Antique
Mechanical Computers

Part 3: The Torres Chess Automaton

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19th Century Developments

The automata of the 18th century were in fact sequence controllers possessing both digital and analog stored programs whose readouts were mechanisms that imitated human and animal actions (computers of a sort). During the next century they inspired a flood of automata, the best of which von Helmholtz described in his 1847 book, *Uber die Erhaltung der Kraft,* as being equal in achievement to the best in any other branch of science. Derek Price's book, *Automata in History,* includes material from von Helmholtz (see bibliographical notes).

In the 19th century men were starting to contemplate how mechanisms might be able to improve the human state. Charles Babbage had this notion in mind when in December 1837, precisely 99 years after Vaucanson's marvelous demonstration (see July 1978 BYTE "Antique Mechanical Computers, Part 1") he wrote the first sentence of *On the Mathematical Powers of the Calculating Engine:* "The object of the present volume is to show the degree of assistance which mathematical science is capable of receiving from mechanism." An obscure accountant of Manchester, Percy Ludgate, working without knowledge of Babbage, expressed the same thought when he wrote in 1909 the first sentence of *On a Proposed Analytical Engine:* "I propose to give in this paper a short account of the result of about six years work, undertaken by me with the object of designing machinery capable of performing calculations, however intricate or laborious, without the immediate guidance of the human intellect."

I think we may be too near to our machines to see the revolution residing in what these men said. Before Babbage and Ludgate, machines amplified or assisted or enabled the *physical* actions of humans. But now these men were suggesting that a machine could assist in or substitute for a *mental* activity of a human. Machines would enter into the realm of the human brain. It was a breathtaking idea, but not an easy one to put into effect. Babbage's two machines were never fairly begun, nor was Ludgate's. (In Babbage's case the reason was not that nineteenth century machine technology was unequal to the task, but rather because he kept changing his concepts and never produced any completed working drawings as he continuously visualized bigger and bigger machines. For him, the end was never in sight, and he left off working at a point where the machine would have been the size of a basketball court and some yards high. His son completed the "Mill" (ALU) with its printhead long after Babbage's death, in 1906. See Randell in the bibliographical notes for a photo of the Mill and a reproduction of the printout of multiples from 1 to 23 of π in 28 significant figures.)

Torres and the Incredible Chess Playing Automaton

Gifted chess players have been known to play several concurrent games, making moves without hesitation from board 1 to board n, then back to board 1. The best chess playing programs of today can't do that with any degree of success against most skilled players. But the remarkable fact is that in 1911 a machine was invented that automatically played a particular endgame of chess (King and Rook versus King) against a human opponent, and detected any false moves!

