Chapter 1:
Basic Concepts of Design of M&C Instruments

Lecture 1: Introduction to Measurement & Control Instruments

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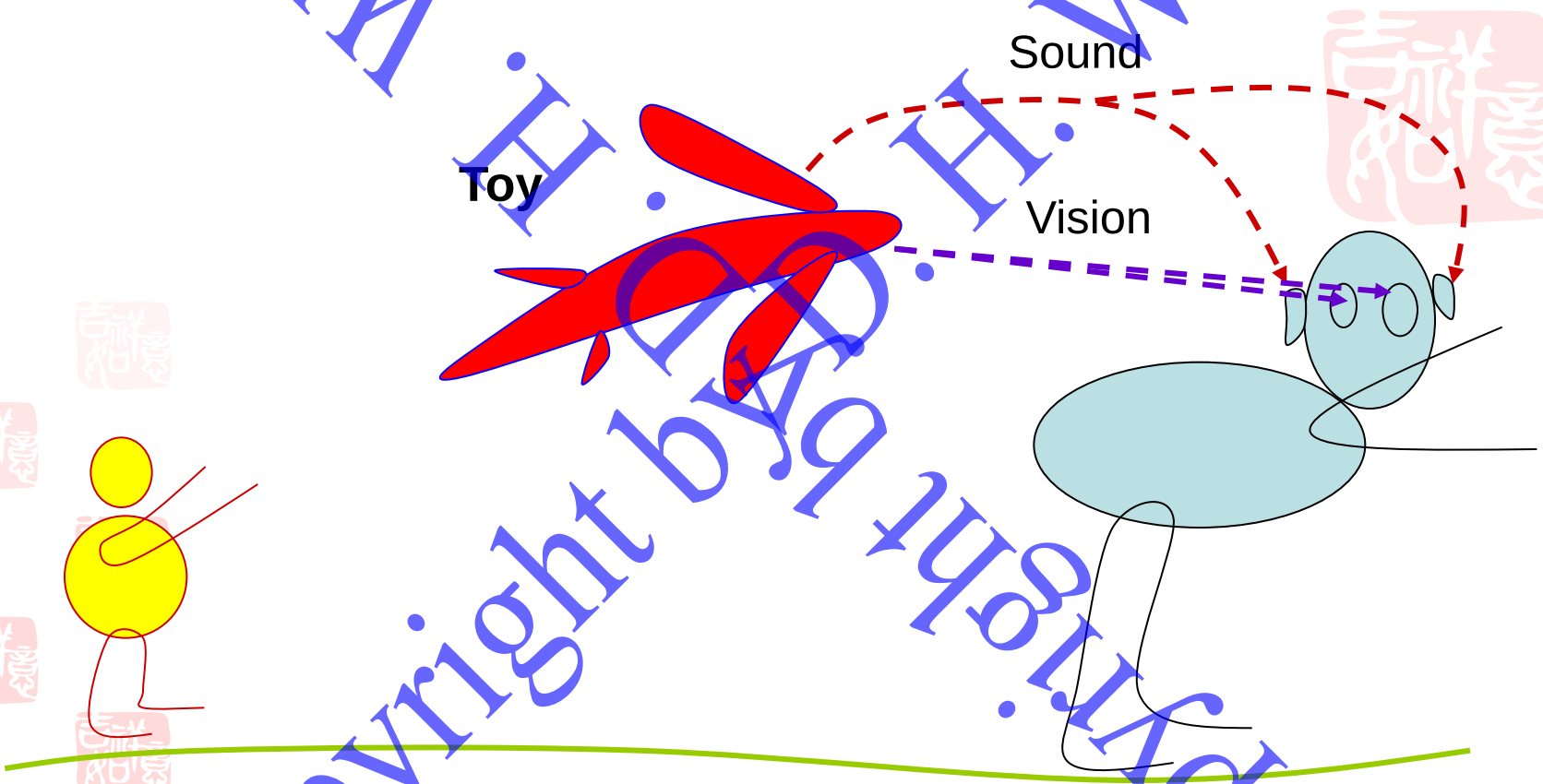
Outline of Lecture 1

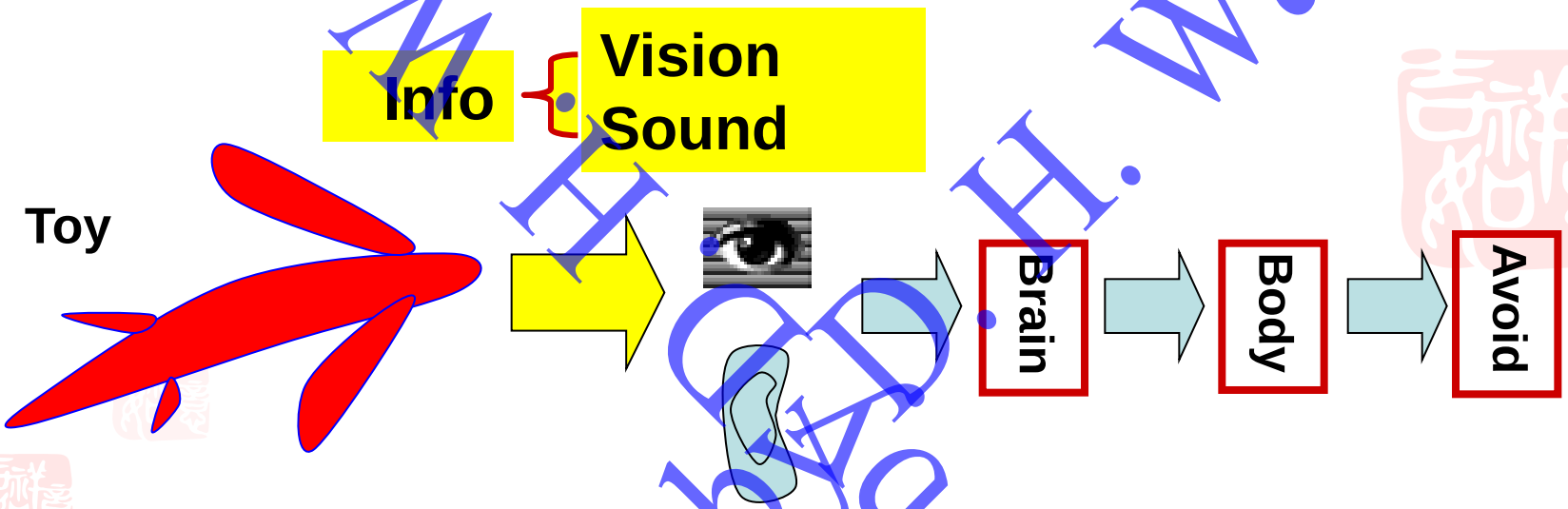
- Concept of meas. & contr.
- Concept of instru.
- 测控仪器的重要地位
- Components of a general instru.
- Types of meas. & contr. instru.
- Meas. and contr. instru.
- Acknowledgement

