precision, take the case of progress marking in football, in which officials manually place the game ball on a line at the end of each play by basing the measurement on their split-second judgment of a tackle. They determine, to the best of their judgment, exactly where the football stopped moving forward. This location becomes the fixed point for starting the next play. In instances where the ball is very close to the threshold for a first down, officials will bring out a ten-yard chain to measure if the ball progressed far enough.[45] The entire scenario provokes necessary reflection: why employ a precise measurement instrument like the chain when the first judgment was imprecise and reflexive? This is the logic of arbitrary precision: decisions must be made to situate fixed points in certain positions, and those fixed, certain positions become crucial to further judgments. Protocols like the referee's locating of the football are part of the rituals that go into making systems appear objective; they are part and parcel of a theater of objectivity. In another sense, fixed points work as the "fictions" that make standardization possible.[46]

A standard, as Lawrence Busch argues, is a recipe for producing and reproducing a narrowly defined phenomenon. A meter stick stands in for a fraction of the Earth's meridian and is easily reproduced in metal, wood, or string whenever a meter is needed.[47] As a proxy for both a specified length and for the process that created it, the meter stick eliminates the need to remeasure the meridian and protects against the variations in other ready-at-hand standards, like the difference in length of various people's outstretched arms.[48] This is the promise of proxies: they allow us to forget. Because scientific and technical proxies are the embodiment of choices about imagining the world within testing environments, like those of the lab, the workshop, the courtroom, and the office, they are important materializations of a hypothesis about the world, forged into small, manageable, usable, workable, exchangeable, and reproducible chunks. They include prototypes, working objects, measurement apparatuses, lab samples, and test and training data—and are supported and buttressed by a whole ecology of objects, manuals, and memos for referencing, checking, and maintaining those materials. To study the material life of proxies is to study the process of capturing the world in usable chunks, to interrogate the choice of some proxies over others, and to investigate the contextual characteristics of maintaining a material apparatus as the basis of a knowledge infrastructure.

Standards are primarily intended to make things run smoothly for interested parties by reducing local differences and increasing interoperability. As Laura DeNardis argues, interoperability is the growing concern of systems that are built to share resources, standardize parts, and exchange information efficiently.[49] There are clear exceptions in which standards actually introduce friction; for instance, proprietary industrial standards that are supposed to make it harder for new entrants to join a market or prevent users from opening the black-boxed content of their media.[50] But even in these cases, we can say that standards are crafted in and through power: they work for certain people in certain ways—industrial standards might protect the market share of existing operators or the financial benefits of existing copyright holders, while state identification standards might limit who can drive, vote, or have their gender identity recognized.[51] Studying the proper functioning of a standard then becomes about identifying for whom it works and under what conditions. If we stipulate this premise, then we can study standards as specifically situated and insistently normative statements about how the world *should* operate—statements that unavoidably embody and codify ethical statements about who or what is a priority.[52]

The smooth functioning of an integrated economy or a system of centralized governance requires the commensurability of people, places, and things to rank, order, and measure. Complexity requires comparison, and standards create and enforce categories that become means of control.[53] Yet, as Geoffrey Bowker and Susan Leigh Star argue, belonging to a category can either be a privilege or an affliction, a condition of possibility or a means of oppression—or something in between.[54] The ambivalence of standards, norms, and categories can compel the abandonment of radical difference in exchange for recognition in an institution. It is a Whiggish view of history as the progress of rights, which treats the recognition of one's difference in a standard or norm as the surest way to economic and political enfranchisement.[55] The danger of recognition in a standard is that it will crystallize an identity or a category that may otherwise be fluid, uncertain, or undecided.

In the eighteenth and nineteenth centuries, standardization was often imagined to be a pathway to interjurisdictional (if not global) harmony. What we now call interoperability was once a test of a country or an empire's capacity to control the basic terms of measurement and exchange, while basic units of measurement for length, weight, and coinage are often regarded as the earliest form of contemporary standardization. By demonstrating the possibility of standardization in these domains, the legitimacy of standardization was later imported into other disciplines and domains.[56] As Kathryn Olesko states, "The techniques and instruments that produced more accurate weights and measures (which made social interactions as well as commercial transactions more exact) migrated early in the century to the sciences where they formed the nucleus of exact experimental practice."[57] Going further, James C. Scott, in his analysis of the modern nation-state, traces its emergence to the provision of basic units and the standardization of measurement. Standards, Scott argues, are "transformative state simplifications."[58] As such, standards appear as primary and ideal instruments of management, and encapsulations of the very possibility of manageability. By using an arbitrary but precise measurement system, states could manage the much-less-precise and much-more-fluid components of their population.

The crafters of the metric system, operating at the height of the Enlightenment and in the throes of the French Revolution, imagined that a new political unity needed an apparently democratic system of units based on a measurement of the Earth's circumference. In a contemporary setting where standards are often equated with state violence, blunt instruments like standardized testing, and the eradication of difference, it is easy to forget that in the eighteenth and nineteenth centuries, standards were imagined as tools for maintaining fairness and justice.[59] Sandford Fleming, the

Scottish-Canadian engineer who proposed a system of time zones (what he called "Cosmic Time"), believed that the implementation of such a system could bring about global, political, and economic harmony.[60] Max Planck went one step further, suggesting that a system of units based on the fixed constants of nature could be a standard shared for all times, by all peoples, and potentially even by extraterrestrials.[61]

The critical and cultural study of standardization is concerned with the ways that quotidian life and practices of making do are structured by standards and infrastructures that are themselves massive, sometimes violent, technologies rendering things interoperable at the cost of heterogeneity and uncertainty. By approaching proxies as leveraged simulations of the world and treating the standardization process as a cultural, performative, and representational practice, we reverse the relationship between the macro scale of standards and the micro scale of lived experience; instead, we can analyze the ways that local contingency enters the standardization process through the representation of the world in usable ways and the embodied labor of animating proxies. Through the cultural lives of proxies, we can trace histories of the cultural interiors of standardization. The history of proxies not only shows how standards are made to contain messy reality, but also what happens when that messiness inevitably leaks out and new realities seep in.

