"Pictures, Models and Measures"

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First, thanks very much to Ivan Welty for organizing this symposium. I was glad to see the phrase "Picture Theory" put in quotes in the title of the symposium, because I am not aware of Wittgenstein ever having used this exact phrase. What I do know is this: there is a point in time before which Wittgenstein does not use the word often translated as 'picture' (Bild) in connection with a proposition; but, after that point, the word and its cognates appear frequently in his writings; not only his writings in the weeks immediately afterwards, but [translations of][1] many works written even decades later feature 'picture' as both a verb [abbilden, tr. as depict] and a noun [bild, tr. as picture].

That point in time is recorded in the notebooks he kept while serving in the military, so we know the date (September 29, 1914), and we know what he said it was that occasioned the insight he regarded as so crucial. We know this not only from the notebook entry itself, but from the fact that he recounted his memory of the occasion of having the insight to several friends, multiple times. What occasioned it, he said, was reading about the use of physical miniatures -- a miniature model -- to portray a traffic accident in a courtroom. The reference in the notebooks is actually very unassuming; placed inside parentheses after "In the proposition a world is as it were put together experimentally" [Im Satz wird eine Welt probeweise zusammengestellt.] is "As when in the law-court in Paris a motor-car accident [automobilungluck] is represented by means of dolls [puppen], etc."

As for the use of the word 'picture' rather than 'model' in the term "Picture" Theory, David Stern explains: "Wittgenstein used the word "Bild" to talk about the model, a term usually translated as 'picture'; [. . .] While both words cover such things as images, film frames, drawings, and paintings, the idea of a three-dimensional model is more readily conveyed by the German "Bild" than the English "picture." However, I would add to Stern's comments that we do see

[1] In this prepared text of my talk, I used brackets around text that I probably will not read when the paper is read aloud, for smoothness of presentation, but which is helpful to have in the ms. to note a qualification or avoid an ambiguity.

Wittgenstein use the word model, too, notably, to relate Bild and Model, in T 2.12 "A picture [Bild] is a model [Modell] of reality." [Das Bild ist ein Modell der Wirklichkeit.]

My view on the role of this event, as I explain in my book [1], is that intellectually the moment was more a recognition of something he had been looking for rather than a conversion. I.e., that the ideas had already been developing. When he had an insight that locked on to the magazine article's description of a miniature setup used in a law-court and served up to him what he needed to formulate his thoughts about the proposition-as-a-picture" and picture-as-a-model , it was more like the recognition a sculptor has in lighting on an appropriate item to use as a found object in an artwork already partially envisioned. ([1], p. 251-252)

To reach this view, I looked at other elements of Wittgenstein's milieu to provide the context in which Wittgenstein viewed the magazine article about "representing by means of dolls", in particular a landmark paper in a physics journal relevant to using physical scale models to represent things on a larger scale, entitled "Physically Similar Systems" and dated July 1914. It was by the physicist Edgar Buckingham, a National Bureau of Standards researcher recruited to serve on an advisory committee on Aeronautics, and seems to be a short communication from the Washington [DC] Academy of Sciences; reading the literature of that era, it is clear that news about technology and, especially, about aeroplane technology in 1914, was eagerly and urgently exchanged across borders and oceans -- remember, there was basically a "Victorian Internet" then -- a transatlantic cable and an extensive network of electronic telegraph communications. I also provided the historical context to another analogy Wittgenstein uses in the *Tractatus* to explain how a proposition depicts: gramophone records. Illustrating with figures, I showed how both the accounts in the Tractatus --- (i) of the proposition as a picture, and (ii) of gramophone records and a symphony score having the same logical form --- underwent development during the war. Just glancing cursorily at the figures, you can see that in the figures I sketched to portray these two views in the *Tractatus* [of the proposition as a picture and of the gramophone record and symphony score having the same logical form] (Figure 1B and Figure 4, respectively), both have a triangular shape , whereas the sketches that portray the pre-war views do not.

The development is illustrated in a series of figures (reproduced from the book in the appendix/handout to this talk), as follows:

-- <u>Prior to mid-1914,</u> Wittgenstein would have had experiences with the fairly new technology of producing music from the grooves of a gramophone record, and, due to the family he grew up in, was party to many critical conversations about the nuances of producing music from musical scores via musicians' performances (whether by playing an instrument, or by voice/whistling). This is shown on **Figure 1A** on the handout [which is from my book]: basically, it shows that a properly trained musician can produce a symphony from the score (written in musical notation); some musicians can also produce a musical score from hearing a symphony. And, that a gramophone machine enables one to produce a symphony from the lines on a gramophone record. It is interesting that the technology of recording sound in lines was developed years before this -- the phonautograph, which produced records that were valued as two-dimensional visual records of sound, without any interest in their value as means of producing/reproducing sound; schoolchildren read in their textbooks how a phonautograph could produce these visual records. Thus I take Wittgenstein to be knowledgeable of both phonautographs and gramophones, and that the mention of the gramophone refers to the process of *producing* sound from the lines on the gramophone record.

-- <u>Also, prior to mid-1914</u>, in the pre-war *Notes on Logic*, Wittgenstein had worked out a view about the relationships between propositions, signs, and symbols. The pre-war view is shown on **Figures 2A and 2B** (from my book, also reproduced on the handout.) So, he already had that much, well before the insight in Autumn 1914: i.e., he had already said that [reading from the handout, figures 2A and 2B] the correspondence between a propositional symbol and reality depends on the simples that the symbol contains, and "that a certain thing is the case in the symbol says that a certain thing is the case in the world." He had written, regarding propositional signs, that "if an x stands in the relation R to a y the sign 'xRy' is to be called true to the facts and otherwise false." He had written, regarding the human skill of understanding propositional signs, that "I understand the form 'xRy' when I know that it discriminates the behavior of x and y according as these stand in the relation of R or not." And, regarding propositional truth functions: "In two molecular functions that have the same T-F schema, what symbolizes must be the same.")

So he already had that much; what happens *after* the crucial insight in Autumn of 1914 gets developed?

One striking thing is that Wittgenstein focuses on pairs of *seemingly dissimilar* representations: "At first sight a proposition -- one set out on the printed page, for example -- does not seem to be a picture of the reality with which it is concerned. But neither do written notes seem at first sight to be a picture of a piece of music, nor our phonetic notation (the alphabet) to be a picture of our speech.'" (4.011) Now, notice: He does <u>not</u> appeal to examples in which similarity is based on visual or geometrical similarity. That's very important. It is often missed.