Leonardo Torres was the inventor, and his machine was displayed in the Mechanical Laboratory at the Sorbonne early in 1914. Photo 1, taken from a 1915 issue of the *Scientific American Supplement,* shows the
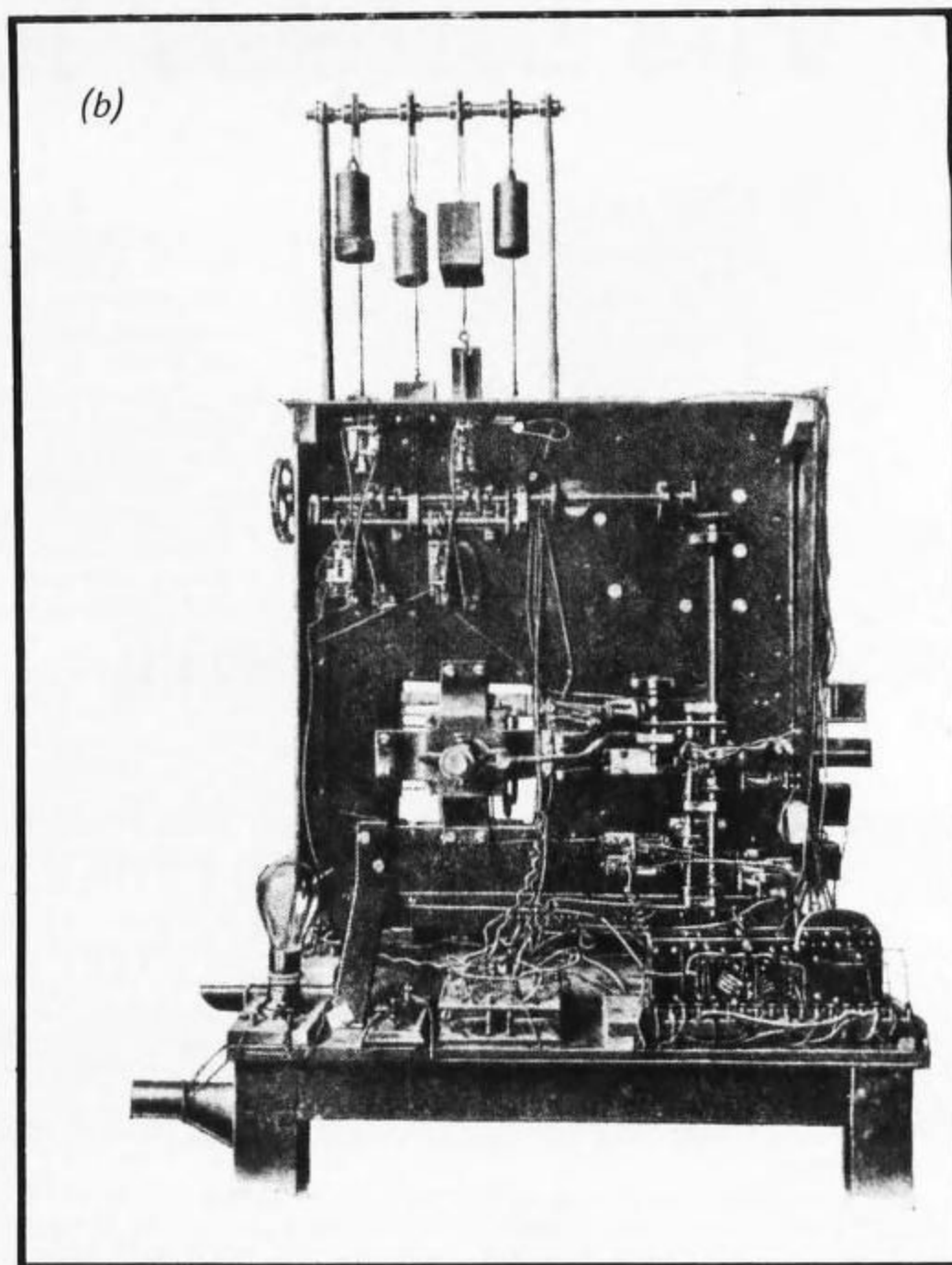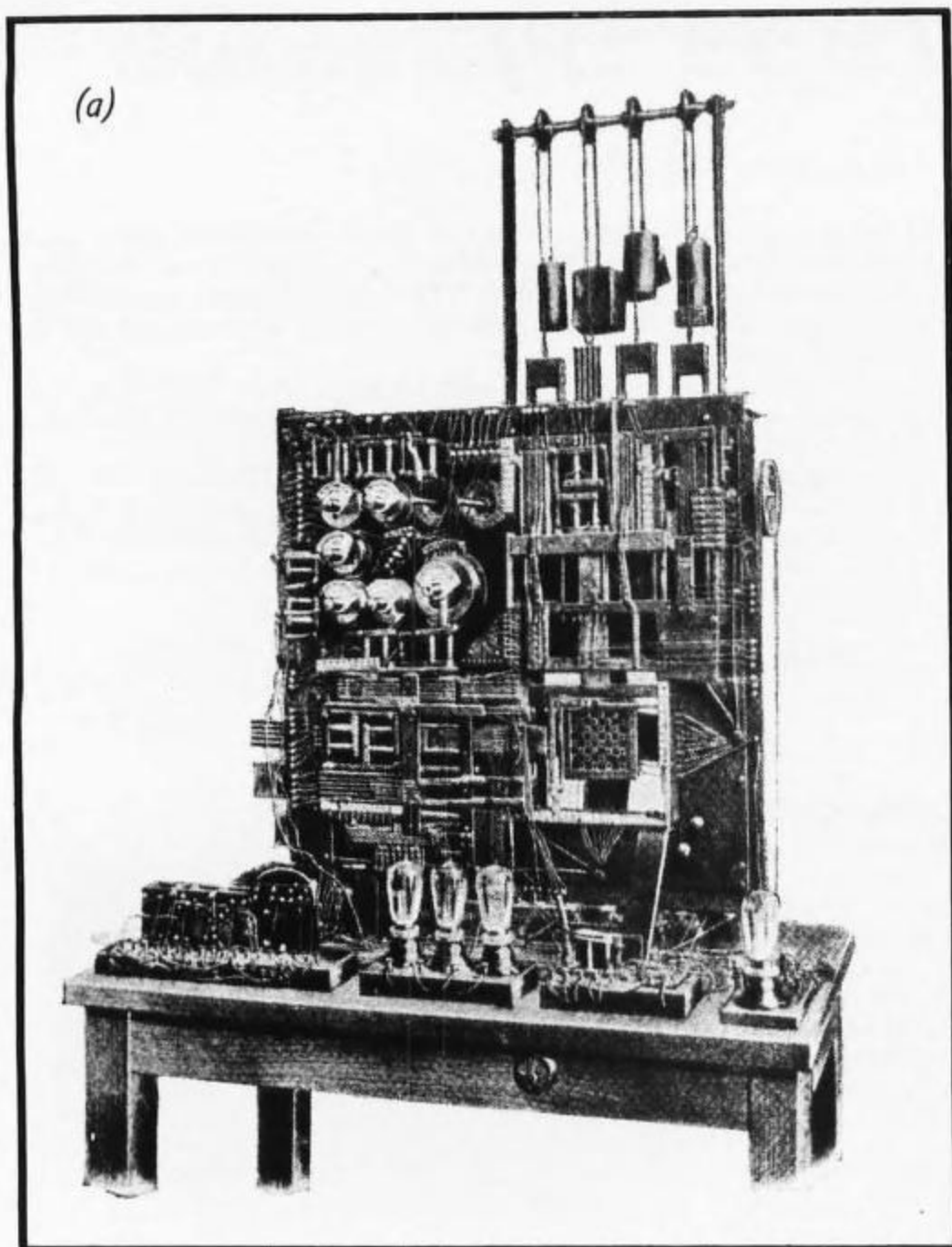
Photo 1: Front (a) and back (b) views of the 1911 chess playing automaton invented by Leonardo Torres. The unit played a particular chess endgame (King and Rook versus King) only and could force a win. The chessboard is shown in the lower right of center in photo 1a. Horizontal and vertical arms moved the pieces (which were actually electrical jacks) from square to square, and the logic circuitry consisted of battery driven relays arranged in a logical tree structure (see figure 3). Photos courtesy of Scientific American (Supplement 80, Number 2079, November 1915).