CLEANING A KILOGRAM

To clean a kilogram, you will need the following supplies:

For cleaning by hand

1) 1 piece of chamois leather
2) A 500 ml mixture of equal parts ethanol and ether

For solvent washing

1) 1-L Pyrex flask containing bidistilled water
2) 1 tube with a 2-mm spout
3) 1 bowl for collecting condensed water
4) 1 tripod that can spin on its vertical axis and extend vertically

5) 1 platinum-iridium disk
6) Filter paper

Time: about 50 minutes

About 6 days before you want to clean your kilogram, begin soaking the chamois leather in the ether-ethanol mixture for 48 hours. Wring out the leather—this helps remove impurities, and you definitely don't want impurities on your kilogram. Repeat this stage two more times by soaking the chamois leather in a fresh bath of ether and ethanol and wringing it out each time.

When your chamois is finally free of impurities, you can begin to clean your kilogram. A kilogram needs to be rubbed with approximately 10 kPa of pressure (figure 2.2). If you do not have a Pascal gauge handy to measure kilopascals,

Figure 2.2
Cleaning a kilogram by hand. In your less-dominant hand, cushion the kilogram in a length of chamois leather. With your dominant hand, take a corner of the chamois, wrap your index finger in it, and clean until you reach the handsome, but not specular, surface you desire. Image: R. R. Mulvin.

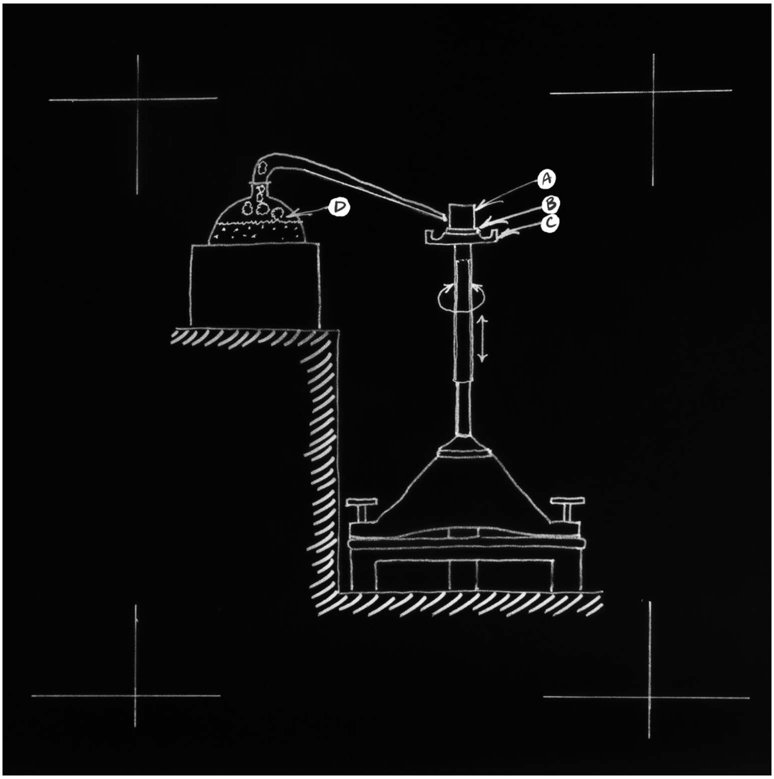

Figure 2.3
The steam-cleaning apparatus for washing your kilogram with solvent. Image: R. R. Mulvin.

simply rub the kilogram fairly hard by hand. Remember that you are trying to return the kilogram to its original luster: "rather handsome, but not specular."

After manual rubbing, your kilogram is ready for solvent washing with steam. Figure 2.3 shows you what your solvent cleaning setup should look like. Place the kilogram (A) on the platinum-iridium disk (B). The disk should fit comfortably on top of the tripod (C). Fill your Pyrex flask (D) about three-quarters with doubly distilled water. Run the tube from the flask to the top of the tripod, pointing the opening at the kilogram but keeping it about 5 mm from the surface. Heat the water with an electric mantle, operating at 350 W.

As the water boils, steam will start to come out of the tube. It should first be pointed directly at the kilogram's uppermost edge. Rotate the tripod on its vertical axis, making sure to steam all 360 degrees of the cylinder. It's like a vertical rotisserie! Start moving the kilogram upward while continuing to rotate it. Blast the kilogram with steam for 15–20 minutes.

Most of the steam should run off the kilogram and into the bowl. It is normal to have a few drops of condensed steam on the kilogram's surface. For these stragglers, take a corner of the filter paper and absorb each drop individually using the paper's capillary action. If you don't have filter paper, you can also blow the drops away with a jet of clean gas.

Next, flip the kilogram on to its bottom so that you can clean the part that was resting on the disk. Repeat the process of steam cleaning the kilogram—rotating it and raising it—so that the cylindrical surface gets a second cleaning. (Of course, you'll want to make sure that the disk under the kilogram was cleaned in advance using the same technique. But you knew that!)

Return the kilogram to its resting place under a glass bell jar (as shown in figure 2.1). If you are accustomed to using a chemical desiccant to dry the air inside the bell jar, it's really not necessary (but there is comfort in tradition). Congratulations—your kilogram is clean![62]

THE METRIC SYSTEM: MEASUREMENTS MAINTAINED THROUGH HYGIENE

For proxies to work, they have to act as fixed points and have to be taken for granted. For this to be possible, they must be orderly. Because, as artifacts, they soak up their surroundings, leak, and decay, all proxies need to be cleansed or risk falling into permanent disrepair. This section considers one practice of hygiene through an analysis of the IPK and the protocols for keeping this small piece of metal clean—a process that extended its life as a proxy and as a component of the metric system. Until recently, the IPK was the last remaining physical artifact that formed the basis of a fundamental unit in the metric system. Because fundamental units are primary building blocks in standardization, the kilogram was a special case: a physical artifact meant to serve as a shared and immutable reference point. Far from an obscure piece of bureaucratic triviality, the standard of mass is inseparable from everyday life and the calibration of the world around us.