--- In the Tractatus, as depicted in **Figure 1B**, the account of how the lines on the gramophone record, and the musical notation of the symphony score, which Wittgenstein describes as two things which "appear to be very different at first", are shown to "have the same logical form." His account of having the same logical form involves processes that result in some graphical product or musical performance: the musician's abilities in being able to "obtain the symphony from the score" and the ability to employ a process that likewise yields the symphony from the lines on a gramophone record. This is what having the same logical form amounts to: translatability, though by no means a *direct correspondence* between *points* on the gramophone lines and *notes* in the symphony score.[2] It's worth emphasizing here again that Wittgenstein did not appeal to the geometric characteristics of the lines on the gramophone record, even though, in his day, the patterns that the lines that a musical performance recorded on a gramophone disc or roll made *were* often appreciated *as two-dimensional drawings* (such as magnified traces of wavy lines made by a phonautograph needle used to record voices and other sounds, or, in physics, Mach's famous schlieren photographs capturing shock waves visually, which were widely reproduced and had become part of popular and artistic culture.) The gramophone example is used to make a point about propositions: "A gramophone record, the musical idea, the written notes, and the sound-waves, all stand to one another in the same internal relation of depicting that holds between language and the world." [T 4.014] What they all have in common, though, he says is "logical structure" [Ogden translation]

If geometric or visual similarity is not what Wittgenstein appeals to in explaining that the musical score and the lines on a gramophone record have the same logical form, what does he appeal to? intertranslatability via serial processes. The processes he appeals to include ones that involve skill, training, and conventions about notation, as well as some mechanical processes. This is, I think, a very important thing to notice. It does not mean that those spatial relations or visual similarity do not play *some* role in the processes of translation, but the account of logical form is not in terms of, and certainly not reducible to, them. Here I suspect Wittgenstein is following Frege in thinking that it is the notion of translation, rather than the notion of interpretation, that is relevant in understanding logical form. In his criticisms of formalism in mathematics, Frege argued against the use of uninterpreted formulae in mathematics and logic. [2] (We are not always careful in distinguishing the terms; for Frege, translation is from one meaningful entity to another; interpretation, as the formalists meant it, was from one *un*interpreted statement *to* an interpreted one.)

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[2] There are a number of other relevant points associated with Figure 1B discussed in "Pictures of Sounds: Wittgenstein on Gramophone Records and the Logic of Depiction"

How *is* the account of logical form that appears in the discussion of the gramophone in the *Tractatus* related to the experience of reading about a miniature setup used in a courtroom to portray something about a traffic accident?

It would be nice to know a little more about how the miniature setup was discussed in the magazine; what kind of evidence was the miniature setup supposed to provide? The setting was a law-court, not a scientific laboratory or even a forensic one. The miniature automobiles involved in the setup are often referred to as "toys" by commentators on Wittgenstein, though I am not aware that Wittgenstein ever did so in his *Notebooks*.

The miniature cars involved may well have been merely toys, but it is also true that in the late nineteenth and early twentieth century, scale models that were serious affairs and scaled to be used as experimental models for particular scientific research or forensic investigative purposes were often called toys, too. Modelmaking combined art and science; by 1914 there were modelmaker hobby clubs and "modelmaker" was a skilled profession. Even rigorously scaled models were sometimes made to be aesthetically pleasing as well as being precision pieces of machinery. Modelmakers of such charming models were known to protest that calling their productions toys failed to do justice to the craftsmanship, knowledge, and precision required in order to produce properly scaled behaviors. Different materials had to be used to provide appropriately scaled densities and flexibilities; surfaces had to be modified to give appropriately scaled mechanical behaviors. So I think one point to keep in mind is that someone with Wittgenstein's knowledge and interests in aeronautical engineering, in which precision scale models were absolutely essential, could hardly suppress knowledge of the logical and mathematical basis for using scale models in physics, when viewing such a miniature setup.

There are some cultural and ethical aspects to the significance of such a court case around 1914, too.

First, the issues of the burden of proof for proving fault in automobile accidents, and whether injury and death caused by automobile accidents should be covered under criminal law or not, were still undergoing change and clarification. There were even questions of ethics involved as to what *kinds* of considerations were *relevant* in applying the existing legal doctrines to the situation of automobile accidents. [3] [e.g., consideration of risk-spreading; role of ownership, role of vehicle being under one's control, role of negligence] This might be something to keep in mind with respect to Wittgenstein's later remark that the most important point of the Tractatus was an ethical one -- what it did *not* say.

Secondly, it is also significant that, in 1914, an important revolution in the use of physical evidence in court cases that would set the agenda for methods used in forensic investigation to this day, was just beginning. The Frenchman Edmond Locard, a protege of Bertillion who claimed to have used the fictional Sherlock Holmes as his inspiration and guide, had just been given a laboratory in Lyon (France) in 1912 in rooms attached to the courthouse, for such scientific investigations. The question of what kind of physical evidence could be admitted, and what it could be used to prove, was of interest to the public, as it hadn't really been settled yet. Other laboratories were established based on Locard's methods: first in 1914, there was one in Quebec [4] ; many others followed. Locard is known best for the methods he developed and disseminated using the microscope for making minute distinctions, such as between many different kinds of dust particles and, following his teacher Bertillion, for the use of various biometrics for all sorts of imprints a person might leave behind. [7] However, Locard was also very much interested in collisions; in his laboratory in Lyon he worked on detecting cause and fault in automobile collisions: what did the evidence left behind from an automobile collision, such as skid marks left by tires, tell people about the collision that had taken place? This is a matter of reading the collision from the skid marks, but in a courtroom, one would *also* want to show how the skid marks could have been created by a certain sequence of events that was the fault of one of the drivers. Could one and the same model have served both to illustrate something such as who had the right of way *and also* to prove that skid marks (lines) left on the road could be translated into a certain sequence of events?

Spurred by such questions, I have spent an inordinate amount of time scouring period magazines for an account of models used in a courtroom such as Wittgenstein described. And, so far, I have found *one*: it appeared in June 1914, and, though the article is in English, the sketch illustrating the account is from a French magazine. It may or may not be the magazine Wittgenstein meant, but it is contemporaneous, so, at any rate, the account is of interest, as reflecting the understanding of how models could serve as evidence in a courtroom setting at that time.

