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SCIENCE & TECHNOLOGY

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CONTENTS

ADVANCED MATERIALS

BIOTECHNOLOGY

Policy on Technology Imports By Ordnance Industry Reviewed

[Text] Since the "Sixth Five-Year Plan" the ordnance industry has imported a large amount of technology and equipment. Industry trade integration, technology trade integration and many other forms were used in selective adoption. Most introduced items are of late 70's and early 80's levels. This has had a major effect on raising the level of China's ordnance industry products, expansion of production capacities, strengthening of testing and measuring methods and the training of workers.

It should be said that the work of ordnance technology importation has achieved substantial economic returns and social benefit. At the same time we must also look at some problems still existing from the previous period which require study and solution. The primary manifestations are rates of introduction of production lines and equipment which are too high while the rates of introduction of specialized technology are too low. Also, because of a lack of overall direction, there is duplication in the introduction of technology and technology digestion and absorbtion is slow.

The ordnance industry has its own unique characteristics. In times of peace, it shares many similarities with ordinary mechanical industries. Regarding the present ordnance industry technology importation work, it is still most important that it be based on profound reform and that policies and methods appropriate to it be chosen.

First, correct directions must be selected and plans formulated.

At present, technology adoption is beingput into practice under conditions of a substantial industrial and technological base and a substantial capacity for digestion and absorbtion. We should progress from the initial starting points and selection should be based on long-term development strategies for the ordnance industry technology and the economy. The important points should be: 1) The essentials of the weapons development strategy, which are those items critical to defeating an invading enemy in future wars, e.g., anti-tank and anti-aircraft weapons, neutralization weapons, tanks and armored vehicles, light weapons and complementary ammunition and photo-electronic instruments; 2) Elimination of areas of

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deficiency in ordnance technology; 3) Newly developed and key technologies, including measurement and testing technology and management technology; 4) Consumer product technology, which has decisive significance in making the ordnance industry and enterprises profitable; and 5) Technology and equipment which is important to the earning of foreign exchange through ordnance industry exports. The relative importance of these five items should be accurately stipulated then put into practice accordingly.

Second, in the integration of software and hardware, emphasis is to be placed on software.

In order to close the technological gap between the ordnance industry and the world standard as soon as possible, both software and hardware must be imported. In the integration of software and hardware, software is to be given priority. The scope of software technology is very broad and we must emphasize importing modern research and design methods, advanced testing methods, computation methods, and processing and managing techniques. For example, computer aided design (CAD), computer aided manufacturing (CAM), computerized engineering analysis (CAE), flexible manufacturing systems (FMS) and micro development systems (MDS), etc. These software technologies are all very different. We must import more advanced and applied technology based on our own foundation and abilities. At the same time, focal points are necessary. We must have those high-level technologies required by planned importation which can take a leading or driving role, and from this mastery of the world's advanced technologies and development and design techniques improve the scientific level of our industry and enterprises.

Third, integration and mutual compatibility of military and civilian needs.

When importing products to guarantee the requirements of the military, whether or not these products have any crossover civilian use must be fully considered. When importing products to ensure the needs of the people, whether or not potential exists for military utilization must be considered. When importing technologies, attention must be paid to crossover use between military and civilian products. Dual use of technology must be treated as an important policy. Dual use represents dual promotion and dual improvement as well as appropriate linkage and compatibility crossover.

Throughout the entire process of technology importation, careful and effective handling of the crossover between the technology of the defense industry and civilian technology can bring into full play the inherent advantages of defense industry technology, spuring the development by civilian industry of new areas of technology based on the original directions of the technology, advancing the technological progress of the entire society and the development of the national economy. Simultaneously, it would be possible to advance the establishment of a defense industry base, raise its standards, increase its returns, and improve its overall ability to meet an emergency.

Fourth, emphasize absorbtion and be creative.

Whether we can strengthen our independent developmental ability through technology importation, and rapidly progress technologically depends upon the degree of absorbtion of imported technology. It must be made clear that our objective in importing technology is not only to increase production capability during the period of importation or accelerate economic growth for a single period of time, but more importantly it is to further the assimilation of foreign technology. In this way, our S&T level can be raised and our ability to independently research, develop, and manufacture new products and new equipment can be strengthened. Strength can be accumulated and a foundation built for the long-term economic development of the ordnance industry. Regardless of whether we base our considerations on full utilization of benefits or on future economic growth, both require that much attention be paid to the work of assimilation, absorbtion and creation of new ideas. S&T management departments at all levels must regard this task as an important mission and actively participate in the demonstration of imported technology and in feasibility studies to confirm the quality of imported technology and equipment. The tasks of absorbtion, assimilation, and creation must become regular practice, firmly grasped and to which much attention is paid.

In the process of implementing assimilation, absorbtion, development, and creation of new ideas from imported technology, by what standards can we judge when we have achieved mastery, development and creation? Could they be considered as follows?

Mastery--Formulation of our own technological conditions or requirements, determination of feasible material substitution policies, mastery of the key technologies, determination through testing of which prototypes or samples meet the technical requirements for imported technology, steady commencement of batch production.

Development--As far as is allowable under contract provisions, imported technology can be applied in whole or in part to similar or different products, thus clearly raising the technical level of these products. Also, products with different specifications can be obtained through extended development based on imported product technology. Specialized products can be derived from general products, products for use in the air or on the sea can be derived from products intended for use on land. The technical level of these products is equal to that of imported technology.

Creation--With respect to product mix and material composition the changes are greater; functional improvement is greater; new breakthroughs exist in principles and mechanisms, etc.

