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# Professor Ying's Nobel Complex

By **WANG FENG** & **HUANG XIN**

Editor's Note:

"The Chinese Dream" is different for each person. Prof. Ying Huaiqiao hopes that his work with virtual instruments will culminate in a Nobel Prize. When novelist Mo Yan was awarded the Nobel Prize for Literature last year, Nobel fever swept China. The Nobel Prize is on the mind of every scientist, spurring them to put lifetime efforts into achieving it. Prof. Ying has already brought cutting-edge advancements to the field of virtual instruments, and considers contributing to the prosperity of the country a personal responsibility.

Professor Ying Huaiqiao is honorary chaiman and director of the Scientific and Technological Committee of the China Orient Institute of Noise and Vibration, and vice president of the Beijing Academy of Applied Sciences. His research focuses on the development of vibration and noise control, signal and information processing, measurement and control technology, fault diagnostics, modal analysis, data acquisition and signal analysis instruments (virtual instruments).

YING was born in Shaoxing, Zhejiang Province, which has a long tradition of devotion to academics, specifically those studying humanities. He attended a primary school whose principal was Cai Yuanpei (1868-1940), a renowned revolutionary educator and late president of Peking University. Ying has always cherished the dream of contributing to the rejuvenation of the country with his learning.

In 1959 Ying was admitted to Zhejiang University to study theoretical physics in the department of engineering physics. Soon after, however, his department merged with the applied mechanics department in the School of Mathematics and Mechanics. This development had major impact on Ying's life. After graduation in 1964, he worked at the China Academy of Railway Sciences to research wind tunnels for high speed rails. Meanwhile he interned at the department of engineering mechanics at Tsinghua University to study wind tunnel testing and analyzing technologies. In 1965, Ying participated in nuclear and hydrogen bomb testing at the Lop Nor nuclear test site in western China. From that experience, he learned about vibration, noise and spectrum analysis in relation to nuclear weapons. Afterwards, he continued studying in this field, but with digital computers.

## Work for the Scientific Development of China

Ying changed majors five times, which helped lay a solid academic foundation and enabled him to research multi-disciplinary programs. He blazed a trail for many in his field of scientific research. In his opinion, his dedication to science is obligatory.

Throughout its lengthy history, China has made many indispensable contributions to global technological development. The nation's four greatest inventions are considered gunpowder, paper making, the compass and printing. However during the last century, China lagged behind much of the world in science and technology. Ying knows well the importance of scientific research and development for a country. When Deng Xiaoping proclaimed in 1988 that science and technology constitute a primary productive force, Ying felt a strong social responsibility and sense of mission in his research.

"Virtual instruments are not the same as their traditional counterparts," Ying said. "They refer to software-based tools which integrate data acquisition and signal conditioning, signal processing technology and PC technology." Ying first came across the bold idea of making virtual instruments way back when he participated in the national defense nuclear project. In 1965, he researched the vibrations and noise of an explosion in an underground railway, and produced a dynamic analysis. But problems related to residual displacement in the underground railway couldn't be solved with the available hardware. This inspired him to "use numerical algorithms and software to replace the hardware."

In 1973, Ying attempted to solve these problems using a computer's digital integral and digital fourier transformer instead of traditional methods employing analog integral and analog filtering. He finally succeeded in 1979 and produced the earliest example of a virtual instrument. That same year, at a meeting of the State Commission of Science and Technology for National Defense Industry, Ying introduced the core concepts of virtual instruments – the idea of making instruments using software. The concept was praised and supported by Zheng Zhemin, former director of the Institute of Mechanics, Chinese Academy of Sciences, Zhang Wei, late vice president of Tsinghua University and academician of the Chinese Academy of Sciences and Chinese Academy of Engineering, and Li Guohao, academician of the Chinese Academy of Sciences and Chinese Academy of Engineering and late president of Tongji University. Ying was ahead of his time, proposing the concept seven years earlier than the globally-recognized U.S.-based National Instruments, which first introduced the concept "software is an instrument" in the West.

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In 1983, Ying Huaiqiao founded the China Orient Institute of Noise & Vibration with his life savings of RMB 300. Over the last three decades, the institute has been committed to sci & tech innovation. Every year, it holds an innovation festival on Jingzhe (Waking of Insects) day, the third seasonal division point, which heralds warmer days and spring rains. Ying hopes that every innovation will resemble spring thunder, injecting renewed vitality into society.

With the passion for rejuvenating the nation and benefiting all of humankind, the institute attaches great importance to talent cultivation, and cooperates with top universities such as Tsinghua and Peking University. It has nurtured a legion of scientific workers, who constitute the backbone of China's virtual instrument research.

In 1988 Ying took his virtual instrument developed for modal analysis of Qiantang River Bridge and applied it to small rocket testing. The instrument was displayed at the Beijing New Technology Fair in March 1993, and later exhibited in Canada. It was implemented during rocket testing of the CZ-3 strap-on booster in 1995 and again in the modal testing of the mobile launch platform of the Shenzhou manned spaceship in 1996. In 2004 it was used in the modal analysis of the arm support system of exercises for overweight astronauts. At the Second National Virtual Instrument Seminar in 2007, the achievements of the Orient Institute were highly praised and Ying was dubbed "Father of China's Virtual Instruments."