Torres was a true amateur who did his work because he loved it.

machine. It seems to have been powered by the array of weights atop the console, but it used electricity (almost surely from a battery) in its logic system, which consisted of commutators and intricate switchgear. Indeed, most of the face of the console is covered with relays and switches with their linkages and wiring, but one can make out the vertical chessboard, sans chess pieces, in the lower right quadrant of the face. It is about 8 to 10 inches (20 to 25 cm) wide and has holes in the center of each of the 64 squares that are really plug holes into which fitted the carved chess pieces (actually jacks on their lower ends used to make electrical contact). Sequential switches of two sorts are visible on the apron in the foreground, and the signalling lamps consist of a 3 lamp cluster in the middle with another single lamp on the right.

The machine in operation must have been an amazing sight, for its visible action was automatic. The sliding arms (poorly shown in the photo; located both above and to the left of the board) would grasp the chosen White piece, unplug it, transfer it to a new computed location, and reinsert the piece

into the board. Then it waited for Black's next move. This is a degree of automation I don't recall seeing since I last gazed at a Linotype, and in 1914 it must have been an awesome spectacle. To be sure, Black always was checkmated, even with the first move, since White (the machine) had too much strength. If Black made a false move, the machine would sense it and light a signal lamp, then wait until the piece was moved to a legitimate square. Three false moves in the course of a game would "jam" the machine, which would not continue play until a reset switch was closed and pieces were properly placed. Possibly the pieces could be placed anywhere on the chessboard upon initiating a game; accounts do not make this clear. At any rate, the algorithm is quite general and directs the White King a square at a time, and the White Rook a row or column at a time inexorably toward the Black King until he is hemmed in.