The IPK is a 39-millimeter-tall, platinum-iridium cylinder housed in three nested, vacuum-sealed, glass bell jars and locked in a vault on the outskirts of Paris.[63] Access to the IPK requires five separate keys, kept by three separate individuals.[64] If Hollywood films are to be believed, there are more keys involved in accessing the IPK than launching a nuclear missile from a submarine (which movies have shown me only need two keys).[65] That much security is necessary to guarantee that this small piece of metal is safe and uncontaminated.[66] Until 2019, the IPK—represented more elegantly by its symbol, 𝔎—was the basis of the unit of mass in the International System of Units. The International System of Units, abbreviated SI, is more commonly known as the "metric system," though the equation of the two is misleading. When I write 𝔎, please imagine that I have written "IPK."

𝔎 was afforded its own special symbol because it is a unique object; though it has siblings and descendants, it is special among its kind. 𝔎 gets its own symbol because of its use in mathematical calculations. Like π (pi) or Ω (ohm), 𝔎 is a fixed value used in the calculation of other values. 𝔎, for instance, is used in the calculation of Ω. Unlike π or Ω, however, 𝔎 previously did not refer to an abstract figure, but rather to a physical artifact. The most important aspect of 𝔎 was that all kilograms referred back to it.

Like many proxies, 𝔎 represented a kind of idealism. As part of the original metric system, it was derived from a scientific endeavor situated in the depths of the Enlightenment and was based on French Republican ideals, which stated that more democratic measurement standards could be based on the so-called invariants of nature instead of the arbitrary whims of kings, lords, or merchants. In this case, the invariant was a fraction of the Earth's circumference (a meridian). While not all proxies are this idealistic, the high-minded surrogate logic behind 𝔎 hinged on picking a piece of metal that could transcend the authority of monarchs.[67]

The choice of a proxy is the choice of a fixed point against which subsequent objects will be judged. Lying beneath the choice to base a measurement system on the invariants of nature is a searching desire for stability in a chaotic world, in which standardization represents a human-built attempt at creating order. By divorcing measurement standards from the whims of monarchs and their emissaries, the designers of the metric system were declaring that the scientific community was the proper locus of power to name proxies.

The management of the metric system is overseen by a three-part bureaucracy, created by the 1875 Metre Convention (also known as the "Treaty of the Meter"): the Conférence Générale des Poids et Mesures (CGPM; General Conference on Weights and Measures), which acts like the UN General Assembly of all signatories to the Convention and meets every four years; the Comité International des Poids et Mesures (CIPM), which is kind of like the UN Security Council to the CGPM, meeting every year and guiding decisions about measurement standards; and the Bureau International des Poids et Mesures (BIPM), which encompasses all of the physical infrastructure of the metric system and its headquarters. The BIPM includes a set of laboratories and offices in Sèvres, in the suburbs of Paris. Together, these different groups and institutions are responsible for guiding changes to the future of metrology and providing protocols to national laboratories and methods for establishing equivalences between national measurement standards.

Despite its origins in a French Republican project aimed at creating democratic standards, the IPK was a rarefied object. Although local measurement standards for length were once embedded in city gates, making them available for traveling craftspeople trying to calibrate their tools, the IPK was, in its lifetime, exceptionally difficult to access. This is a deep but functional irony of proxies, as they need to be both easily realizable and secured against interference. 𝔎 manifests this irony in a very obvious way: most of the world engages with the metric measurement of mass on a daily basis. (Even the pound unit of weight in the US customary system is actually defined as a fraction of the kilogram.) Yet a tiny number of people have ever interacted with 𝔎. It's like the pope, but even more secretive. Each measurement of mass that relied on the soundness of the metric system relied on the fact that 𝔎 was safely kept where almost no one could see it. Yet when it is withdrawn from its safe enclosure to be cleaned, it transitions from the secure basis of being a worldwide measurement system to become a working object and a profane artifact of the laboratory; *hygiene* is what connected the kilogram's idealism with its realization as a scientific instrument.

Sporting the French designation *nettoyage et lavage* (cleaning and washing), the hygiene protocols for 𝔎 were a response to the object's specific history—crafted in the nineteenth century, locked in a vault—and its position atop a referential hierarchy. 𝔎 is a privileged case in the history of measurement standards that nonetheless demonstrates many of the basic features that proxies share. It was selected and agreed upon by committee and convention, and it is invested with self-referential importance, such that replacing it required a wholesale rewriting of the metric system. The history of 𝔎, then, is both a general history of the manual maintenance of proxies and a history specific to the material conditions and constraints of this one specific piece of metal.

THE HIERARCHY OF KILOGRAMS: TRACEABILITY

Measurement science uses the relationships between objects and institutions to maintain the authority of standards. The referential relationship between 𝔎 and other kilograms is called traceability. Traceability is a term used in a wide range of disciplines, operations, and practices. Genealogy uses a kind of traceability, as does forensics. In measurement science, traceability refers to "a property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty."[68] There are two things to note. First, this kind of traceability deals in a logic of material presence. The unbroken chain of calibration means that each kilogram in the chain of kilograms must have been compared, side by side, to a kilogram one level above it in the hierarchy. Second, each step away from 𝔎 adds to the uncertainty of each kilogram's precise mass. Traceability is the combination of calibration and citation: a measurement operation with a history. As one introductory textbook puts it: "To say that a package of butter weighs a pound means that it has been connected by some long and complicated series of comparisons to The Kilogram in Paris, and weighs 0.4539237 times as much."[69]

In practice, this means that local inspectors possess a kind of working standard that is checked against, for example, county, state, or national prototypes so that they can verify a scale in a grocery store—a practical mass measurement instrument—with the knowledge that the standard is traceable to 𝔎 (figure 2.4). Most national laboratories have prototypes that are traceable to 𝔎; these are referred to as "secondary standards," which are calibrated through direct comparison with each other or 𝔎, the primary standard.[70] Traceability is the capacity of a system to account for its connections: in this case, to quantify, document, and disseminate the difference between two individual pieces of metal. But not just any traceable difference will suffice. The kilograms involved in the traceable hierarchy of mass standards need to have the lowest possible level of uncertainty.