Concept of M & C



Concept of M & C (Cont.)

Concept of M & C (Cont.)



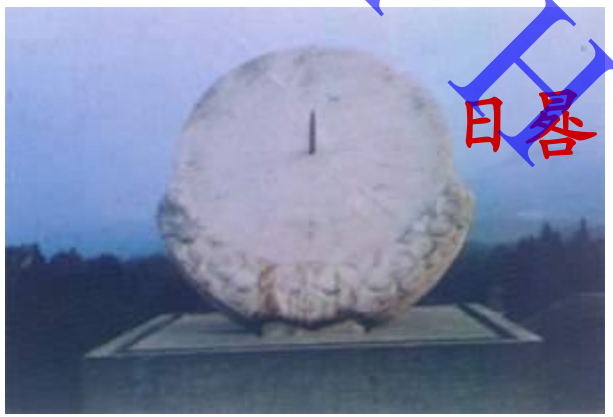
Sensor Processor Actuation

... measuring is the key to know!

From: http://ewh.ieee.org/soc/im/index.html

Concept of Instruments

“布手知尺，掬手为升，取权知重，滴水计时”。



日晷

铜壶滴漏
元延祐三年

大禹惜寸阴，
陶侃惜分阴；
吾辈方少年，
更应惜秒阴。

--《惜阴》

衣润熏笼暖，灯残漏箭长。

--陆游《晨起》

Concept of Instruments (Cont.)

We make it visible.

From: http://www.carl.com

❒ 仪器 是一种信息工具，是一种传递事物变化信息的媒介，一般以量化的形式对需要测试的对象取得反映其变化的信息（传感器），通过对信息的转换处理变成人们易于观察检读，以及对检测对象变化进行分析的形式。在现代化的过程中，有时又加以智能化的成分，使能起到反馈或控制的作用，以保证生产正常有效的进行。

王大珩，关于发展我国仪器工业的一些建议，*大自然探索*，1997，16（62）：21-22

Concept of Instruments (cont.)

- 仪器在国民经济中的重要作用可比喻为“画龙点睛”，表现在以下几个方面：
  - 以仪器及自控手段装备生产过程，实现现代化技术改造，以保证生产的规范化，保证产品质量，提高生产效率，降低成本。
  - 仪器是科研工作重要的现代化检测手段，仪器技术的先进性代表着高新技术的发展前沿，也标志着国家科技水平及其自主开发能力。
  - 在产品质量评估与论证等有关法制实施工作中，仪器起着“物质法官”的作用。
  - …

Concept of Instruments (cont.)

- 仪器在国民经济中的重要作用可比喻为“画龙点睛”，表现在以下几个方面：
  - …
  - 作为信息工具的一个组成部分，仪器也是当今国际市场经济竞争中的一个重要方面。
  - 从总体上看，仪器仪表科研与工业在实现国民经济的两个转变和贯彻两个国策(科教兴国和可持续发展战略)中，都有着重要不可或缺的地位。

--王大珩，关于发展我国仪器工业的一些建议，*大自然探索*，1997，16（62）：21-22

测控仪器的重要地位

- The Nobel Prize in Physics has been awarded to 178 individuals since 1901. (John Bardeen was awarded the prize in both 1956 and 1972.)
- 有1/4的诺贝尔物理学奖获得者的工作关于仪器科学与技术

http://nobelprize.org/nobel_prizes/physics/laureates/index.html

部分因从事仪器科学与技术研究获得诺贝尔物理学奖的科学家

Albert A. Michelson

The Nobel Prize in Physics 1907

"for his optical precision instruments and the spectroscopic and metrological investigations carried out with their aid"

Frits Zernike

The Nobel Prize in Physics 1953

"for his demonstration of the phase contrast method, especially for his invention of the phase contrast microscope"

Dennis Gabor

The Nobel Prize in Physics 1971

"for his invention and development of the holographic method"

http://nobelprize.org/nobel_prizes/physics/laureates/index.html

部分因从事仪器科学与技术研究获得诺贝尔物理学奖的科学家

Ernst Ruska
The Nobel Prize in Physics 1986
"for his fundamental work in electron optics, and for the design of the first electron microscope"

Gerd Binnig
The Nobel Prize in Physics 1986
"for their design of the scanning tunneling microscope"