## Chasing Nobel

Scientists are like lighthouses for modern society. James Watt invented the steam engine, ushering in the industrial revolution. Albert Einstein changed human perceptions of space, and Alexander Graham Bell draw people nearer by inventing modern communication.

However, every scientist experienced extraordinary difficulties and setbacks on their way to success. A paragraph


Prof. Ying at the 22nd national conference on vibration and noise control technologies.

from ancient philosopher Mencius aptly describes scientific research: When Heaven invests great responsibility in a person, it first tests his resolve – exhausts his muscles and bones, starves his body, leaves him destitute, and confounds his every endeavor. In this way his patience and endurance are developed, and his weaknesses are overcome. Ying has survived strokes three times and suffered myocardial infarction four times. His fragile health however has never stopped him from working on the frontlines of scientific research.

Ying has invented 121 technologies, most notably the one for transfer function testing, real-time control and inversion. It was regarded as a new method to improve precision and range of virtual measurement instruments – a key technology on par with fiber optic communications invented by Charles Kuen Kao, who won the Nobel Prize in physics in 2009. The technology places China abreast of the U.S. as a leader in the most advanced technology in virtual instruments.

**Ying has devoted his life to climbing the mountains of science. Now in his 70s, he continues to chase his dream.**

Ten of Ying's inventions solved world-class scientific problems:

(1) Platform-style DASP-VI (virtual instrument) base. It enabled the production of instruments through software and combined software and hardware to replace traditional instruments. The new method, which represented a major breakthrough, enormously influenced instrument manufacturing and testing technology. It gave China a cutting edge in VI research and development.

(2) Varied-time-base (VTB) transfer function (admittance), which has reached the world advanced level and obtained a patent in China. The technology has been applied in dozens of key national projects, including the 750-ton mobile launch platform of Shenzhou spacecraft, CZ-3 strap-on booster, and the modal analysis of the arm support system of the exercises for overweight taikonauts.

(3) High-precision technology to measure frequency, amplitude, phases and dampness. The YSL high-precision "varied-frequency-base" method, invented by the Orient Institute, provides a million times greater precision in frequency and amplitude than conventional measurements abroad.

(4) The ultralow-frequency signaling for fast measurement technology, a global leader in the realm.

(5) His analysis method of three cepstrums – CEE cepstrum, CEF cepstrum and CFE cepstrum, which also leads the

world in this field.

(6) FFT/DFT method, which has become one of the most used methods in spectrum zoom. It is the most advanced technology in the world.

(7) "One-in-three-out" vibration AVD parameter represents a real-time testing and analysis method. It developed the whole-period differential and integral calculus method, realizing real-time continuous measurement of the "one-in-three-out" vibration AVD parameter.

(8) Automatic modal analysis method, which allows ordinary technicians to obtain expert-level modal analysis results simply.

(9) Dual-24-bit high-precision data acquisition device with 160dB ultra-range and varied-amplitude-base technology.

(10) Transfer function testing, real-time control and inversion. This key technology provided a new method to improve the precision and amplitude of instrument measurement. The invention solved one world-class problem by expanding instruments' testing scope and frequency and improving precision. The technology is competitive internationally.

Thus far, the product, widely used in many sectors such as national defense and aerospace, has been sold to over 2,000 clients producing RMB 200 million in revenue. It has considerably boosted technical reform and the growth of the emerging industry.

Since 1973 when he first engaged in the VI, Ying's name has been synonymous with state-of-the-art technology. He compiled and published China's first monograph in this field, *Vibration Testing and Analysis* in 1979, published *CZ Seismometers and Seismic Technology* in 1982, and *Waveform and Spectrum Analysis and Random Data Process* in 1983. In 1985 he raised the idea of portable laboratory, and made it a reality.

Facing complicated international market competition, Ying believes that the industrialization of China's virtual instruments is promising despite many obstacles. World recognition is his aim, which continues to drive him. With his firm resolve, Ying and his virtual instruments are looking at a bright future.

## Dedicated to the Motherland

"Only obtaining constant breakthroughs brings happiness to my heart," Ying told journalists when describing the current situation and future of the VI. His entire career is characterized by enthusiasm and dedication.

On December 8, 2012, Chinese novelist Mo Yan, the first Chinese to win a Nobel Prize for literature, delivered his acceptance speech at the Swedish Academy. For Ying and his unremitting efforts in science, the Nobel Prize for physics is still a dream – a dream which inspired his lifelong dedication to science.

In 2001 Ying received China's Excellent Worker in Science and Technology Award. In 2009, he was voted the Chinese Scientific Person of the Year. In 2010 he was awarded second prize for Beijing Science and Technology.

Ying has devoted his life to climbing the mountains of science. Now in his 70s, he continues to chase his dream. The world needs more scientists like Ying – working hard for the advancement of a nation and happiness of the people.