Figure 2.4

Traceability in the wild—in this case, proof that a scale at a New Jersey branch of a popular chain of grocery stores was recently inspected. Similar stickers are seen on any scale that an employee operates (deli, butchery, fish, and so on), including the scales used by cashiers. This interdependent network of inspected scales guarantees that the measurable weight of goods is consistent throughout a given store, within a particular state or nation, and that all of them are ultimately traceable to 𝔎.

THE PROTOTYPE KILOGRAM: A SYSTEM OF FIXED POINTS

The metric system is the most wide-reaching set of measurement standards in history. And among modern standards, it is also one of the longest lasting, having been in force in some form since 1799. Many of the protocols surrounding the metric system established the means through which international standardization efforts could take place. Tellingly, the 1798–1799 Congress on Definitive Metric Standards, organized by the French government, was likely the first international scientific conference of any kind.[71]

Prior to the creation of the metric system in the late eighteenth century, the Ancien Régime in France believed that the flourishing of the British economy was due to their standard measurement system, and the lack of such a system in France prevented them from participating in the kinds of frictionless trade possible in Britain.[72] A uniform system of measurements, the monarchy's chief minister of the nation believed, could solve the national food crisis, so he recommended declaring the local Parisian set of measurements as the new national standards. As Ken Alder writes, "A modern nation needed a standard, *any standard,* and the surest course of action would be to declare the units used in Paris the national units."[73] Instead, as scientists and bureaucrats worked on a new system of measurement—what would become the metric system—revolution broke out in France and standardized units, universal decimalization, and fixed points based on the Earth were each held up by Republican figures as symbols of the egalitarian possibilities of nonauthoritarian rule. The French Academy of Science wanted a universal measurement based on the "invariants of nature." This was an attempt to erect a standard that could be enacted—that is, performed—neutrally, objectively, and beyond the control of the monarchy.

Here, a subtle shift was made to align scientific objectivity with political neutrality and egalitarianism. Hence, the meter was based on a fraction of the Earth's quarter-meridian: "They vowed to choose a set of measures which would 'encompass nothing that was arbitrary, nor to the particular advantages of any people on the planet;'" and a set of measures that could establish "a uniform language for the objects of daily economic life."[74]

Despite the language of the proposal—the insistence that the measurement system would "encompass nothing that was arbitrary"—there is no natural or guaranteed alliance between something called a "meter" and the Earth.[75] Indeed, as later calculations would show, even the measurements of the meridian were erroneous and based on inaccurate, though no less precise, conjecture about the Earth's shape.

In the metric system, the length and shape of a meridian constituted a way of encoding a necessary fiction as a starting point for a new measurement system. The fiction itself was also a heavily encoded signifier, reflecting the social, political, and economic idealism of a nation on the brink of revolution and promising that citizens would be able to share information and conduct business through a standard that was independent of the sovereign. As an outgrowth of the political upheavals of post-Revolutionary France and Enlightenment ideals, the early years of the metric system were tumultuous—and imposition of the new system was often met with violent pushback. But its designers persisted.

In 1799, a prototype meter and kilogram, called "Le Mètre des Archives" and the "Kilogramme des Archives," were produced using provisional measurements of the meridian. The Kilogramme des Archives was based on three interrelated, fixed points: the length of the meter, itself based on a fraction of a terrestrial meridian, and the mass of distilled water at its melting point. Here, 1 cubic centimeter of pure water equaled 1 gram and, to make the prototype more practical (instead of tiny), its mass was 1,000 grams. Yet once the meridional measurements were shown to be inaccurate, the inaccuracy was ignored. That is to say, the *precision* of the inaccurate measurements and the precision of the prototype's construction were far more valuable for the social and political work that the new measurement units would perform, as fixed points, than the accuracy of their referential measurements.

As Scott notes, three factors in particular led to the metric system's ascendance:

> First, the growth of market exchange encouraged uniformity in measures. Second, both popular sentiment and Enlightenment philosophy favored a single

standard throughout France. Finally, the Revolution and especially Napoleonic state building actually enforced the metric system in France and the empire.[76]

While Napoleonic conquest within Europe is often credited with the success of the metric system, recent research has highlighted the role of industrial standardization. Beyond mere market exchanges, international expositions became major trading sites and stages for the benefits of standardization.[77] For nearly a hundred years, the metric system ebbed and flowed in its adoption and enforcement. Despite being illegal in England (it was legalized in 1896) and the United States (1866) for much of the nineteenth century, the metric system grew into a singularly powerful and deeply entrenched standard through both industrial adoption and military imperialism.

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The true moment of ascendence for the metric system came in 1875, with the signing of the Metre Convention. The conference to sign the Metre Convention took place in Quai d'Orsay, in Paris, and lasted from March 1 until May 20. Over those seven weeks, attendees planned the creation and maintenance of new physical standards for the meter and the kilogram.[78] This meant deciding on the design and selection of new physical artifacts, as well as the establishment of a new bureaucracy to oversee the system. At the 1875 conference, attendees considered whether the Mètre des Archives and Kilogramme des Archives would serve as the bases of the new standards, as the intervening decades had shown these standards to be far from true derivations of the "invariants of nature" on which they were supposedly based. They decided to retain these prototypes as primary models and to produce new meters and kilograms as facsimiles. The choice of an original fixed point, the precise-if-inaccurate measurement of a terrestrial meridian had, it turned out, locked in a system of measurement whose usefulness superseded the drawbacks of its inaccuracies. At each stage of renewal and revision in the metric system, the original, arbitrary decision to base the system on meridional measurements was reaffirmed and resanctified.