Heinrich Rohrer
The Nobel Prize in Physics 1986
"for their design of the scanning tunneling microscope"

http://nobelprize.org/nobel_prizes/physics/laureates/index.html

部分因从事仪器科学与技术研究获得诺贝尔物理学奖的科学家

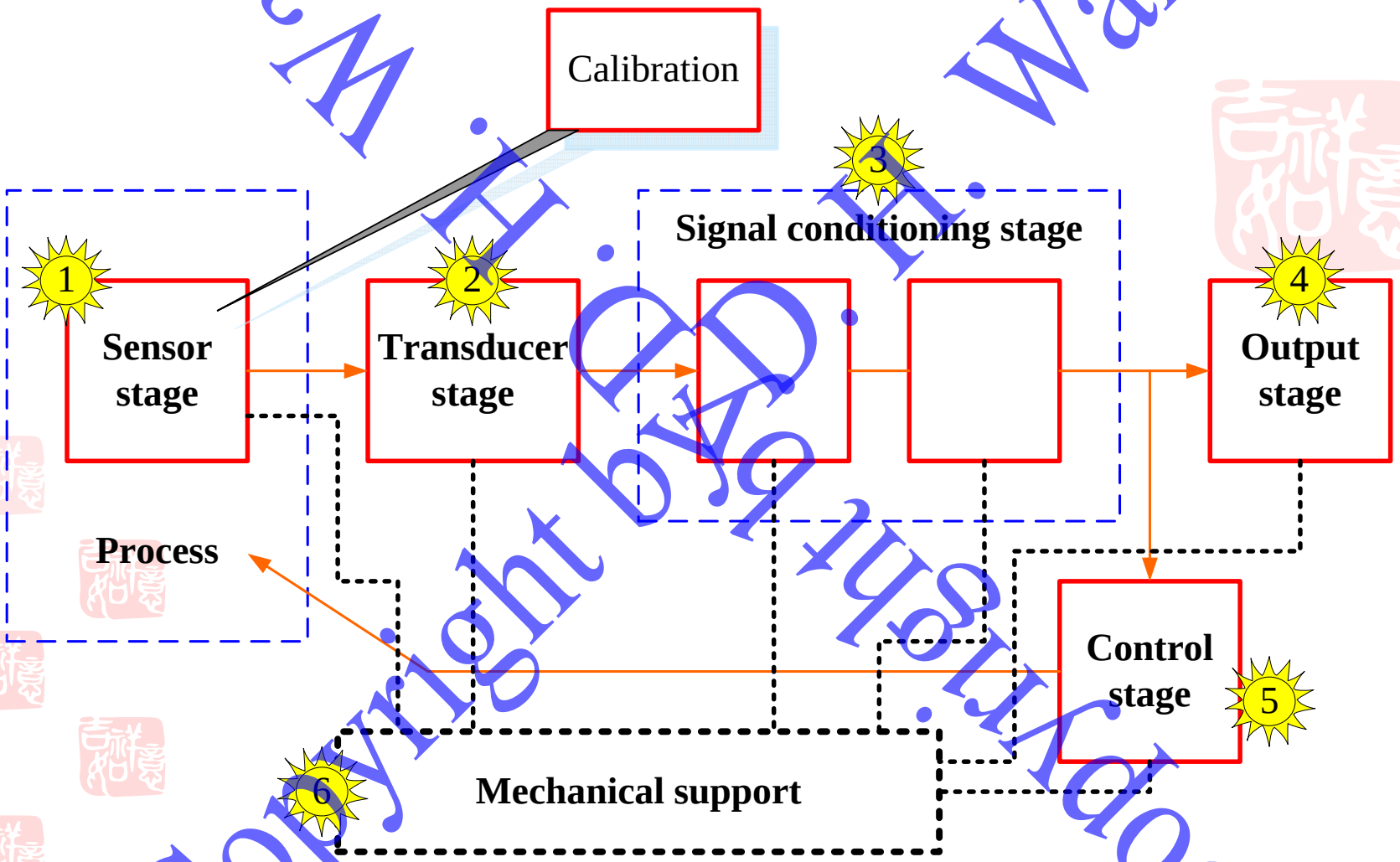
Norman F. Ramsey
The Nobel Prize in Physics 1989
"for the invention of the separated oscillatory fields method and its use in the hydrogen maser and other atomic clocks"

John L. Hall
The Nobel Prize in Physics 2005
"for their contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique"

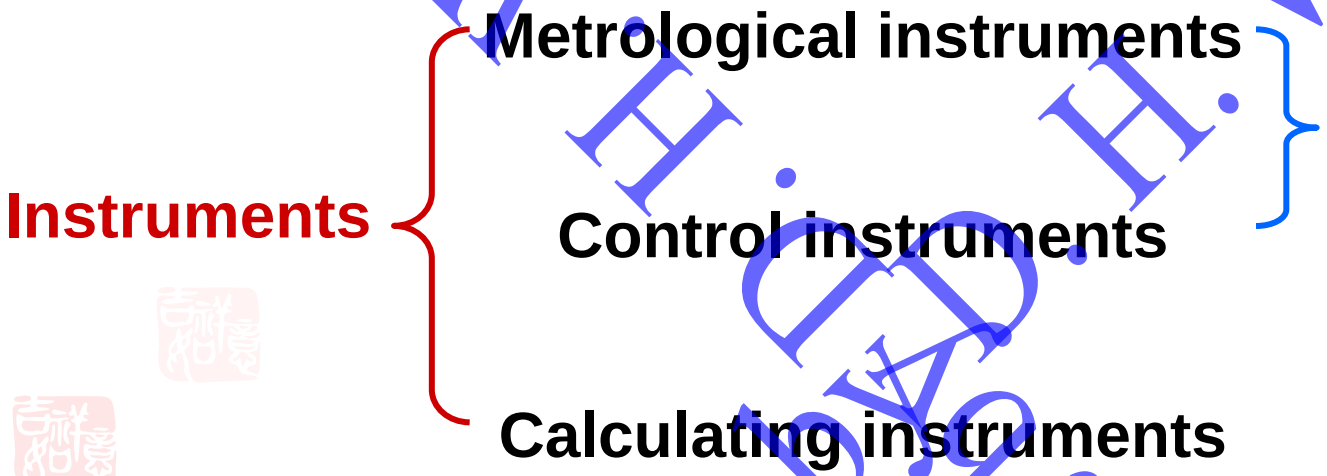
Theodor W. Hänsch
The Nobel Prize in Physics 2005
"for their contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique"