The magazine article I found shows a personal-injury lawyer seated at a table on which a large clean white piece of paper covering the entire tabletop has been lain; the outlines of the roads leading into an intersection are sketched on the paper. Five "miniature" vehicles are on the table; although referred to as 'miniatures' in the article, they are *large* miniatures: most of the automobiles must be at least the size of a breadbox, it appears to me, and they look quite detailed. There are several doll occupants in the vehicles, and they seem arranged with care, in different postures; some are unprotected, their vehicles being open like a convertible. One three wheeled vehicle is toppled. The account says that the lawyer is "studying a case to place the responsibility for the accident" and to get "a clear idea of the different phases" of it. We are told that he acts out "the whole occurrence" so that "the questions of right of way, traffic regulations, rules of the road, and such matters" are made clear. The lawyer also uses the model to communicate: "Thus equipped, he is able to place his case lucidly before the court." [13] This account seems to fit with Wittgenstein's mention of dolls (puppen); it is the injury to the humans that is of most importance to the personal injury lawyer. This account also fits well with von Wright's description that "At the trial a miniature model of the accident was presented before the court. The model here served as a proposition; that is, as a possible state of affairs." ([8], p. 21)

One striking (to me[3]) thing is the context of this "found object" (the model of a traffic accident): a court of law. Much of what the lawyer wants to present using the model involves conventions and, especially, violations of "traffic regulations" and "rules of the road."   The physical aspects of the model are surely part of judging whether there have been violations, as well as in determining the sequence of events that led to an injury, and to how the injury was caused. But whether there have been traffic violations, and who had the right of way, involves rules and conventions as well. In the *Notebooks*, in following up on his thoughts about a proposition as a picture, Wittgenstein remarks that a picture might be used to portray how *not* to fence. ([9] NB 5 November 1914 entry) The model might be used to portray a violation of a traffic rule, or it might be used to portray a state of affairs that did not occur, say, in showing negligence, to show what *would* have happened (a possible state of affairs) had a driver acted otherwise than he or she did.

Another striking thing in the account of the model of a traffic accident in this magazine article is the mention of the dynamics of the model: "the different phases"; "the whole occurrence", which draws attention to the miniature model of the traffic accident as a dynamic model. There is, after all, a vehicle that has been overturned, and one that is in the process of turning a corner. Certainly the way the lawyer is using the model is, at first, investigatively, or experimentally, to examine the situation and the possible ways it might have developed to yield the outcomes known to have occurred, and the possible ways it could, counterfactually, have developed.

As I explained in my book, what I see in the *Tractatus* is an account of how propositional sign, truth function, and world are related that looks very much, even in details, like an analogue of the account of using model experiments --- e.g., ships, aeroplanes, propellers --- to represent actual

[3] I mentioned it at the end of Sterrett (2000) "Physical Pictures: Engineering models circa 1914 and in Wittgenstein's *Tractatus*; long version at http://philsci-archive.pitt.edu/661/1/Sterrett-UNC-CH-PPTalk2.pdf As for the content of the talk, the content Sterrett 2005/6 [1] supersedes that talk.).

or imagined ships, aeroplanes, and propellers circa mid-1914. Actually, the methodology used -- physically similar systems -- is very general. The quote from Hertz' preface that the form we give our images in thought is such that "the necessary consequents of the images in thought are always the images of the necessary consequents in nature of the things pictured"[4] is often cited in connection with Wittgenstein's *Tractatus*, but I do not think Hertz meant to be saying anything novel with that statement in the preface; statements to that effect are quite common in nineteenth century physics. The idea that one can formulate a picture or model -- a concrete physical setup as well as an imagined or mathematical one -- and set up a correspondence between them such that the consequents of manipulating quantities in the model that correspond to the thing modeled are the corresponding consequents in the thing modeled was also quite common. When it was an equation rather than a physical model, and the consequent a matter of mathematical deduction, Hertz' statement would fit. The use of dimensionless parameters as a criterion for this kind of similarity between two physical systems -- i.e., similarity of systems S and S' (which is the terminology used to describe the relationship between a model being tested experimentally and the thing it modeled) exists when the relevant dimensionless ratios formed from the corresponding quantities in the two systems are equal -- was also developed in physics in the second half of the nineteenth century. What I often found, though, was that mathematicians, physicists or engineers writing about similar systems and similarity would often comment that the methods were not well enough known, that they were powerful and elegant and that there was much to be gained by adopting them. [10]

What happened in July1914, with the "Physically Similar Systems" paper was significant, though, in that the method was generalized so that it no longer involved deriving the required criteria from an equation that described the phenomenon. Rather, similarity criteria (the dimensionless ratios that must have the same value in each of the two systems (model and thing modeled)) could be derived from the "most general form" of a physical equation, which contained no arithmetical constants. The most general form of a physical equation was written using the notation of functions. This often sounds not really possible; where does the information come from, if not from an equation of physics such as a partial differential equation? The reason it is possible is due to what is built into the system of measurement. It is the July 1914 formulation of similarity between physically similar systems as a methodology of using model experiments, that I use to draw the analogy shown in **Figures 3 and 4**, between experimental models and propositions in the *Tractatus*, respectively.

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[4] Quoted in David G. Stern's *Wittgenstein on Mind and Language*, p 37, from Heinrich Hertz: *The Principles of Mechanics*, Tr. by D. E. Jones and J. T. Walley. (Dover, New York 1956) [11]

I am not going to lay that analogy out again in this talk; it is given in my book. I'd like to point out, though, some of the historical and biographical details supporting this suggestion. Here are just a few such details: Most saliently, the topic of similarity in science and engineering was prominent in the years immediately preceding 1914, and the paper "Physically Similar Systems" came out when Wittgenstein was already back from Norway, and staying in Vienna, where access to scientific news and literature was excellent. A timeline (from a forthcoming paper "Physically Similar Systems: a history of the concept" [10]) reproduced on the handout shows the intensity of publications related to similarity throughout 1914. I cite lots of other supporting details in the book. Another one quite close in time to the 1914 insight was that the use of mechanical similarity was cited in a Nobel Prize Lecture given in December 1913 that received wide coverage in the Press, including cartoon caricatures of the Nobel Laureate, Heike Kamerlingh Onnes, as "Dr Zero" in newspapers and magazines [the Prize was for achieving the liquefication of helium]. Wittgenstein was in Vienna during *that* time period, too; even though he had been in Norway in 1913, he came back to his family home in Vienna for Christmas of 1913. Onnes had helped derive a more general "theory of corresponding states" in physical chemistry than van der Waals' initial version, and cited Newton's theory of mechanical similarity with awe. Wittgenstein could hardly have missed the association of Onnes' work with model experiments, as Newton and, to some extent, Galileo, were often cited in the scientific and engineering literature on using experimental models as the first to use and write about similitude. With regard to the homage to Newton, I also note in my book [1] the significance of the recently discovered fact that Wittgenstein purchased exactly the two works by Newton and Galileo that were cited in the literature on dynamic similarity and similar systems. These purchases don't seem to be easily explained by any other interest -- the work by Galileo was extremely rare and expensive, and it seems to be the only work by Galileo Wittgenstein owned.