A renowned British assayer and refiner, Johnson & Matthey, was chosen to produce thirty prototype meters and forty prototype kilograms to serve as national reference standards for signatories to the Metre Convention.[79] The first three kilogram prototypes were produced together and, as such, 𝔎 is one of three "identical" artifacts, chosen for having the smallest measurable difference to the Kilogramme des Archives. The word "identical" is tentatively used here because 𝔎 was vested with its position atop the hierarchy of mass measurements precisely because it is *not* identical to any other object. When it came time to compare the new prototype kilogram with the Kilogramme des Archives, the measurements were carried out in the grand hall of the Paris Observatory (among the greatest symbols of Enlightenment science), which was located directly on the same meridian that was used to formulate the metric system.[80]

I highlight these rituals because they do nothing to make measurement science more accurate. But they clearly perform a cultural function: through the theatrical performance of objectivity and the rituals of commensuration that surround the manufacture and consecration of new proxies, we glimpse the ways that institutions shore up the arbitrariness of human decision-making. Here, the choice of one tiny piece of metal over others in order to stand as a sacred and self-defining unit was explicitly drawn together with the measurement of the Earth, the legitimacy of academic science, the larger political movements of Republican France, and the institutional markers of seriousness, prestige, and history.

THE RITUAL BURIAL

𝔎 was joined by six other check-standard kilograms, called *témoins* (witnesses). The wording here is important. The meaning of the French words *témoin* or *témoinage* (witnessing) is comparable to their counterparts in English. The witness kilograms are meant to attest to changes in 𝔎. They do not do this through eyewitness accounts or oral testimony; rather, they attest to changes in 𝔎 by being brought into measurable comparison. The only knowledge that we have of 𝔎's absolute mass comes from comparisons conducted with a mass comparator, which is like a kind of scale that *only* measures differences between two objects. The witnesses' bona fides are established through a shared history and through their identity as kilograms: they were produced from the same metallic alloy from the same refining company, some at the same time as 𝔎 and some in the years afterward; and they are housed in the same environment, in the same vault, with the same air and the same exposure to light.

According to the BIPM, any factor that is shared by 𝔎 and its witnesses can be ruled out as a factor contributing to changes in the mass of 𝔎.[81] That is to say, the officials at the BIPM believe that anything that would bear on 𝔎 would also bear on its witnesses. It is afforded more care and attention than most measurement tools, but the use of *témoins* and the attempt to control for 𝔎's historical specificity—to identify what is special to it that might explain some change in mass—highlight a facet of commensuration in all measurement operations: measurement is a process of developing conditions for identifying difference.

In 1889, fourteen years after the signing of the Metre Convention, it came time to vest the prototypes and the *témoins* with the imprimatur of the institution at the first meeting of the CGPM. During the *troisième séance* (third session) of the General Conference, the attendees entombed 𝔎 along with 𝔐, the prototype meter. The two would serve as the basis of length and mass measurements in the metric system for decades to come, but first it needed to be sanctioned by the attendees of the conference. In the early afternoon of September 28, 1889, the attendees of the CGPM gathered to enclose the new prototype meter and kilogram. The minutes from the session describe the process as "*enfermer*," which translates in a number of ways: "to enclose," "to lock up," or "to sequester." Peter Galison translates this act as "burial" and "interment," which might exaggerate the inaccessibility of the prototypes to future access, but usefully highlights the ritual nature of the event.[82]

Eight objects were enclosed that day: 𝔎 and 𝔐 were each joined by two *témoins*, a thermometer, and a copy of the report describing the ritual. This network of objects created a circuit of referentiality based in a documentary regime of verification, with each piece pointing back to another: the report signifying the consecration of the objects, the thermometer attesting to the fact that the objects are kept at a stable temperature (that of melting ice), the *témoins* as corroborators of the prototypes, and the prototypes as embodiments of the measurement system's authority.[83] The entire vault was locked by three keys, behind an outer door locked by an additional two keys, and the keys were given to three separate officials.[84] This process, consisting of burying objects in front of an audience, with reports of their sanctification, and locking those things away with keys to make them transcend their profane origins, attests to the ritual, manual, and documentary conditions that enable, create, and maintain proxies at the basis of standards. Like Jacques Derrida's analysis of the signatures on the Declaration of Independence, where "the signature invents the signer," the Prototype Meter and Prototype Kilogram had no authority *until* they were hidden from view, locked in the dark along with the documents declaring their power.[85] Likewise, the authority of the documents that are buried alongside the meter and kilogram is performed by the copresence of the consecrated objects. One does not predate or include the other; they work together to constitute a verifiable institution.

The ritual burial of 𝔎 and 𝔐 began a new era in the metric system. There was now widespread international agreement among a plurality of nations to assign foreign (Parisian) artifacts as the basis of their measurement systems. Even in the United States—a country famous for its refusal to use the metric system in civic measurements—the Metre Convention changed the meaning of standard units. The United States was an original signatory to the convention, and in 1893 it changed the definition of its customary units (feet, inches, pounds, ounces) to be based on fractions of the metric system. The allure of international interoperability was too powerful to resist. But the 1889 ritual gets short shrift in the history and philosophy of measurement.

