

## Historic Mechanism Teaching Models in Taiwan

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**Abstract**—As the Mechanical Engineering specialty was being initialized in Taiwan's education, the mechanism teaching models had been adopted at colleges and universities. This paper is devoted to introduce the historic mechanism teaching models in Taiwan. By statistics, 114 models are concluded from three universities' collections, in which 106 items were imported from Shimadzu Seisakusho Ltd. (Japan) and 8 were from W.M. Welch Scientific Company (USA). It has found that, based on the archival and geographical evidences, the Japanese models are inferred to be the possible descendant of the famous models designed by Franz Reuleaux in the late nineteenth century. This result sketches the effects of Reuleaux's design creation upon Taiwan's education in mechanism and machine theory in the early twentieth century.

**Keywords:** mechanisms, teaching models, history of machines and mechanisms

### I. Introduction

When the study of mechanism and machine theory was thriving in the middle nineteenth century, the mechanism teaching models had been used in colleges and universities for teaching and research purposes. Probably, the earliest renowned mechanism teaching models were constructed by Robert Willis (1800-75) as denoted in his published book in 1851 [1]. However, most of Willis' models were lost and now only a few are available at Cambridge University. Apart from Willis' models, Franz Reuleaux (1829-1905), named the *Father of Kinematics*, also built a large collection of 800 mechanism models in Berlin [2] and authorized a German workshop, Gustav Voigt Mechanische Werkstatt, in Berlin, to manufacture over 300 of these models for technical schools to use in education. Unfortunately, most of them were destroyed during World War II. Nevertheless, some originals and reproductions can be found in the Deutsches Museum in Munich [3], Swiss Federal Institute of Technology (ETH) in Zurich, the University of Hannover, the University of Porto in Portugal [4], Kyoto University [5], and Cornell University. Among these worldwide collections, the Cornell University's collection is the largest one, in which 220 Reuleaux-Voigt models are available from their renowned website, the Kinematic Models for Design Digital Library [6].

In Taiwan, there also exist a number of historic mechanism teaching models which are aged more than ninety years old. During 1920-40s, Taiwan's three oldest engineering schools, the School of Industrial Instruction, Tainan Technical College, and Taipei Imperial University, consecutively imported several dozens of mechanism teaching models from Japan and a few from USA. Being the major mechanism collection in Taiwan, the Japanese models were built in 1913 by an educational physics manufacturer, Shimadzu Seisakusho Ltd. (島津製作所). It is particularly significant that, based on some evidences, the Shimadzu's models appear to be the reproduction of Reuleaux's models. Meanwhile, they proved the westernization of machine industry in East Asia during the early twentieth century.

This paper is developed to introduce Taiwan's historic mechanism teaching models. The history and materials of these artifacts are described. And, the relationship between Taiwan and Reuleaux's models is interpreted.

### II. Beginning of Mechanical Engineering Education and Mechanism Teaching Models in Taiwan

The mechanical engineering education in Taiwan was officially enlightened in 1912 since Taiwan's first engineering school, the School of Industrial Instruction (now known as the National Taipei University of Technology, NTUT), was established. Along with the school foundation, the Department of Mechanical Engineering was set at the same time. After, the Tainan Technical College (now known as the National Cheng Kung University, NCKU) was established in 1931 associated with the Department of Mechanical Engineering. Then the Department of Mechanical Engineering at Taipei Imperial University (now known as the National Taiwan University, NTU) was built in 1943 shortly after the university foundation in 1928. Briefly, the above three academic institutions were the pioneers of mechanical engineering education in Taiwan.

As old as Taiwan's mechanical engineering education, the history of using mechanism teaching models in Taiwan was over ninety years. For educational purpose, the three oldest Mechanical Engineering Departments attained a considerable number of mechanism teaching models shortly after the department initiations. They purchased these models from Japan in major and from USA in partial. And, these models all

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came from the identical manufacturers abroad. For the Japanese models, they were built by Shimadzu Seisakusho Ltd., an educational instrument manufacturer in Kyoto. For the US models, they were manufactured by W.M. Welch Scientific Company in Chicago. By overviews, only both of these two types, the Shimadzu and Welch's products, represent the historic mechanism teaching models in Taiwan.

### III. Collections of Historic Mechanism Teaching Models in Taiwan

As described above, Taiwan's historic mechanism teaching models were attained by the three oldest engineering schools (now the NTUT, NCKU, and NTU). And these models were obtained from Shimadzu in Japan and Welch in USA. However, by the destruction of World War II and time elapsed, not all of them had survived. By statistics, only 114 models are now still available in the Departments of Mechanical Engineering at the three universities. Table 1 lists current collections at the three universities based on the mechanism type classification. It can be easily found that almost all survived models were produced by Shimadzu. Besides, it should be noted that many models preserved at different universities were very alike to one another since the three universities imported these models from the same manufacturers.