These historical and biographical facts are merely supportive, though: my main reason for thinking that the methodology of physically similar systems, which by the time of Wittgenstein's reading of the magazine article in September 1914 had already been presented in the short communication "Physically Similar Systems" in July, is in fact the analogy between the account of how models portray in it, and the account of a proposition given in the Tractatus. In particular, the "no logical constants" principle that Wittgenstein referred to as the Grundgedanke of the *Tractatus* has a clear analogue in the account [equations in science that contain arithmetical symbols are replaced by ones that do not contain any such connectives, by employing functional notation]. Most significantly, the analogy yields an account of objects that I find aligns perfectly with the statements in the *Tractatus* about objects and facts composed of objects, sans logical constants.   This part of the analogy is shown on the handwritten handout to my talk at HOPOS 2000 (and is reproduced in the appendix to this manuscript of the talk). [Reading from Handout: Whereas the methodology of experimental models speaks of the "most general form of a physical equation" as containing no algebraic constants, Wittgenstein writes of the "general form of a proposition" containing no logical constants. Whereas, in the dimensional equations used in Buckingham's July 1914 "Physically Similar Systems" paper, dimensions or quantities combine in only certain ways to form dimensionless parameters, in the *Tractatus* we are told that objects combine in only certain ways to form states of affairs."   I see the way objects function as completely analogous to the way that dimensions do.

One thing that is not shown on the figures in my book is how the elements in the model correspond to the elements in reality. This is very straightforward, although implicit: since the similarity of the two systems is a matter of certain key dimensionless parameters (ratios) having the same value in the model as in the thing modeled, one can simply show the correlation between model and thing modelled from those ratios alone. To take an easy case, consider Mach number, a degenerate case of a dimensionless parameter: (velocity of a moving body v)/(velocity of sound in the fluid at the fluid conditions that obtain v_s).   Suppose we have a case in which similarity is established by the Mach number being the same in the model as in the thing modelled (again, a degenerate case). Then, letting v depict the velocity in S and V depict the velocity in S', we can say that $v/v_s = V/V_s$ We can then say that the velocity v corresponds to the velocity V v_s/V_s; this gives the model its "feelers", which shows exactly how the velocity in the model corresponds to the velocity in the thing modeled. Measuring one of these two velocities can be used to tell us what the other, corresponding, velocity is.   With this in mind, we can make good sense of the following statements in the *Tractatus* [5]:

2.1511 That is how a picture is attached to reality; it reaches right out to it.
2.1512 It is laid against reality like a measure.
2.15121 Only the end-points of the graduating lines actually *touch* the object that is to be measured.
2.1513 So a picture, conceived in this way, also includes the pictorial relationship, which makes it into a picture.
2.1514 The pictorial relationship consists of the correlations of the picture's elements with things.
2.1515 These correlations are, as it were, the feelers of the picture's elements, with which the picture touches reality. [5]

And, as for the statements following just after the above lines in the *Tractatus*, the ones about the picture having something in common with what it depicts: clearly, though we do not need to be using the same units in the model and what it models, the systems of measurement need to have some things in common [we need to be using the same system of measurement between the model and the thing modelled (not necessarily the same system of units, but of the same system of measurement in a sense that can be made precise)] in order to use this method to construct a model that is able to picture what it models. So, that makes sense too. ([Exactly what they must have in common is, I think, part of the investigation in the Tractatus.)]

While I don't want to repeat the arguments in the book here, I would like to point out that the analogy I laid out in the book (depicted in **Figures 3 and 4**) addresses what I think is a common worry about what's known as Wittgenstein's "Picture Theory." The worry, I think, is that just knowing that the elements of a picture correspond to elements in reality doesn't yield enough to guarantee that the picture will track reality. "Having the same logical form" just seems too scanty a basis to most people, I suspect. Then, there is the problem with the point that, as Wittgenstein says, "The possibility of propositions is based on the principle that objects have signs as their representatives." I think people are bound to ask how this is supposed to be guaranteed, too.

I consider some of these worries to be genuine worries about endorsing the picture theory -- at least the Picture Theory as it is often understood. I don't think it is very easy for a reader of the *Tractatus* to understand how the proposition as a picture is supposed to account for what it purports to account for in any rigorous way. In fact, I think Wittgenstein *knew* others weren't going to understand his point, yet, that he felt that what he wrote *was* correct. He did, after all, write in the preface that, although he wasn't sure he had accomplished the task of expressing the thoughts expressed in the book very well, that " the *truth* of the thoughts that are here communicated seems to me unassailable and definitive." ([5], pgs. 3 - 4) I'm going to go with that line: Wittgenstein didn't think anyone would understand the thoughts he tried to express in the *Tractatus*, yet he thought the truth of those thoughts was "unassailable and definitive."

I find that the key to making sense of the thoughts he attempts to express in the statements in the *Tractatus* about objects, states of affairs, and propositions is to recognize that his account draws on the existence of *quantitative* science, i.e., the existence of measuring systems and equations that express relationships between measured quantities. It is in the design and standardization of systems of measurement --- which, in a coherent system of measurement, include a connection to reality, as they require that the units that have different dimensions associated with them be 'coherently' related to each other, which involves establishing physical relationships; as a result, the relationships between dimensions (kinds of quantities) are formalized. Since I see dimensions as analogous to objects, this explains many of the otherwise inscrutable claims about objects we find in the *Tractatus*.

Again, the historical and biographical details are supportive of my suggestion. First, there is the context that, in 1914, many physicists and engineers would know what a dimension was, would be quite competent in using dimensional equations. They would consider it quite natural to think of combining dimensions, which is done without any arithmetical connectives, and with expressing a dimension in terms of combinations of others. I say this because significant debates on the topic of which units should be used in physics were still in very recent memory in 1914; and these debates required the language of dimensions. In fact, Hertz had entered the debate with a very philosophical argument; Jed Buchwald discusses it in his book *The creation of scientific effects* ([12], Chapter 12) In his argument, Hertz uses the notation of dimensions, i.e., he writes ML^2T^2 to indicate the dimensions of the units of work; M, L and T denote respectively the dimensions Mass, Length and Time, just as they do on page from the Handout to HOPOS 2000 talk reproduced in the appendix to this paper.