The focus instead tends to fall on the definitions of the meter and kilogram that followed after those artifacts were sealed into the vault. At the third CGPM in 1901, the mass standard was defined explicitly:

> The kilogram is the unit of mass; it is equal to the mass of the international prototype kilogram.[86]

This declaration meant that the kilogram, as a unit, is only ever the mass of 𝔎, and the mass of 𝔎 is always equal to 1 kilogram. By this definition, 𝔎 could not include a measurement error, as it contains no uncertainty.[87]

This is the only way that it can serve as a stable ground for determining difference in other prototypes and, for that matter, any measurable difference of mass.[88] This assertion of 𝔎's lack of inherent error is strictly conventional. A "kilogram" had no natural meaning except that which is assigned by decree to one particular piece of platinum-iridium. The original Kilogramme des Archives, which 𝔎 was meant to reproduce, was based on both the measurement of the meter and the density of water. The meter, in turn, was based on a fraction of painstaking (if inaccurate) measurements of the Earth's meridian. Objects can seal in provisional, mistaken, or hurried knowledge and assumptions about nature, behavior, and political process. The mass standard, then, is at once a rich index of a political process and a flawed index of a natural attribute of the Earth.

BAD HYGIENE

The circular definitions of the metric system's mass and length standards have produced no shortage of philosophical consideration.[89] Ludwig Wittgenstein turned to the International Prototype Meter to prove a point about the conventionality of paradigmatic thinking. He writes by way of example in *Philosophical Investigations*: "There is one thing of which one can say neither that it is one metre long, nor that it is not one metre long, and that is the standard metre in Paris."[90] What Wittgenstein is arguing is that there are certain concepts (or, in this case, objects) that are paradigmatic and self-sufficient, such that they create the standard by which other objects of that kind will be understood, measured, classified, and otherwise ordered. Some have dismissed Wittgenstein as fundamentally misunderstanding or misstating the function of measurement but he, and likeminded philosophers, expose both the conventionality of measurement and an aporia at the center of standards.[91] It is this kind of paradigmatic thinking that Michael de Podesta invoked when he began his lecture at the RI with his definition of measurement.

An object cannot be compared with itself—we need methods for separating objects from each other *and* from themselves. As Natalie Melas describes, comparison implies both a *comparator* and a *perspective*, as all comparison is situated by who or what is doing the comparison and from what position.

In comparative literature, as Melas argues, the Western canon provided the background against which other literatures could be compared (and, accordingly, shapes the inclusions and exclusions of what is considered serious literature). In mass metrology, the kilogram served that purpose.[92] As Karen Barad states, "there is something fundamental about the nature of measurement interactions such that, given a particular measuring apparatus, certain properties *become determinate*, while others are specifically excluded."[93] In the case of mass measurements in the metric system, 𝔎 appears to create the possibility for a determinate mass property in its traceable descendants; through traceability to 𝔎, other kilograms are granted the property of being kilograms, and gain the seriousness of measurability.

But with no ground of its own, 𝔎 cannot resort to traceability for its own determination. Instead, as Barad writes, "which properties become determinate is not governed by the desires or will of the experimenter but rather by the specificity of the experimental apparatus."[94] 𝔎 gained its status as a kilogram through a piece of circular logic embedded within the written documentation for the metric system. 𝔎's statutory status as a self-sufficient measurement standard provoked a couple of uncomfortable questions: *Could* a decree be the grounds for determining a measurable property? Is the decree part *or* parcel of the measuring apparatus? Changes that the BIPM made to the definition of mass in subsequent years, short of answering these questions, show how the metrology community has, at least, struggled with their answers.

In its 1921 definition for mass, and, with it, the kilogram, the BIPM tried to obviate the need to determine the true mass of 𝔎. The self-sufficient definition vested the act of determining the kilogram's mass in the institutions of the metric system—in its conventions, practices, and protocols, but also in its vaults, bell jars, and keys. But the need to compare 𝔎 to its *témoins* created friction. By the middle of the twentieth century, BIPM officials were aware of the mounting problem of 𝔎's poor hygiene. Earlier in this chapter, I stated that 𝔎, by definition, cannot contain uncertainty—it is, at all times, equal to 1 kilogram. This is, in practice, true. However, the kilogram does have an absolute uncertainty—a rate or amount by which its mass is increasing or decreasing—which could, in theory, be estimated through comparison to its *témoins,* though never fully determined (or put more simply: we cannot be certain about its uncertainty). However, there is a more fundamental uncertainty that has prevented any attempt to estimate how much 𝔎 has changed over time, and that is a form of uncertainty that results from an untimely act of cleaning.

When the assayer and refiner Johnson & Matthey manufactured 𝔎 and the other forty original kilograms, the committee responsible for overseeing the production specified at which stages, and in what ways, the pieces of platinum-iridium were to be washed and cleaned.[95] At times, this meant cleaning with some combination of steam, alcohol, or distilled water. The final step, when the manufacturing was complete, was a steam bath.[96] (The apparatus used to clean kilograms from 1882 to 1889 can be seen in figure 2.5.) The kilograms were then left to dry under a bell jar in the presence of a desiccant, anhydrous potassium hydroxide.

Great care and meticulous specifications were put into the directions for precise hygienic treatment of the kilogram prototypes, and yet no directions were provided for the upkeep, maintenance, and ongoing hygiene of the prototypes *after* being manufactured. It is important to remember that in the mid-to-late nineteenth century, the possibility of a truly functional metric system was an unprecedentedly large standardization project. Although most countries, municipalities, and merchants had experience with their own measurement standards, less thought had ever been paid to how a material proxy would be maintained for a longer period and in a verifiable way.