http://nobelprize.org/nobel_prizes/physics/laureates/index.html

Components of a General Instrument



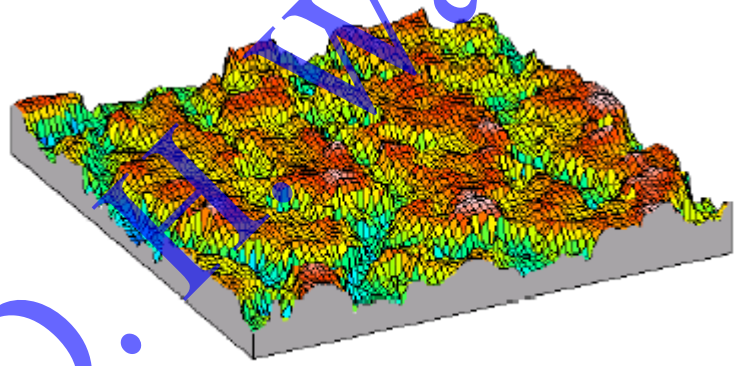
Types of M&C Instruments



Metrological Instruments

- Geometrical metrological instruments
- Thermal measuring and testing instruments
- Mechanical measuring and testing instruments
- Time and frequency measuring and testing instruments
- Electromagnetic measuring and testing instruments
- Wireless measuring and testing instruments
- Optical and sound measuring and testing instruments
- Ionizing and radiation measuring and testing instruments

Metrological Instruments--Geometrical



3D topographic view

Metrological Instruments--Thermal

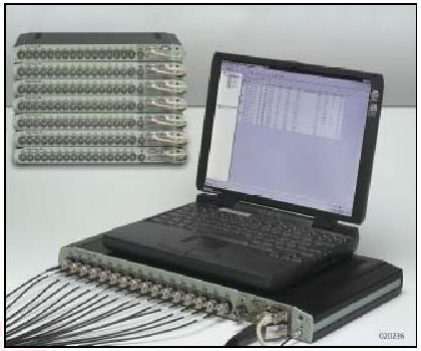
- 包括温度、湿度、流量测量仪器，如各种气压计、真空计、多波长测温仪表、流量计等。

Thermal Mass Flowmeter
for gas measurement

Thermal Flow & Level Switch
for gases and liquids.

Metrological Instruments--Mechanical

- 测力仪、硬度仪、加速度与速度测量仪、力矩测量仪、振动测量仪。



16-channel DeltaTron Conditioning Amplifiers

Scanning Laser Doppler Vibrometer

Metrological Instruments--Time and Frequency

❒ 各种计时仪器与钟表、艳原子钟、时间频率测量仪等

New Optical Clock Promises More Accuracy than Cesium.

WWVB Radio-Controlled Clocks

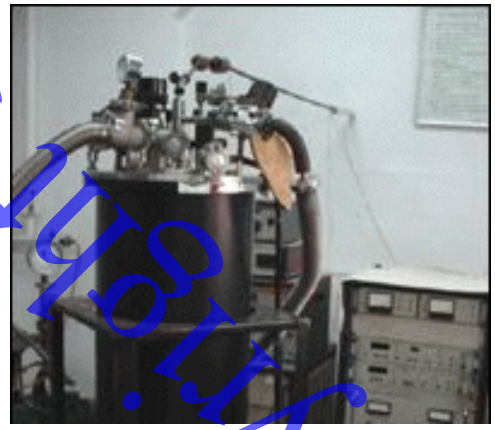
Metrological Instruments--Electromagnetic

- 电磁计量在整个计量工作体系中有着特殊的重要性
  - 一方面，电能已成为人们利用能量的最广泛的形式，各种各样的电动力机械和电器已成为现代社会生活中不可缺少的部分；
  - 另一方面，由于电信号特别容易传输和处理，各种各样的物理信号一般要转换为电信号后再处理。
  - 电磁量的基本单位是电流单位安培。
- 电磁计量仪器：用于测量各种电量和磁量的仪器

Metrological Instruments--Electromagnetic

- 电磁计量在整个计量工作体系中有着特殊的重要性
- 电磁计量仪器：用于测量各种电量和磁量的仪器
  - *Ex*：各种交、直流电流表、电压表、功率表、电阻测量仪、电容测量仪、静电仪、磁参数测量仪等。