I think of a dimension as a *kind* of quantity. But, and this might have been difficult for even scientifically trained commentators and readers of the *Tractatus* coming upon it after 1930 or so to imagine: not only the system of units, but the issue of how many basic units were needed in order to be able to do physics, was in flux in the late nineteenth century. There were the basic units of mass, length, and time, as in Newton's day, but there was the new question of how to handle units for measurements made of quantities regarding electricity and magnetism. It was easy enough to define units of each, in terms of a laboratory procedure involving an electrical or magnetic pole. But, it was impossible to answer: "Which is more basic: an electrical pole or a magnetic pole?" Contradictions arose no matter which system of units was preferred; in addition, many additional units were added and adopted, without increasing the number of basic units, because they were more practical to use. Some argued that three basic units (mass, length and time) were sufficient. It wasn't until 1901 that the Italian Giovanni Giorgi showed that by adding a fourth basic unit, and hence admitting a fourth dimension (a fourth basic kind of quantity) to the system of units, that the global physics community could solve the problem in an especially desirable way, in that the resulting system of units would not conflict with the use of the practical units already used in everyday technological and laboratory work. In 1914, though, these had not yet been adopted formally. The topic was still live, and so was the language that was then considered the language of science: dimensional analysis. And, we do see Wittgenstein bring up measurement, as in his statement quoted above, that a proposition is laid against reality like a measure.

Secondly, I don't think Wittgenstein says nearly enough to explain what's needed to the reader who does not know very much about model experiments, dynamical similarity, and similar systems. In his defense, someone writing in 1914, which I have called "The Year of Physically Similar Systems" [10], coming on the heels of Onnes' fame, might assume that the whole family of similarity concepts had finally won the day in physics and were going to be as common as the notion of gravity from now on. Sadly, the opposite happened and the war seems to have disrupted collective memory about them.

Also, the arguments about the basis for measurement in the new physics, and the role of measurement standards in physics, had basically been made. It is true that, in 1914, it would still be awhile before the solution Giorgi proposed around 1900/1901 was eventually adopted by the international agencies charged with deciding such things -- but the debates that delved into the fundamental questions of measurement in electromagnetism, were over. So, even though there would still be active discussion of them in 1914, and the language of dimensional analysis would then still be quite common, the occasions for using it in debates in which the question of how many different dimensions were needed was a live question were fewer and fewer. The result is that we philosophers are put in a deficient position with respect to understanding comments about measurement and modeling unless we are willing to go back and learn what physics was like in 1914 -- and I don't mean current reconstructions of what was known in 1914 phrased in anachronistic terms.

So, I'd like to make a suggestion about understanding Wittgenstein's *Tractatus*, at least the parts of it associated with the so-called "Picture Theory": I suggest that it might help if we as a philosophical community get to know the scientific milieu in which the *Tractatus* was conceived a little better, including the language and methods of physics of the day. Especially, the language and methods, including systems of measurement, of the [physics] logic underlying the use of model experiments.

References

[1] Susan G. Sterrett: *Wittgenstein Flies A Kite: A story of models of wings and models of the world* (Pi Press/Penguin, New York 2005/6)

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Figures to Accompany S G Sterrett's talk
"**Pictures, Models and Measures**"
at the 2015 Pacific APA
in the Invited Symposium:
"Wittgenstein's 'Picture Theory' "
1 pm Friday, April 3rd, 2015

By mid-1914, prior to the point when he locks on to the idea that "In the proposition a world is put together experimentally" and "the proposition *only says something in so far* as it is a *picture*", Wittgenstein already has this much (Fig 1A from [1], p. 216) available, from his experience:

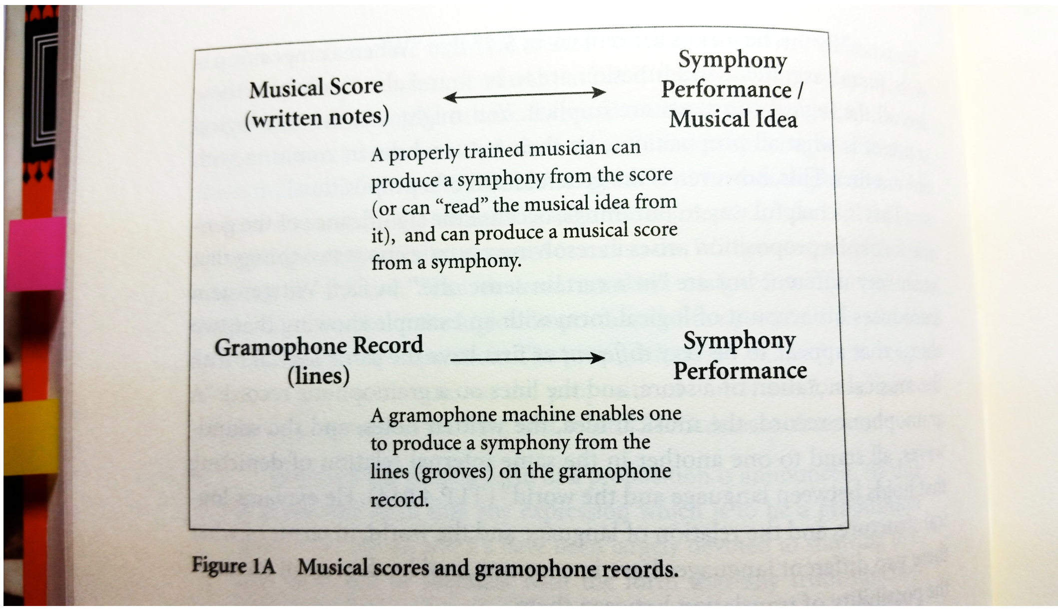


Figure 1A **Musical scores and gramophone records.**

and, in the pre-war *Notes on Logic*, he has already recognized relationships between propositions, signs, and symbols, as follows (Fig 2a from [1], p. 223) :