Hence, there was no mention of cleaning kilograms again until 1939. At this point, Albert Bonhoure investigated the effect of cleaning on the mass of platinum-iridium kilograms. He used a chamois leather cloth, soaked first in ethanol and then in redistilled gasoline, to rub all the surfaces of the cylinder. Although World War II interrupted his investigations, Bonhoure cleaned 𝔎 and its *témoins* in 1946. That's when he made a fateful mistake: he cleaned the kilograms *before* noting their masses and how each compared to the other. This untimely act of hygiene wiped the traceable history of measurable contamination off 𝔎 and its siblings. This decision of Bonhoure's to clean before measuring fundamentally changed the capacity

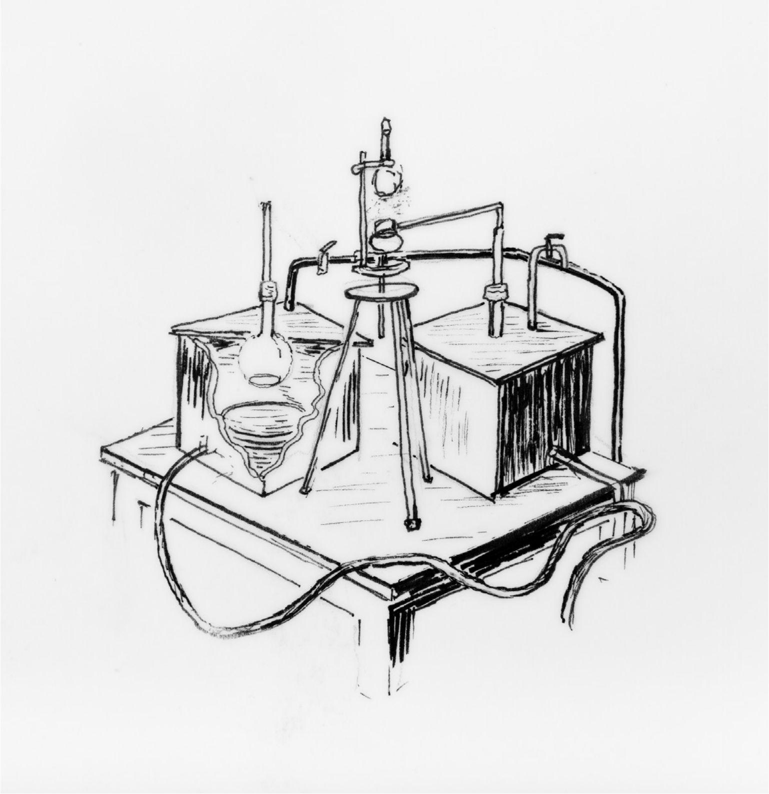

Figure 2.5

An artist's rendition of an apparatus for cleaning prototype kilograms from 1882–1889. Steam and alcohol vapor were directed alternately at the kilogram. A similar apparatus can be seen in Girard (1990), 6. Image: R. R. Mulvin.

to quantify the relationship between 𝔎 and its descendent kilograms—and forever marked the definition of mass with an uncertainty borne of bad data hygiene.[97]

Data hygiene is a set of manual protocols for maintaining the authority of data but there is also a temporality to these protocols. Once 𝔎 was cleaned, cleanliness became a part of its history—a pivotal moment that altered its commensurability with other objects. The history of its hygiene then became a crucial part of accounting for its materiality. But by mistiming the act of cleaning—by wiping and *then* measuring—Bonhoure left a gap in the documentary regime that maintained 𝔎's authority as a ground of value.

Despite this untimeliness, the BIPM used Bonhoure's new cleaning protocols on all kilograms that were subsequently sent to the BIPM for verification; the only provisional remedy to the erasure of 𝔎's history was to also scrub the objects it was compared with. There were a total of three periodic verifications of 𝔎 and the national standards that are descended from it. These periods lasted several years (the first from 1899–1911, the second from 1947–1954, and the third from 1988–1992). During these verifications, the BIPM invited members of the Metre Convention to send their national prototypes to be verified against 𝔎 and the BIPM's other working standards. By means of rotating comparison—pairing up different kilograms with each other—the BIPM scientists deduced changes of mass in national prototypes, and these changes were registered as innate errors in those prototypes. The verifications also allowed the possibility—with no absolute certainty—of deducing some estimated mass changes in 𝔎.

The third periodic verification, beginning in the late 1980s, allowed the greatest comparison among 𝔎, its *témoins*, and other nations' kilograms. It also became a staging ground for developing a more complete technique for cleaning and washing kilograms, which could be "addressed in a more searching way than had been done previously."[98] The technique developed by G. Girard, through the third verification, was interpreted earlier in this chapter in the instructions for washing your own kilogram, and describes a method for *nettoyage et lavage* that cleanses the surface of the kilogram while apparently doing no damage to the object.

In 1989, cleaning shifted from a supportive protocol in the maintenance of mass standards to being a constitutive part of the definition of mass. Henceforth, the kilogram would be defined by reference to 𝔎 *immediately after cleaning*. The full definition reads as follows:

> *The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.*
>
> It follows that the mass of the international prototype of the kilogram is always 1 kilogram exactly, m(𝔎) = 1 kg. However, due to the inevitable accumulation of contaminants on surfaces, the international prototype is subject

> to reversible surface contamination that approaches 1 *μg per year in mass*. For this reason, the CIPM declared that, pending further research, *the reference mass of the international prototype is that immediately after cleaning and washing by a specified method.*
>
> The reference mass thus defined is used to calibrate national standards of platinum-iridium alloy.[99]

This redefinition of the IPK makes it clear that the mass standard is not simply defined by reference to its Enlightenment ideals—the transcendence of nature's invariants, represented by the length of a meridian—but rather by reference to the history of the maintenance of 𝔎 and the makeshift methods for mediating between its environment and its metal alloy.

Starting in 1989, the metric system was, by definition, inseparable from the protocols for maintaining 𝔎, and we can detect a historical awareness in the new definition—which is otherwise meant to be a succinct description of a basic unit—with the references to the "inevitable accumulation" of contaminants and a quantifiable amount of "reversible" contamination. This statement declares the awareness that all objects are porous and leaky: they absorb their environments and leave their own traces. In this formulation, the keepers of the metric system appear to understand and incorporate the same critique that Barad made against the whims of the scientist. The documentary history of the mass standard shows a growing awareness that 𝔎'S milieu, as well as the manual protocols for its maintenance, are as much a part of the kilogram as were the finely tuned instructions for crafting the object.