In 1922 an improved version was displayed. Photographs and a description may be found in Chapuis (see bibliographical notes). This more modern machine had a horizontal chessboard grooved to accom-
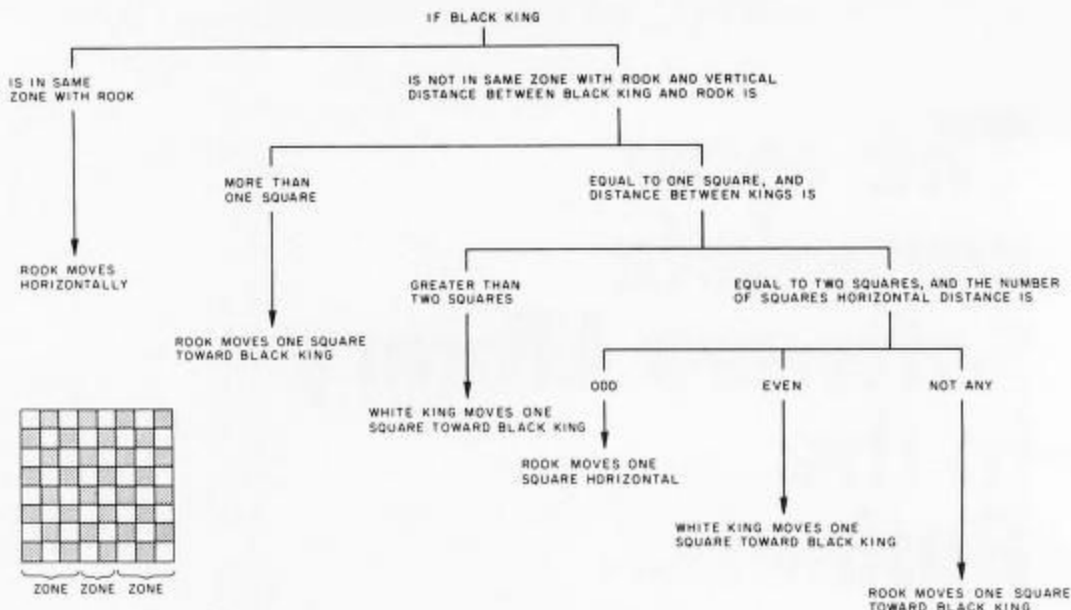
IF BLACK KING

IS IN SAME ZONE WITH ROOK

IS NOT IN SAME ZONE WITH ROOK AND VERTICAL DISTANCE BETWEEN BLACK KING AND ROOK IS

MORE THAN ONE SQUARE

EQUAL TO ONE SQUARE, AND DISTANCE BETWEEN KINGS IS

ROOK MOVES HORIZONTALLY

ROOK MOVES ONE SQUARE TOWARD BLACK KING

GREATER THAN TWO SQUARES

EQUAL TO TWO SQUARES, AND THE NUMBER OF SQUARES HORIZONTAL DISTANCE IS

ODD

EVEN

NOT ANY

WHITE KING MOVES ONE SQUARE TOWARD BLACK KING

ROOK MOVES ONE SQUARE HORIZONTAL

WHITE KING MOVES ONE SQUARE TOWARD BLACK KING

ROOK MOVES ONE SQUARE TOWARD BLACK KING

ZONE ZONE ZONE

Figure 1: A chart of the algorithm used by Torres' 1911 chess endgame playing automaton.

modate wires that sensed the location of a piece, and a complex clutch and gear system within the tabletop accomplished White's moves, via magnets. It was all powered by a few small electric motors, and a phonograph record pronounced the words "echec et mat" when Black was checkmated. Figure 1 shows a chart of the action, drawn from the *Scientific American* article. *[According to David Levy in* Chess and Computers, *the Torres machine is still in good working order and can be seen in the museum at the Polytechnic Institute in Madrid SPAIN. . . .CM]*

Torres was one of those vital persons who ornaments the history of science: a person of intense curiosity and independent means who devotes time and energy to the exploration of arcane subjects many decades before the professionals find their way into the original excavations and mine the uncovered veins of ore left behind. He was a true amateur who did his work because he loved it; history is studded with these men: Schliemann, Humboldt, Lavoisier, Rumford, Kelvin, Babbage, Bohr, etc.