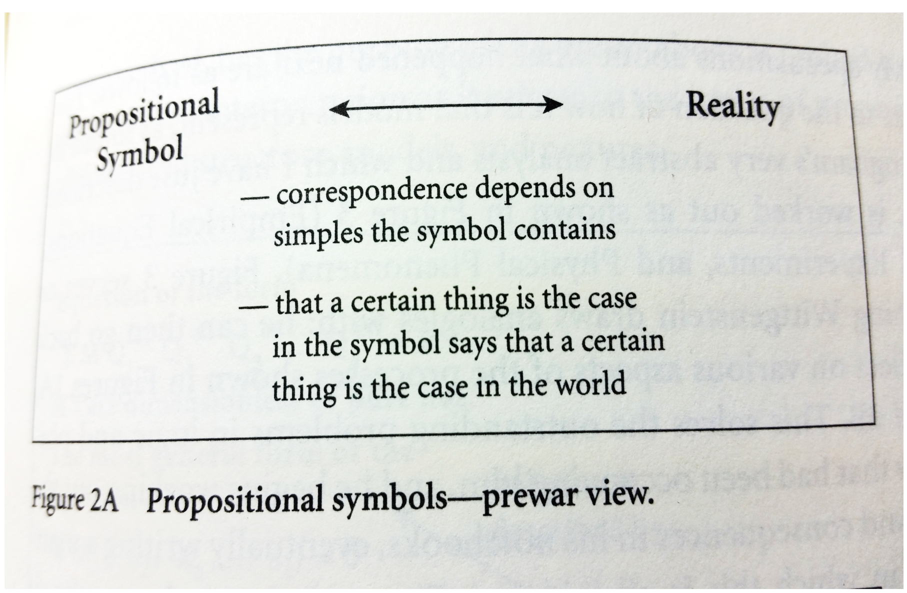


Figure 2A **Propositional symbols—prewar view.**

and (cont'd):

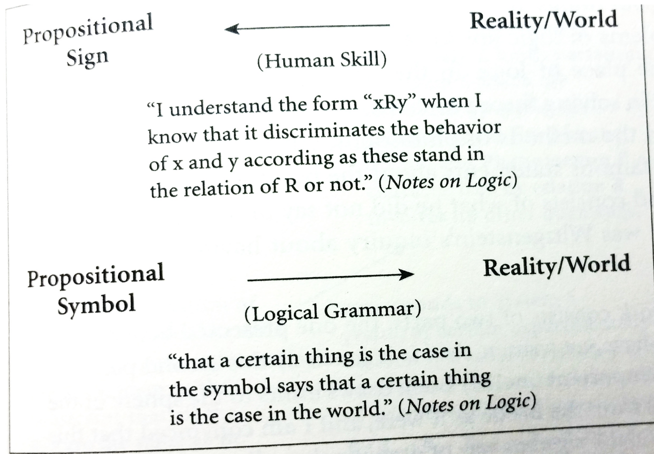


Figure 2B **Propositional signs, symbols, and truth-functions—prewar view.**

Regarding propositional signs: I say that if an x stands in the relation R to a y the sign "xRy" is to be called true to the facts and otherwise false. (Notes on Logic)

Regarding propositional symbols and truth functions: "In two molecular functions tha have the same T-F schema, what symbolizes must be the same." (Notes on Logic)

Then, during the war, **after** picking up the thoughts above about picturing, and developing them, the views I have depicted above in Figures 1A and 2A & B are revised, in a way that builds upon them. In the *Tractatus* what we see for the two very different-looking gramophone records and symphony scores, what having the same logical form amounts to:

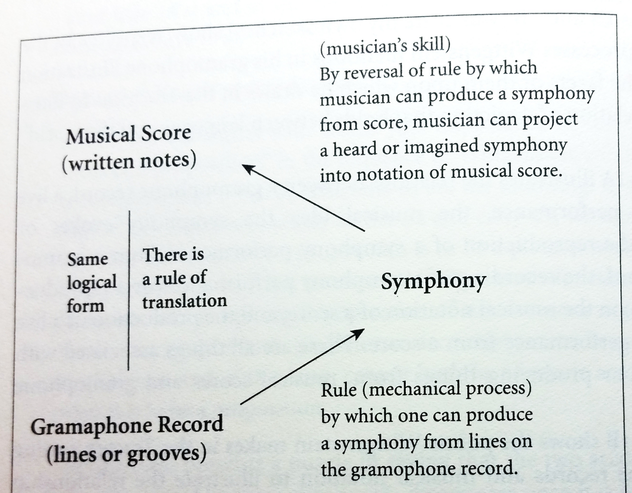


Figure 1B **Written notes and gramophone records in the *Tractatus*.**

In the Tractatus, the score and the gramophone record "stand in the same internal relation" of depiction, which is what having the same logical form amounts to.

The account of propositions in the Tractatus is considerably developed; I depicted it in Figure 4. Then, I showed how like the account of experimental models first presented in July 1914 and, depicted in Figure 3, the account of propositions in Figure 4 was:

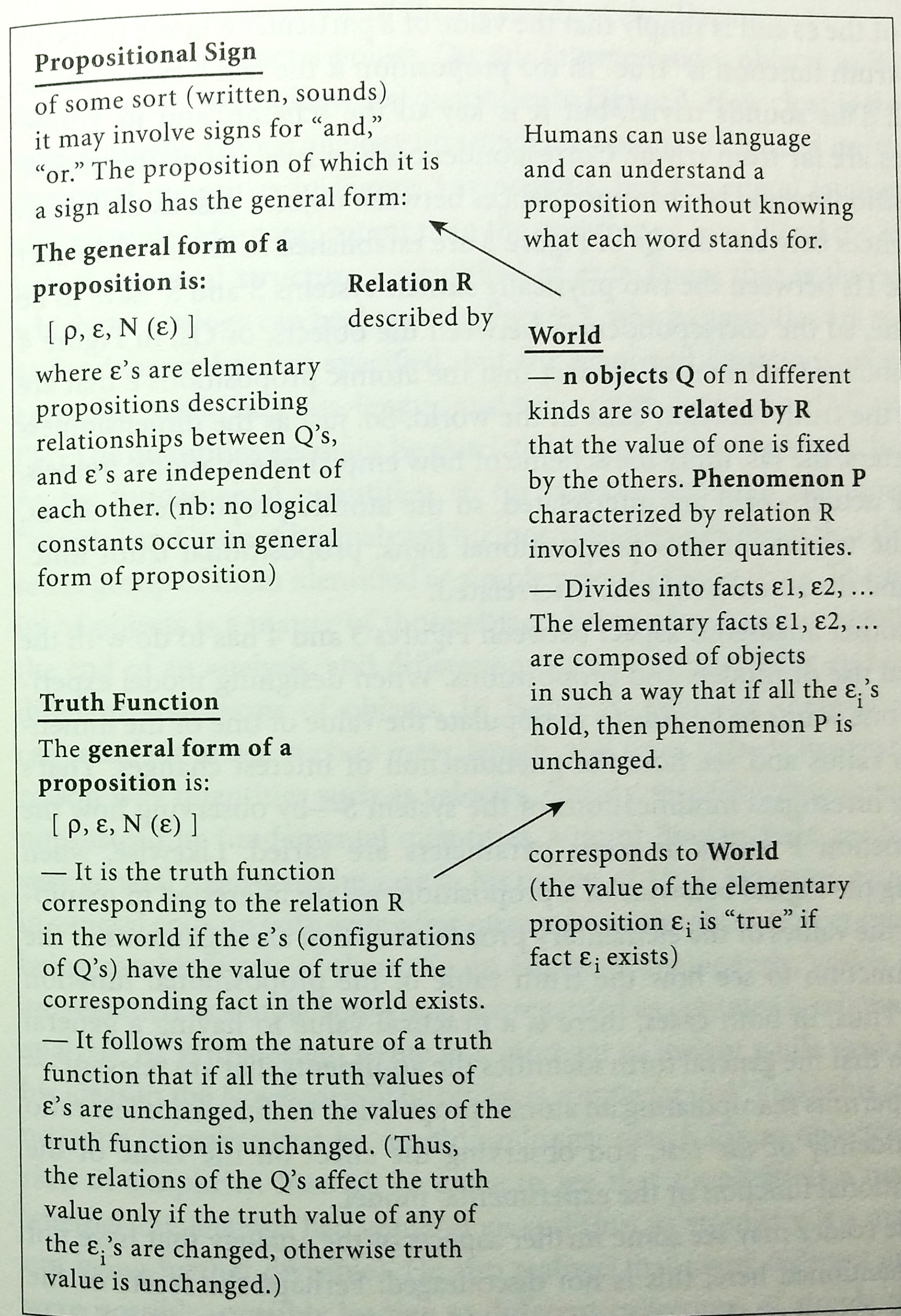


Figure 4 Propostions in the *Tractatus*.

Equation of the form

$$\Sigma M\, Q_1^{b1}\, Q_2^{b2}\, Q_3^{b3} \ldots Q_4^{bn} = 0$$

M's are dimensionless or pure nos.

The **most general form of the equation** is:

$$\phi\,(\pi_1,\ \pi_2,\ \pi_3,\ \ldots\ \pi_i) = 0$$

where π_i's are dimensionless products of Q's and are independent of each other.

Relation R
described by

System S
n physical quantities Q
of n different kinds pertaining to system S which are so **related by R** that the value of one is fixed by the others, and **Phenomenon P** characterized by relation R involves no other quantities.

System S′
is the transformation of System S that would result from altering the values of the Q's subject to the constraint that all the π_i's are the same as in System S.

corresponds to System S (value of certain experimentally-determined values measured in S′ correspond to those in S, by rules of correspondence obtained from

$$\phi\,(\pi_1,\ \pi_2,\ \pi_3,\ \ldots\ \pi_i) = 0$$

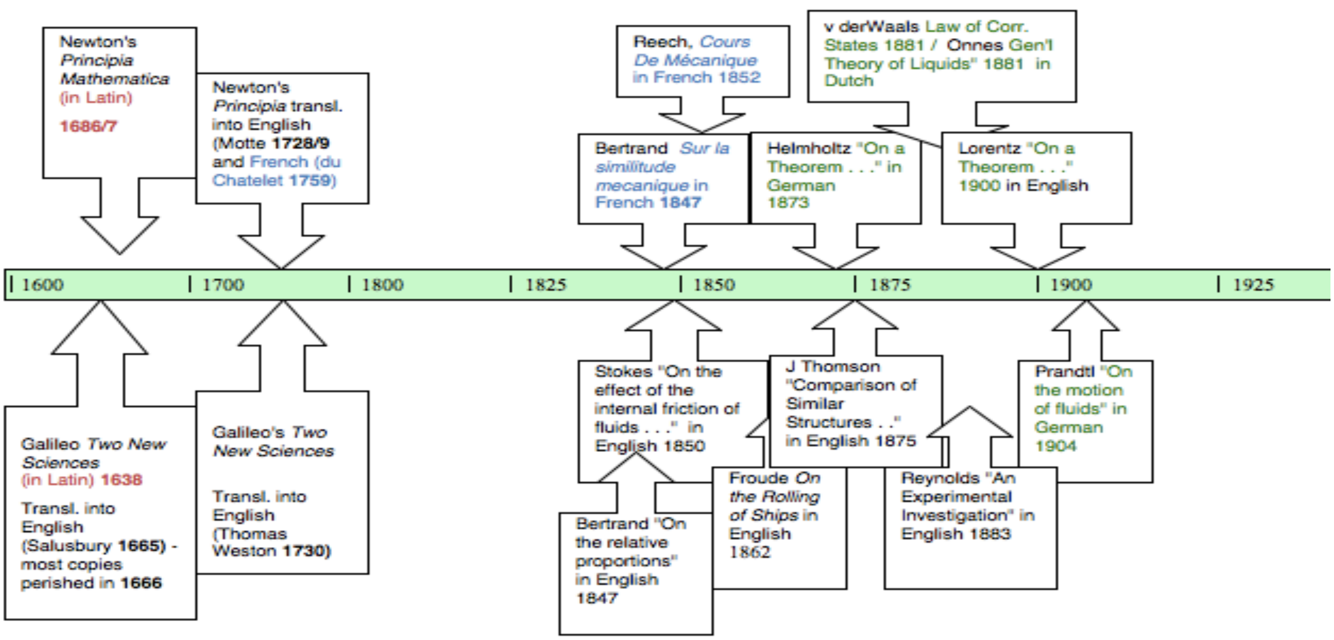
and principle of dimensional homogeneity)

References:
Buckingham, "Physically Similar Systems." *Journal of the Washington Academy of Sciences*, July 1914.