Table 1 List of Taiwan's historic mechanism teaching models

Mechanism Type	Collection No. (Shimadzu/Welch)		
	NCKU	NTU	NTUT
Lower Pairs	1/-	-/-	-/-
Higher Pairs	-/-	-/-	-/-
Simple Kinematic Linkages	1/-	-/-	-/-
Slider-crank Mechanisms	1/-	2/-	1/-
Cam Mechanisms	3/-	3/-	1/-
Gear Mechanisms	9/-	15/-	7/-
Belts and Chains	4/-	3/-	-/-
Ratchets	1/-	1/-	-/-
Screw Mechanisms	1/-	2/-	1/-
Couplings	2/-	6/-	2/-
Friction Drives	1/-	1/-	-/-
Compound Mechanisms	6/-	13/-	4/-
Mechanical Elements	3/-	-/-	-/-
Machine Systems	8/5	3/2	-/1
<b>Total</b>	<b>41/5</b>	<b>49/2</b>	<b>16/1</b>
		<b>106/8</b>	

### IV. Shimadzu's Models

#### A. History

Founded in 1875, the Shimadzu Seisakusho Ltd. started a business regarding manufacturing educational physics and chemistry instruments in Kyoto, Japan. In 1913 [7], they fabricated a group of mechanism teaching models and marketed them abroad. These mechanism teaching models had been available on the business catalogs published in 1929 [8, 9], Fig. 1.



Fig. 1 Shimadzu's catalog published in 1929 (courtesy of Shimadzu Foundation Memorial Hall)

During 1920-40s, the School of Industrial Instruction (NTUT), Tainan Technical College (NCKU), and Taipei Imperial University (NTU) purchased a number of the Shimadzu's mechanism teaching models shortly after their foundations. Now, there are totally 106 models survived and preserved in the Departments of Mechanical Engineering at NTUT, NCKU, and NTU, respectively. The model classification is summarized as Table 1.

#### B. Materials

The Shimadzu's mechanism teaching models preserved in Taiwan were formed either by metals on a wood/metal pedestal or purely by wood. For the metal models, cast iron and brass were used and processed with heat treatment to resist rusting with age as well as handling by students. Fig. 2(a) shows several samples of the Shimadzu's metal models. On the other side, there are very few models that were built purely by wood. For example, Fig. 2(b) is a wood model demonstrating an erect steam engine. In addition, as shown in Fig. 3, a metal trade mark was nailed on the pedestal of most models, in which the company name and locations of the branches of Shimadzu Seisakusho Ltd. were indicated.

#### C. Consanguinity

The Shimadzu's mechanism teaching models are extremely possible the descendant of Reuleaux's models. After a careful comparison and literature survey, the evidences can be concluded as follows.

#### Branch in Berlin

As the indication on the model trade mark, Fig. 3, Shimadzu Seisakusho Ltd. had a branch company in Berlin at least before the vintage of these models. Coincidentally, Reuleaux built his models in Berlin and Voigt was also located in Berlin. Commercial communication and/or manufacturing technology might have been exchanged between Shimadzu and Voigt. Thus this geographical relationship lights up the inference to connect the Shimadzu's models with Reuleaux's design.



(a) Samples of the metal models



(b) A wood model

Fig. 2 Shimadzu's mechanism teaching models



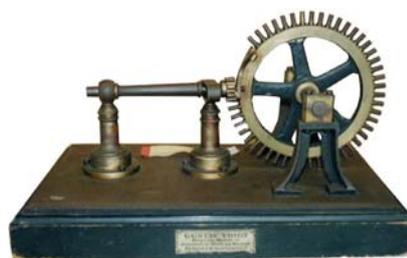
Fig. 3 Trade mark on Shimadzu's models

#### Kyoto University Collection

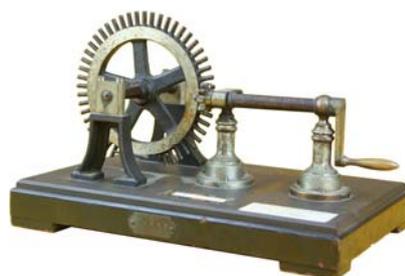
Located at the birthplace of Shimadzu Seisakusho Ltd., Kyoto, the Kyoto University imported 19 Reuleaux-Voigt models from Germany in 1903 [10]. Subject to the limited knowledge for designing mechanism teaching models in the early twentieth century in Japan, it can be inferred that the Shimadzu Seisakusho Ltd. might inquire helps from Kyoto University and further produced their models by referring Kyoto University's collection. Furthermore, by comparing the Shimadzu's models and Kyoto University's collections, it can be found that several models are almost identical. For example, Figs. 4(a) and (b) show two extremely similar models possessed by the Kyoto University and NCKU, respectively. Hence this evidence reinforces our inference in tracing the origin of Shimadzu's models.