量子化霍尔电阻国家基准



超导强磁场标准

Metrological Instruments--Radial

- 如示波器、信号发生器、相位测量仪、频率发生器、动态信号分析仪等。

EE5111A 型多功能测试仪

EE5113 型无线电综合测试仪

适用于无线电台、移动通信收发信机和射频、音频参数的测量

射频信号发生器，调制发生器，双音频信号发生器，射频频率计，射频功率计，调制度表，噪声测量，音频频率计，直流音频数字电压表，数字存储示波器

Metrological Instruments--Optical and Sound

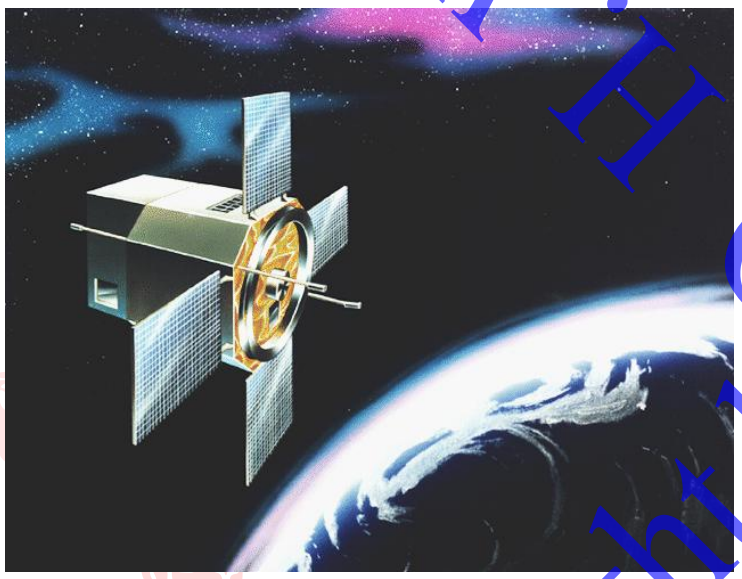
- 光度计、光谱仪、色度计、激光参数测量仪、光学传递函数测量仪等。

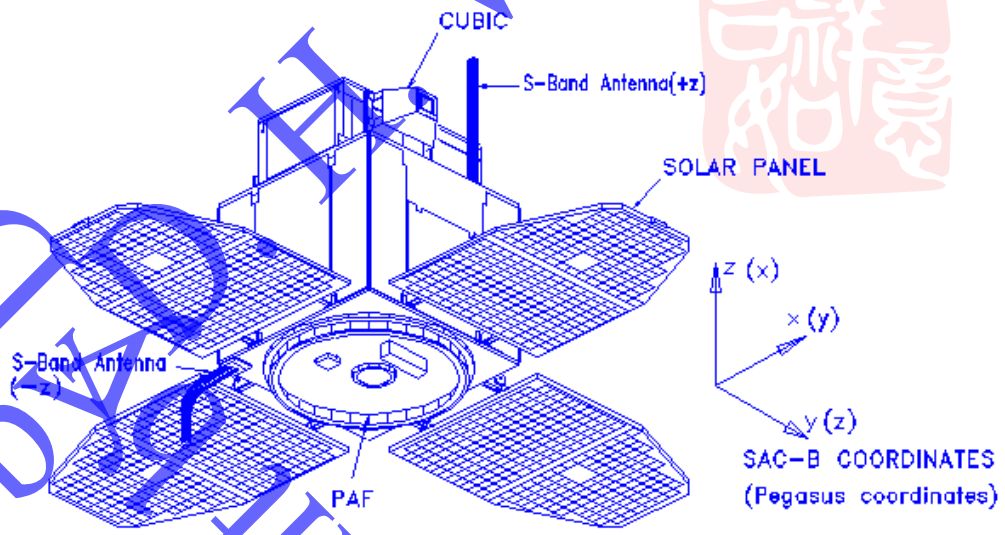
IRPrestige-21傅里叶变红外光谱仪
日本岛津制作所

Eliminator多通道近红外光谱仪
杭州微光仪器有限公司

Metrological Instruments--Ionizing and radiation

❒ 如各种放射性、核素计量，x、Y射线及中子计量仪器等。





SAC-B satellite - an Argentine - US mission
to advance the study of solar physics and astrophysics through the examination of solar flares, gamma-ray burst sources and the diffuse soft X-ray cosmic background.

Metrological Instruments--Ionizing and radiation

❒ Scientific Objectives of the SAC-B mission

- to observe the hard and soft X-ray emissions from solar flares to further the understanding of the interaction of accelerated particles with the ambient solar atmosphere.
- to observe gamma-ray bursts and correlate them with observations made by other similar detectors.
- to study the spectrum of the diffuse X-ray background for selected regions of the sky.
- to gain understanding on :
  - location of the source plasma for auroral phenomena in the magnetosphere.
  - …

Metrological Instruments--Ionizing and radiation

- **Scientific Objectives of the SAC-B mission**
  - **to gain understanding on:**
    - **the morphology of the current system, e.g. the ring current as a funcion of magnetic parameters like Kp and DST, and its effect on the transport of mass and energy within the magnetosphere, especially during sub storms and in connection with aurora phenomena.**
    - **the spatial and energy dependence of the ratio O+/H+ as a funcion of time, in order to clarify the transport between the magnetosphere and the ionosphere.**

Metrological Instruments--Ionizing and radiation

- The scientific instrument components of SAC-B
  - The Hard X-Ray Spectrometer (HXRS)
    - …
  - The Goddard X-Ray Experiment (GXRE)
  - The Cosmic Unresolved X-Ray Background Instrument using CCDs (CUBIC)
  - The Imaging Particle Spectrometer for Energetic Neutral Atoms (ISENA)

Metrological Instruments--Ionizing and radiation

- The scientific instrument components of SAC-B
  - The Hard X-Ray Spectrometer (HXRS)
    - The HXRS will observe the hard X-ray spectrum between 20 and 320 keV of rapidly varying events on time scales as short as tens of milliseconds. In addition to the study of the temporal evolution of X-ray emissions during solar flares the HXRS will provide information on the temporal evolution of non-solar gamma-ray bursts.

Calculating Instruments--Ex.