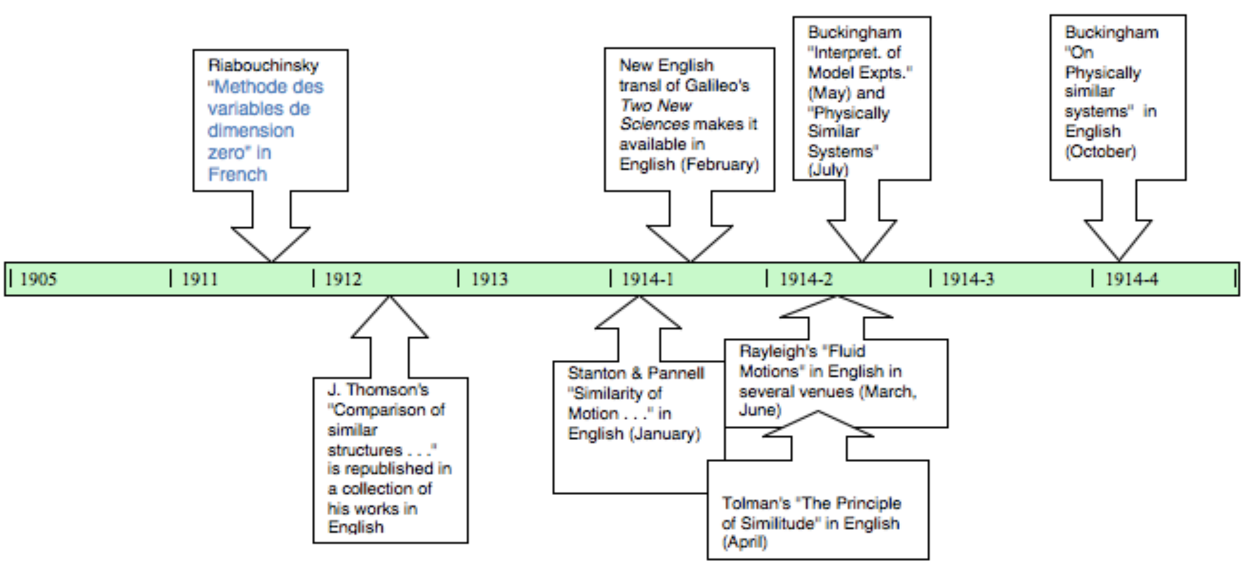
All features of Figure 3 are in the July 1914 paper. They are also in Buckingham, "On Physically Similar Systems." *Physical Review*, October 1914.

Figure 3 **Empirical equations and experimental models—Buckingham 1914.**

Some important works in the History of the Concept of Physically Similar Systems to 1904



Some important works in the History of the Concept of Physically Similar Systems 1905 - 1914



THIS HANDOUT WAS DISTRIBUTED AT HOPOS2000 JULY 2000 Vienna, Austria

(note: I would say objects are 'kinds of quantities' (length, viscosity) instead of 'quantities" now.)

(1911-1914 in Vienna, construction of improved 'free jet' tunnel)

(1)

PHYSICAL PICTURES:

Engineering Models circa 1914 and in Wittgenstein's Tractatus

by Susan G. Sterrett† . July 6, 2000.

METHODOLOGY OF EXPERIMENTAL MODELS circa 1914	VIEW IN Tractatus Logico-Philosophicus
"Most General Form of A Physical Equation"	"General Form of A Proposition"
-- contains no algebraic constants.	-- contains no logical constants.
-- arises from kinds of physical quantities	— arises from the forms of objects
Quantities combine in only certain ways to form dimensionless parameters.	Objects combine in only certain ways to form 'sachverhalte' ("states of affairs", "atomic propositions")

Exs. of Dimensionless Parameters:

Mach number: (velocity)/(celerity) dimensions are: $[L^{1}T^{-1}L^{-1}T^{1}] = [1]$

Reynolds number: $\dfrac{(\text{density})(\text{velocity})(\text{length})}{(\text{viscosity})}$ dimensions are: $[M^{1}L^{-3}L^{1}T^{-1}L^{1}M^{-1}L^{1}T^{1}] = [1]$

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Fold 2

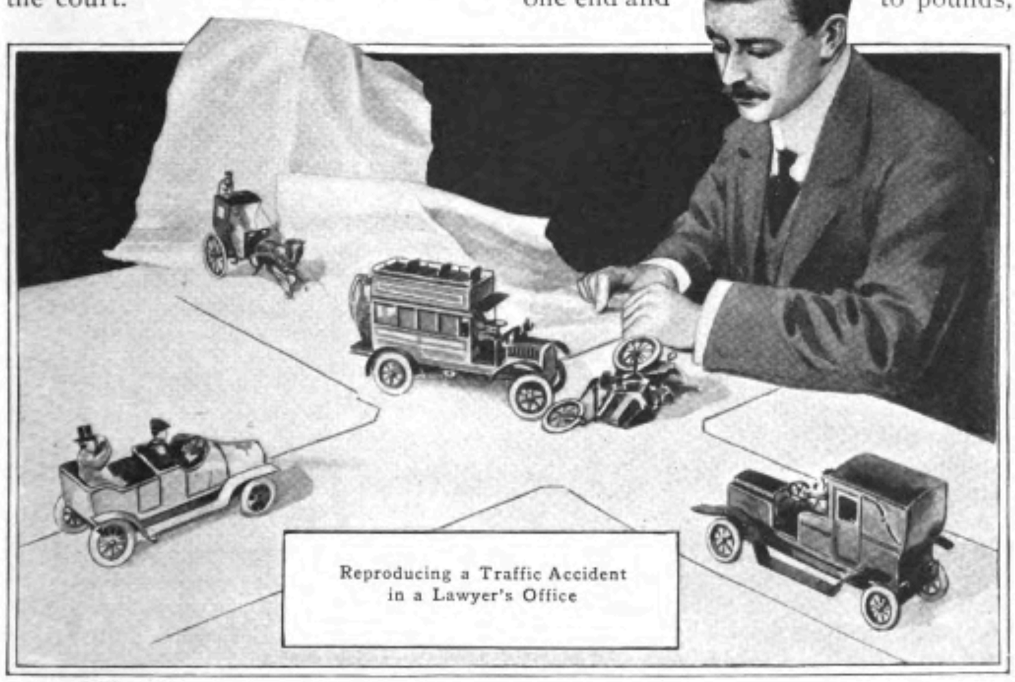
From Reference [13] , page 819

LAWYER STUDIES ACCIDENT WITH PLAT AND TOYS

A London lawyer, who specializes in personal-injury litigation, in studying a case to place the responsibility for the accident, and obtain a clear idea of the different phases of the affair, reconstructs the whole occurrence on a plat or plan of the locality, placing miniature vehicles representing the parties in such position that the question of right of way, traffic regulations, rules of the road, and such matters, are clearly shown. Thus equipped, he is able to place his case lucidly before the court.

Scale Designed to Meet Parcel-Post Requirements

and accurate scale for use in weighing the many-shaped packages sent by parcel post, has resulted in the adoption of a new model, the invention of a Chicago man. The new scale is low, entirely constructed of steel, and the beam is below the level of the platform, so that projections from odd-shaped packages do not hamper the easy reading of the weight. The beam is set to ounces at one end and to pounds,



Reproducing a Traffic Accident in a Lawyer's Office

Courtesy L'Illustration