#### 1907 Voigt Catalog

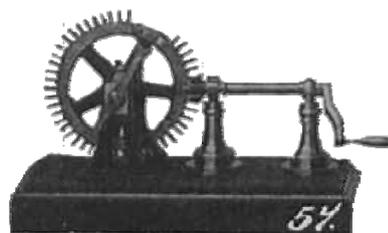
In 1907, Voigt published a catalog [11] to list their Reuleaux's models, in which totally 368 models were available. By observation of this catalog, it was found that several Shimadzu's models are almost identical to



(a) Kyoto University's model (from [5])



(b) Shimadzu's model (NCKU collection)



(c) Model picture in 1907 Voigt Catalog (from [9])

Fig. 4 The pin-gear models issued from three different references

those as illustrated in the catalog. For example, Fig. 4(c) is a Reuleaux's model on the Voigt catalog which is closely resembled to the Shimadzu's model in Fig. 4(b). In addition, Figs. 5(a)-(c) provide some other twins from Shimadzu's models and Voigt's catalog. Consequently, this evidence may confirm our speculation that the Shimadzu's models were the reproduction of Reuleaux's models.

## V. Welch's Models

### A. History

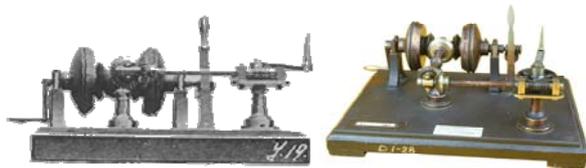
The W.M. Welch Scientific Company was a manufacturer over 120 years old in producing science education products. Their business started in Iowa and was vital after it moved to Chicago in 1903. The School of Industrial Instruction (NTUT), Tainan Technical College (NCKU), and Taipei Imperial University (NTU) purchased several mechanism teaching models from Welch during 1920-40s, as they had moved to Chicago. Now, there are totally 8 models survived and preserved in the Departments of Mechanical Engineering at NTUT, NCKU, and NTU, respectively. The model classification is summarized as Table 1.



(a) An adjustable belting



(b) A double-roller slot coupling



(c) A gear transmission with clutch

Fig. 5 Similar models in Voigt catalog (left, from [11]) and Shimadzu's design (right)

### B. Materials

The materials of the W.M. Welch's mechanism teaching models were found in iron, cast iron, and brass. Some of these models were formed by a monolithic mechanism illustration, but some were with pedestals. For example, Fig. 6(a) shows two Welch's models without pedestals and Fig. 6(b) illustrates a model with cast-iron pedestal. Similar to Shimadzu's models, the Welch's models also have a trade mark on each model, Fig. 7. But the Welch's marks are by painting only.

In addition to the use of metal materials, some special instruments are attached to a few of Welch's models. For instance, a bulb connecting with a transformer is equipped in the four-stroke engine models, Fig. 6(b). The bulb is installed inside the cylinder (from the front view) and the transformer is set under the left gear (from the back view). When the model is running, the bulb will be periodically lighted as the engine undergoes the power-stroke stage. Hence this auxiliary demonstration makes an easier understanding of the engine cycle for students.

### C. Consanguinity

The W.M. Welch's mechanism teaching models in Taiwan have several brotherhoods in other universities overseas. Figs. 8(a) - (c) conclude three similar models possessed by NCKU, University of Cincinnati, and Kenyon College in Ohio, respectively. By comparison of the figures and data, it is obvious that (1) the formations of these three models are very alike, (2) their



(a) Models without pedestals



(b) A model with bulb and transformer: front (left) and back (right) views

Fig. 6 W.M. Welch's mechanism teaching models



Fig. 7 Trade mark on Welch's models

manufacturers were all central to Chicago, and (3) the model vintages are all about 1930s. Accordingly, it may be inferred that these three models all have brotherhoods that were originated with an identical parent design. And, it may be inferred that the business of manufacturing educational products was very prosperous in Chicago in the early twentieth century.

## VI. Taiwan's Antique Mechanism Teaching Models Digital Museum

In spring 2006, under the support from National Science Council (Taiwan, ROC), an on-line museum (<http://www.acmcf.org.tw/antique/>, Fig. 9) was developed by the authors for exhibiting all Taiwan's historic mechanism teaching models. The goal is to collect, exhibit, and investigate all Taiwan's antique mechanism models and to provide teaching materials for the courses of Mechanisms and its related. NCKU, NTU, and NTUT collections are available in this museum. Additional multimedia such as model movies and CAD files are also provided in this website for assisting illustration.



(a) Taiwan's model (NCKU collection)  
[W.M. Welch Co., Chicago, c.1930s]



(b) University of Cincinnati's model (from [12])  
[Central Scientific Co., Chicago, 1928]



(c) Kenyon College's model (from [12])  
[Chicago Apparatus Co., Chicago, 1936]

Fig. 8 Similar designs to Welch's models at different universities [Manufacturer, Manu. Location, Vintage]



Fig. 9 Homepage of Taiwan's Antique Mechanism Teaching Models Digital Museum

## VII. Conclusions

When the studies of mechanism and machine theory were thriving in the early nineteenth century, the mechanism teaching models had been used for education in colleges and universities around the world. As the history of these aged models is figured out, the development of the preliminary studies on mechanism and machine theory can be sketched accordingly. This paper is, therefore, devoted to study the historic mechanism teaching models in Taiwan. As a result, it has proven that the Reuleaux's design creation was imported into Taiwan even as the mechanical engineering discipline was being initiated in Taiwan's education. And, this surprising discovery also interprets the influence by Reuleaux on leading Taiwan's study in kinematics.

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