Leonardo Torres was born in 1852 in Santander on the north coast of Spain, and was trained as a civil engineer. Unfortunately I could learn only very little about his life since the biography by his son is in French and is not available to me, but a few facts emerge: he was a patriot, and a capable politician as well, who arranged for the Spanish government to liberally subsidize

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his "large and well-equipped mechanical laboratory at Madrid." Perhaps this is related to the fact that in 1906 in Bilbao harbor he displayed before the King a small scale radio controlled boat which "could select between various rudder positions and speeds, and cause a flag to be run up and down a mast." A lifelong Francophile, during World War I he designed a plane called the Astra-Torres for the French Air Corps. He also pursued quite mundane things: designs for aerial cablecars, apparatus to test lubricating powers of oil, a "universal pantograph" that automatically corrected any unwanted jiggles by a special linkage.

One of his first interests was mechanical analog computing devices, perhaps before 1900. He was familiar with Babbage's publications. In a paper dated 1920 he outlined an electromechanical calculating machine he exhibited in France. The machine consisted of a modified typewriter and several boxes of apparatus, connected only by a bundle of wires, all mounted on a table for display. (A picture of the machine is in Randell's book; see the bibliography.) The operator types in the numbers desired to be manipulated together with the sign of the operation to be performed, and after a few moments an = followed by the result is typed out. This is a 4 function machine that can deal with perhaps six or seven digits. This was in 1920, mind you! He revealed the

theoretical underpinning for his calculating apparatus in general terms in 1914, in the *Essais sur l'automatique*. (In 1914, *automatique* was a new word, translatable as automation or as automatics.)

Torres' essay is so lucid and fresh that today, 64 years after publication, it still casts much illumination on the human and machine interface. After describing a first type of automaton, a machine designed to mimic the movements of a living creature, he describes a second type of automaton (Torres' own italics), "... those that imitate, not the simple gestures, but the thoughtful actions of a man, and which can sometimes replace him." He gives examples: "... the self-propelled torpedo, which *knows* how to maneuver in order to arrive at its target, the balance which weighs coins so as to *choose* the ones which are of legal weight." He speaks of the need for a "... special chapter of the theory of machines which would be called *Automatics*" and of the need to investigate "means for constructing automata endowed with a *pattern of behavior* of greater or lesser complexity." "These automata will have *sense organs*, ie: thermometers, magnetic compass, manometers, etc" together with "limbs, ie: machines or mechanisms capable of executing the operations which they are instructed to do." And they will need power sources. "Moreover, it is essential, being the chief objective of *Automatics*, that the automata be capable of *discernment*; that they can at each moment take account of the information they receive, *or even information they have received beforehand*, in controlling the required operation." *"It is necessary that the automata imitate living beings in regulating their actions according to their inputs, and adapt their conduct to changing circumstances."*

After noting that construction of mechanisms which play the role of sense organs is not difficult in theory, and that new apparatus to achieve this measuring (sensing) function is invented every day (what cannot be measured today will be measured tomorrow or shortly), he adds that the same may be said of devices to effect the automaton's work. No one can point to a limit in the inventing of machines to perform functions. But, "It is not the same when one asks whether it is possible to construct an automaton which, in order to decide on its manner of working, *ponders* on the circumstances which surround it. The estimate is, I believe, that this may be done only in some very simple cases ... it is thought possible to automate the mechanical operations performed without thinking by a workman, but that those requiring the exercise of mental faculties will never be executed mechanically." "I shall try to show in this article, *from a purely theoretical point of view, that it is always possible to build an automaton whose actions depend on a greater or lesser number of circumstances, according to rules which one can impose arbitrarily during its construction."* In reference to this quote, Torres described a simple digital device, but with the novelty that it displays a worked out form of conditional branching: ahead of its time, like so much of Torres' writings and work.

In his writings, Torres selected his words so carefully that it is possible to argue his distinction between "to discern," a process of 'input which he welcomes and illustrates as measurements; and "to ponder," a verb he seems to reserve for human thought, where more has to be taken into account than just the information of the moment or information previously received. And what is that "more"? I suggest that only people who know mechanics very well can appreciate fully the chasm between their creations and those of life (ie: between organic information and mechanical information). Randell observes, and I heartily agree, that "In all this work [Torres] was deliberately exploit-

ing the new facilities that electromechanical techniques offered and challenging accepted ideas as to the limitations of machines." But he not only exploited, he revelled; he did more than challenge: he expressed his disbelief and undertook to amaze his skeptics.