- 银河-I 巨型计算机(1983.12.)
  - 1983年12月,银河-I巨型计算机由国防科技大学计算机研究所研制成功。这是我国当时运算速度最快、存储容量最大、功能最强的巨型计算机，标志着我国进入世界研制巨型机的行列。

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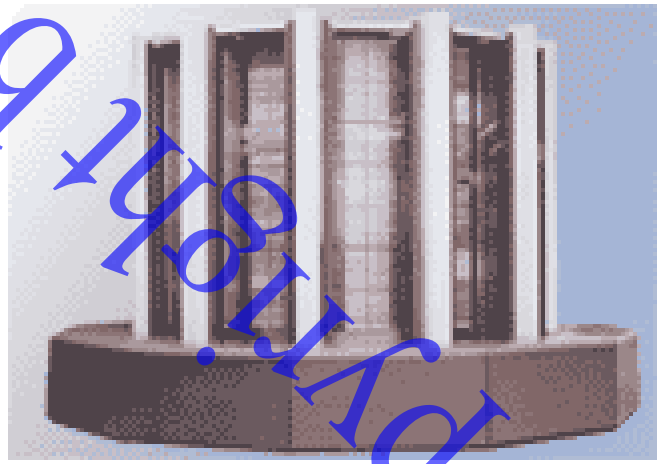
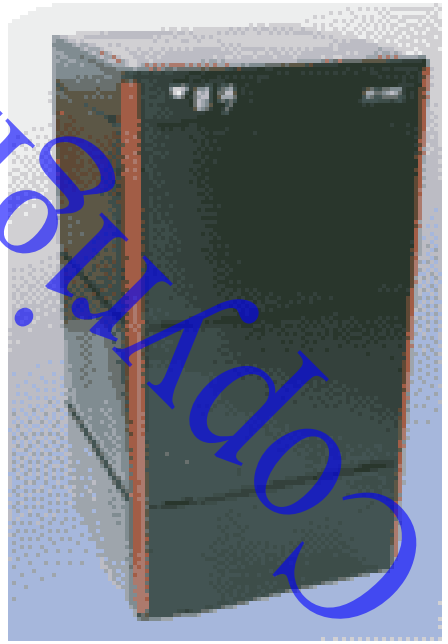


Calculating Instruments--Ex.

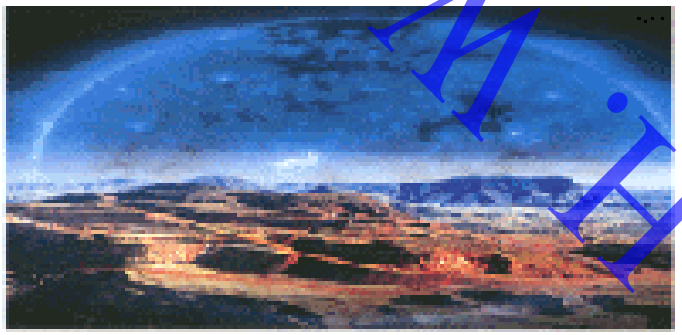
- 银河-II巨型计算机(1992.11.)
  - 我国自行研制的第一台面向大型科学/工程计算和大规模数据处理的通用十亿次并行巨型计算机系统。银河-II主机为我国高性能向量中央处理机共享主存紧耦合系统，基本字长64位，峰值速度为每秒10亿次以上运算操作，拥有两个独立的输入输出子系统。各项技术指标达到了八十年代中后期国际先进水平。

Calculating Instruments--Ex.

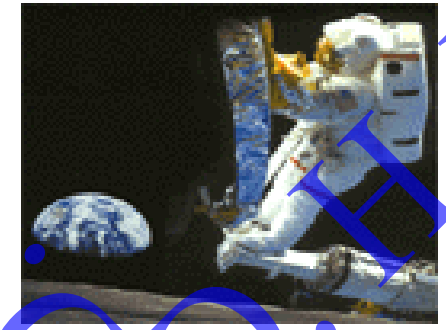
- 银河-III巨型计算机(1997.6.)
  - 银河III采用分布共享存储结构，峰值性能达到每秒130亿浮点运算。具有良好的可扩展性，系统规模可从几十亿次到几千亿次平滑扩充。银河III在MPP资源管理与处理机调度、并行I/O软件、高性能优化编译、网络软硬件设计等技术方面均达到国内领先水平，系统综合技术达到当时国际先进水平。