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Data hygiene, as an analytic term, is meant to illuminate the labor of maintaining proxies, data, and knowledge infrastructures. Initial considerations of 𝔎's material hygienics concerned its metallic alloy, the reputation of the company that crafted it, and the security of its enclosure; later in its life, having built up a history of care, new concerns developed regarding the contaminants of its environments, the traces that it picked up through circulation, and the potential to account for its history when it was compared to its fellow kilograms.

Proxies intersect and collide with their environments in unpredictable ways, despite attempts to control their circulation, to fix them as known quantities, and to protect them from interference. Before it was replaced, several people tried to deduce the source of deviations between 𝔎 and its siblings. Although it is known that 𝔎 and other, lesser reference kilograms change in mass, there is no agreed-upon explanation for their changes. One possible explanation includes the presence of atmospheric mercury used in other parts of laboratories.[100] Mercury, which may fall on floors and seep into the ground, eventually vaporizes and resettles in metals like the platinum-iridium surface of 𝔎. Cleaning cannot undo the eventual mass gains from mercury contamination. As Andrew Barry reminds us, this process is typical of metal, though counterintuitive:

> Metals are not the hard, inert objects that they are often thought to be. . . . They have become "informationally enriched," and part of the driving force for this informational enrichment comes from growing efforts to regulate the properties of the materials and the actions of those who develop and use them.[101]

𝔎 exemplifies this view—a view that we can extend to other proxies as well. The hard shell of platinum-iridium is shown to be porous, and the practices of the kilogram's handlers are deeply encoded with more than a century's worth of informationally enriched maintenance—a fact that drove the creation of a protocol for cleansing 𝔎 of this rich, lived history.

All physical proxies feature some kind of instability that produces a demand. Sometimes these physical artifacts are, by conventional decree, too instable and need to be replaced—"standards are not static, never definitions, but representations of something infinite, merely provisional drafts certain to be corrected, stand-ins for better ones to come."[102] But if they are not replaced, then physical proxies require supportive practices to keep them viable. Proxies—even those erected on a scaffolding of the French Revolution's most idealistic promises—are in constant need of maintenance. The protocols that kept 𝔎 viable lasted over many stages of its existence: its crafting, its endowment as the prototype kilogram, and its maintenance as a ground of value. Protocols for creating, storing, cleaning, and employing proxies are part of what make up the apparatus through which measurement operations become possible, and they comprise the theater of objectivity that allows a community to trust a proxy as a credible stand-in.

Whether it's the conspicuous performance of referees and officials dragging a set of chains on to the field to judge a first down in football or the trained hands of scientists rubbing a kilogram with a piece of chamois leather, ritual bolsters the significance of measurement. Cleaning the kilogram, like burying it, is not just an act meant to protect against scrutiny; it is also an internal act that signals to professionals that the work they are doing is meaningful. In commercial and regulatory standards, path dependence will often compel accordance with a standard because of the power of history, economics, and learned behavior. In the actual crafting of a standard and in its maintenance, rituals can serve a similar function by helping to conceal the fissures of arbitrariness. By developing protocols for keeping kilograms clean, officials at the BIPM invested a performance—the embodied practice of cleaning—with the endorsement of scientific necessity. These hygienic protocols were manual and practiced, and they mediated between the kilogram as a piece of scientific hardware and a piece of metal in the care of people.

Consider one of the final changes to the milieu of 𝔎: it moved homes. In 1889, the Prototype Kilogram and Prototype Meter were buried in a safe together, an act that compelled "cascades of rituals" that included the redefinition of the kilogram to incorporate manual cleaning.[103] From 1889 to 2002, 𝔎 and the witness kilograms were kept in that same safe. In 2002, the "safe was replaced by a new modern one because the old one was becoming increasingly difficult to open."[104] The problem of doors, the "hole-wall dilemma," as Bruno Latour calls it, exposes the negotiated treaties between people and technologies.[105] Such a treaty is on display in Sèvres, where maintaining a proxy as the basis of a standard was conditioned by the capacity to work a sticky door. And because the kilogram's specific milieu (including its atmospheric contaminants) will inevitably shape its physical composition, this particular door problem will have had a material effect on the makeup of the mass standard. How it changed and to what degree would always depend on where it was kept. Decisions about its milieu would not determine whether it changed, but *how* it changed. This is what institutions do: they stabilize social life and structure the behaviors they house.[106]

𝔎 was an inordinately long-lived proxy with a rarified biography. The choice of 𝔎 over other pieces of metal (or glass, or wood, or water) was arbitrary—its shape, composition, and mass were all decided with reference to a contrived set of invented units. And yet the choices that led to 𝔎, however contingent, were specially planned, designed, and treated in ways that were meant to transcend this arbitrariness. All proxies are conventional and all standards contain material aspects, but the conventional materialism that 𝔎 embodied defined the standard itself; there was no separating the metric system from 1889 to 2019 from the worldwide agreement over the material specificities of 𝔎 and the practices for keeping it as clean as possible.

As the history and end of the IPK indicate, there is a basic discomfort with the provisional nature of data hygiene protocols. They give lie to the claim that science operates hermetically and objectively by providing access "to the pure technological realm."[107] Data hygiene is a necessary, though not sufficient, condition of bringing things into measurable relationships. Although the choices of materials, shapes, sizes, and compositions may be arbitrary, those choices matter, and they solidify in forms that need maintenance. As we will see in subsequent chapters, when the choice is not *which metal* but rather *which image* to stand in for other images, or *which human* to stand in for other potential humans, the choices will have a significant impact on the composition of proxies and the potential for justice within systems of standardized knowledge.