Torres worked on what he enjoyed, and a spirit of breathless, childlike fun is visible in all his activities. Imagine in 1906 a radio controlled boat that coasts up to a dock where stands the King of Spain, cuts its engine, heels sharply to starboard, and runs the royal flag smartly up and down the mast! The King salutes, the crowd cheers *¡ Viva la España!* What ecstasy it must have been for Torres. This is something beyond a demonstration of Hertzian waves as applied to potential weapons of war. It is something human: a radio controlled triumph. But such moments do not recur frequently. Torres the inventor-scientist is almost surely speaking in this quotation from the *Scientific American* article (see bibliography) about his 1911 chess player: "There is no claim that it will think or accomplish things where thought is necessary, but its inventor claims that the limits within which thought is really necessary need to be better defined, and that the automaton can do many things that are popularly classed with thought." You can hear the muted sadness, the resignation mingled with pride. Well, it still can play a flawless endgame of chess. If only it could be made to live. The next one I make will, at least, talk.

BIBLIOGRAPHICAL NOTES

1. The information in these articles has been synthesized from various sources I have encountered in reading about the history of computers, several histories of which make mention of Vaucanson in the sentence that directly precedes the one about Babbage. I found no literature explaining Vaucanson's creations until I came across:

   Chapuis, Alfred E, and Droz, Edmond, *Automata: Historical and Technological Study,* Editions du Griffon, Neuchatel SWITZERLAND, 1958.

   Here an astonishing and catholic variety of automated devices are described and illustrated, most of them trivial, such as pictures with clockwork-driven, moving figures. It is maddening that Chapuis' *Automata* treats the great mechanical computers of the past with little care. Chapuis and Droz were in a unique position because they read French, the language of most of the original docu-

ments. They had pursued the field of automata so long (Chapuis & Edouard Gelis published *Le Monde des Automates* in 1928, as well as making a film about automata in 1945) that their fame on the continent would have enabled them to study the machines minutely. They meticulously reconstructed the dates of inception, untangled the inventors of automata, and deduced the fate of the machines. Their myriad illustrations are unsurpassable.

2. You can read a translation of Vaucanson's own description of his automata in:

Ord-Home, Arthur W J G, *Clockwork Music*, Crown Publishers, New York, 1973.

which is currently in print. This book mentions and illustrates the Eureka poetry composing machine, a violin playing device, and quotes a newspaper account of one or two astonishing automatons (unless they are fabricated) such as a life-size mannequin that plays violin sonatas under keyboard control. There is little else of interest regarding stored programs. Lots of fun, though.

3. A most valuable survey which speaks of a great many mechanisms and machines from the historical viewpoint, but describes them hardly at all is:

Price, Derek J deSolla, *Automata in History: Origins of Mechanism and the Mechanistic Philosophy*, Technology and Culture, volume 5, number 1, 1964.

which is worthwhile for the long perspective it offers on mechanics, and for the sense of continuity it conveys regarding human endeavor. You begin to learn that the world has always been filled with restless, thoughtful, imaginative and inventive people.

4. It is fun to read a splendidly researched volume like:

Carroll, Charles Michael, *The Great Chess Automaton*, Dover Publications, New York, 1965.

which is still in print and describes a nearly century long hoax (for which Vaucanson had unwittingly cleared the path), as well as Maelzel's actual mechanical achievements that blossomed into an industry by 1900.

5. For me the doyen of computer historians is:

Randell, Brian, *The Origins of Digital Computers: Selected Papers*, Springer Verlag, Heidelberg, New York, 1973.

where the developments that preceded and led up to the digital computer are spelled out event by event. As if Randell's crystalline commentary were not enough, he includes original papers (some in lucid translation) by Babbage, an incredibly clever man, and just about everybody who did anything useful in the development of computers, such as Aiken, Hopper (the only woman in the book), Eckert, Von Neumann, Goldstine, and Mauchly. They are included here, along with Leonardo Torres. Many machines are also included, such as the Zuse relay computer of wartime Germany, the Bell Labs relay computer, Altanasoff's Iowa State computer with its novel capacitor storage system, and of course, ENIAC and EDSAC, those feeble giants.

6. The following article makes fascinating reading:

Anonymous, "Torres and His Remarkable Automatic Devices (He Would Substitute Machinery for the Human Mind.)", *Scientific American Supplement 80*, number 2079, 6 November 1915.

7. Torres' machine is also described in:

Levy, David, *Chess and Computers*, Computer Sciences Press, Potomac MD, 1976. ∎