Calculating Instruments--Services

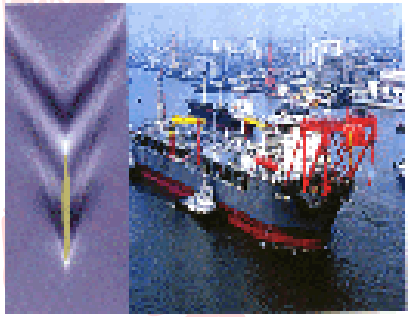


石油勘探

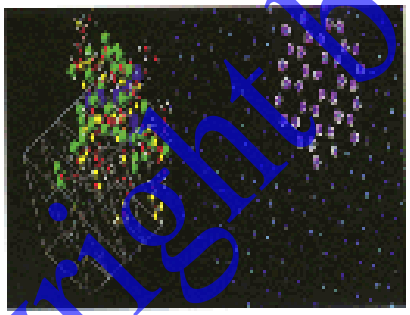


航天航空

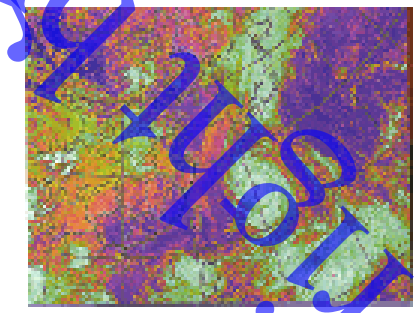
汽车制造



船舶设计



生物物理

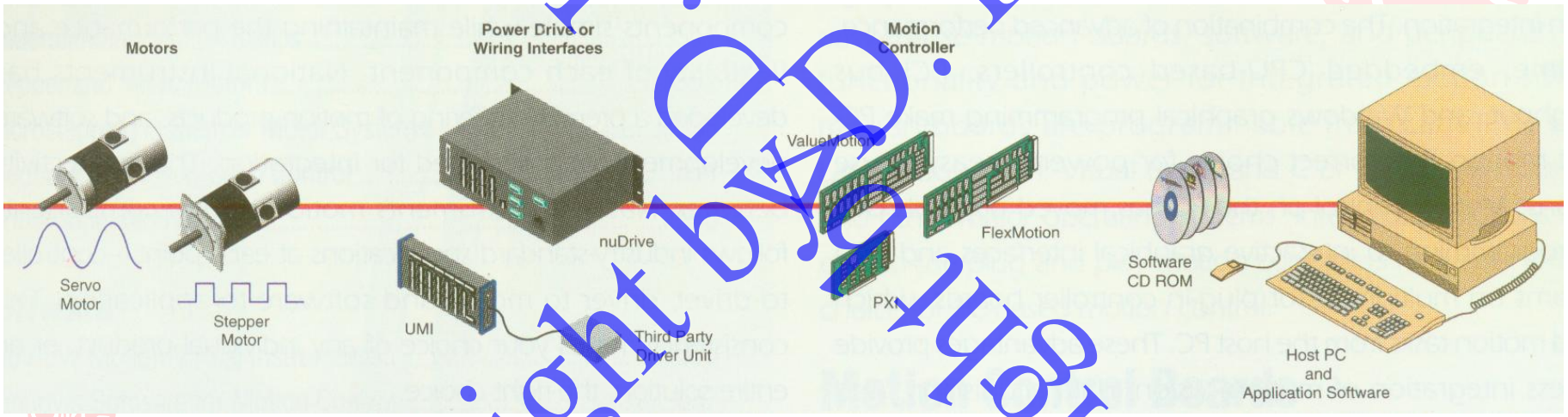


气象预报和环境监测

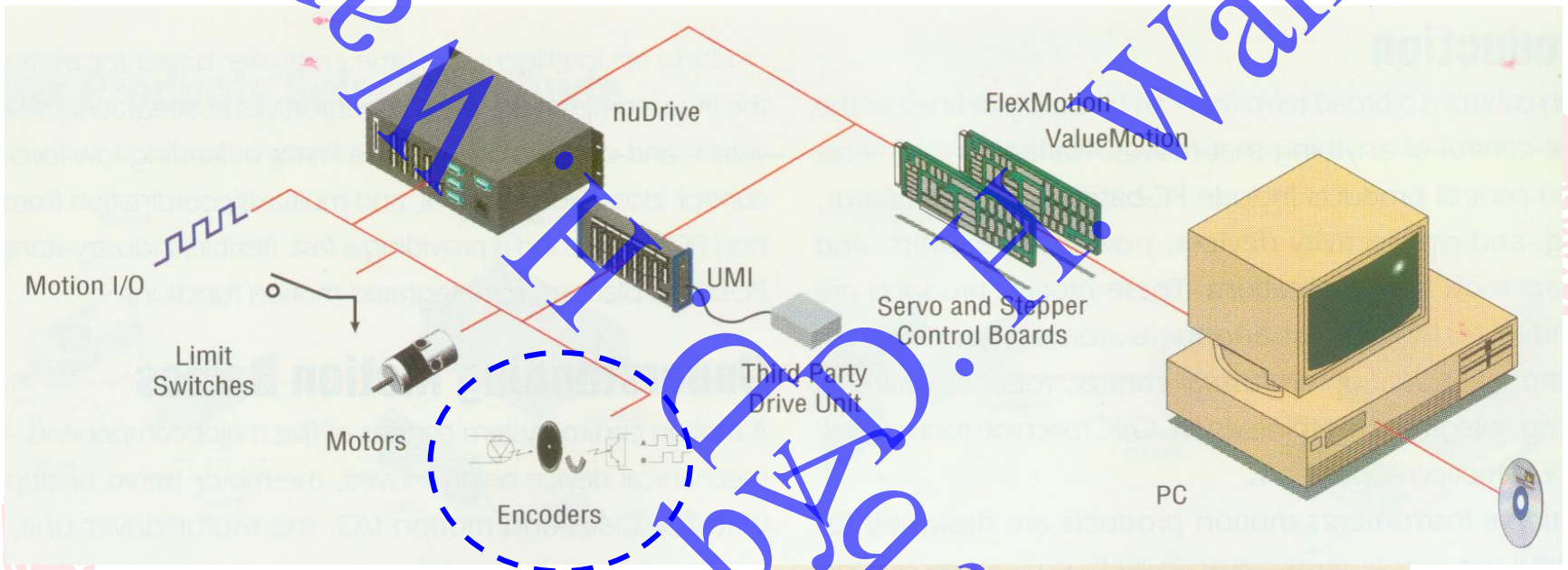
基因研究

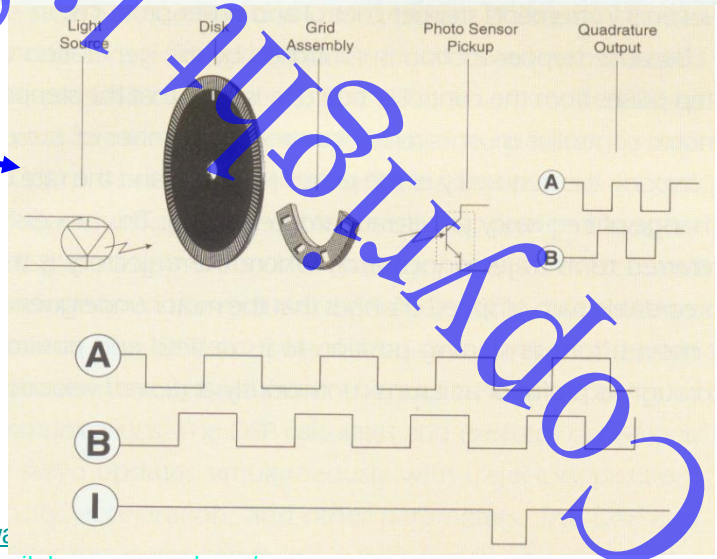
Control Instruments--Open loop

- 控制仪器与控制装置是针对控制对象按照生产要求设计制作的控制装置和自动调整与校正装置。



Control Instruments--Closed loop

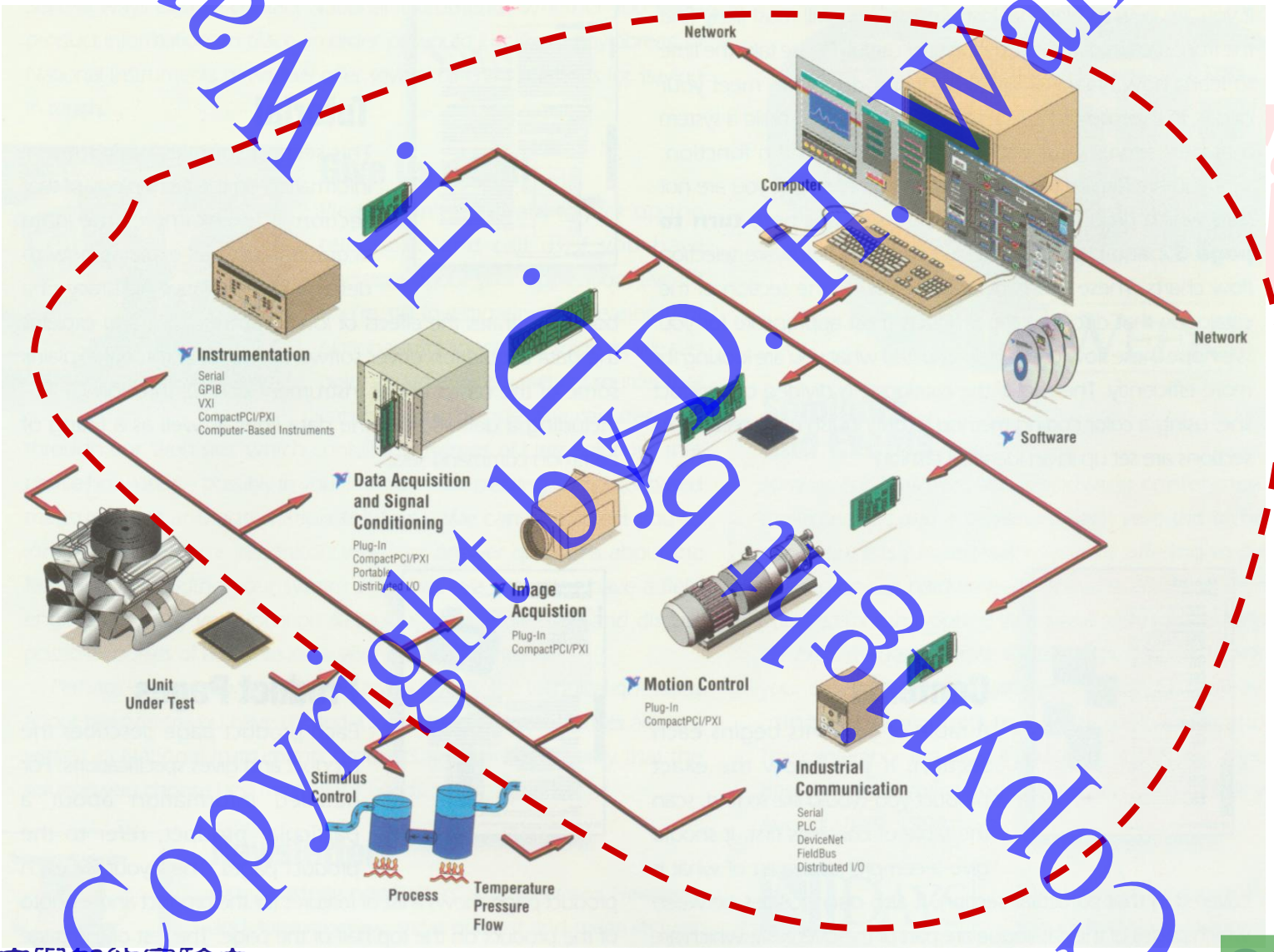




Instruments for Measurement and Control

- 在现代计量测试仪器中，测量与控制已经密不可分
  - 如在纳米测量技术中，精密工作台的纳米级精密定位必须采用带有检测装置的闭环控制系统，否则很难达到预定的高精度、高效率和高可靠性。
- 测控仪器/Measurement and Control Instruments
  - 利用测量与控制的理论，采用机、电、光各种计量测试原理及控制系统与计算机相结合的一种范围广泛的测量仪器。

Measurement and Control Instruments



The End

Thank you very much for your attention !

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URL: http://www.pilab.coe.cqu.edu.cn/