Fifth, many sources of funding and policy encouragement.

Fund raising can be put into practice according to the following several methods.

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First, Ministries, Provincial (or Municipal) Offices (or Bureaus) of
Machinery, the Offices of the Commission of Science, Technology and Industry
for National Defense and related enterprises should establish a special
fund for assimilation, absorbtion, development, and creation based on
imported technology. Second, the proportion of scientific research funding
accounted for by funding for technology development should be appropriately
increased and the focal points of technology development funding changed
to technical reform, assimilation, and creation. Third, solution and
rational allocation of funding between technology importation and the
assimilation, creation functions must be stressed. At present, a common
phenomenon is having the money to import but lacking the ability to
assimilate. In the future, any importation project with an assimilation
or creation mission will have funding for those missions allocated simul-
taneously with funding for importation. Fourth, strive for the support
of financial departments. As regards equipment of major importance to the
military, critical needs of the national economy and items required in
accordance with development programs, we should fight to obtain loans from
banks at preferential interest rates with longer repayment terms.

Concerning importation of technology for the ordnance industry, relevant
and encouraging policies should be formulated.

Appropriate protective policies should be adopted and import taxes raised
to protect those domestic products which have reached a level comparable
to the international standard for similar products and for which there is
a substantial domestic production capacity, thus ensuring a market for
these newly created products.

Whether or not pricing is regulated, enterprises can independently set
prices during the testing period on any product determined by the planning
and management departments to have reached a level comparable to the
international standard and for which the domestication of production has
exceeded 80 percent. After the test-marketing period, formal pricing will
be fixed by price control authorities according to the limits of their
jurisdiction.

For tax revenue, a policy which fosters the new and limits the old should
be adopted. On those products developed and created from technology
importation, product taxation should be appropriately reduced during the
initial production period. Conversely, for those older products with less
advanced function, lower prices should be adopted, product taxes increased
and other methods utilized as restrictions.

For reward and encouragement, it is suggested that the following measures
be adopted:

First, in rewarding science and technology, increase the proportion of reward
which goes for technology importation, assimilation and creation. Thoroughly
change the past concepts which do not consider assimilation and creation
to be invention. The accomplishments of assimilation and absorbtion should
be treated as S&T accomplishment and should be eligible for S&T accomplishment

and development rewards. The results of development and creation should be eligible for rewards for invention. Also, in the future, a regulation should be made to the effect that enterprises can take a certain proportion of the first year's income from sales of any items of assimilation or creation listed in Ministry or Bureau programs, for use as special item bonuses. This would be calculated as a loss andnot taxed under incentive tax. This is to reward and encourage meritorious workers.

Second, when the process of assimilation, creation and domestication of production of imported technology causes profit to decrease and the decreases are examined and ratified by the financial departments, worker benefits and incentives should still be provided.

Third, a contract responsibility system can be implemented with respect to certain assimilated and absorbed items, e.g., testing and measuring instruments and equipment and dies. A contract program would be proposed by the enterprise and after ratification by project management, labor and wage departments, income to contractors would be exempt from incentive tax.

In addition to those methods listed above, information exchange should be improved to facilitate selection of the best programs and avoid repetition. Also, horizontal unification must be developed to extract the best, comprehensive results from importation of technology.

Development Strategy for High Technology in China's Colleges and Universities

[Article by Su Fei [5685 5481], et al., Jilin Industrial University]

[Summary] Research universities not only provide an appropriate environment for the maturation of scientists and technical specialists, they also provide enterprises with many scientific research accomplishments and technical resources.

The universities for which a role in high-tech research is planned are limited to those universities participating in the high-tech "national team" (which was formed by the organization of high-tech projects arranged by the State). These research universities, composing the country's principal force in scientific research, should proceed based on their actual strengths and areas of special competence. Without affecting the precedence of normal scientific research instruction, an elite capability should be concentrated to initiate high-tech development work.

Development of high-tech is a rigorous test of a university's scientific research management system. It requires conditions and an environment closely related to the "ten special features" of high-tech, in addition to the conditions necessary for development of ordinary scientific technology. For example: 1) The high yield, high efficiency and fast paced characteristics of high-tech require that research universities have a contingent of specialists dedicated to technology transfer work. 2) The highly competitive and highy intellectual nature of high-tech require that an ideal environment be provided by research universities for talented S&T personnel. 3) The high level nature, capital intensiveness and high risk involved with high-tech make necessary the rational selection and allocation of research capability (including personnel, materials and finances). 4) The high degree of interdisciplinary penetration and integration requires univerities to

seek out a unified scientific research system, i.e., an organic unification of universities, scientific academies and enterprises.

In an analysis of China's present university situation, the following positive factors are: 1) The universities have relatively strong foundations in the economy and scientific research, also they have strong S&T contingents; 2) they have the superiority of unified organizational management and overall planning; and 3) in the wake of China's thorough reform of its S&T system, the scientific research management systems of the universities certainly will gain further improvement as well as many methods to overcome defects such as the gap between research and production and low level research projects. Major negative factors are: 1) About one-third of the effort of research workers is wasted solving problems in project ratification, trial production and accountability procedures. 2) Funding is inadequate. 3) The risk involved with high-tech development dissuades many people from particiption out of fear that a long period without results may influence their reputation.

China's research universities can be divided into levels based on their capacity to develop high-tech. The strategy for those institutes of the highest level (universities which compose the "national team") is modeled in diagram 1, while the strategy for middle level institutions (key universities which are not members of the "national team") is modeled in diagram 2. The universities included in the third level (universities not classified as key institutions with weak research capability) can, based on the particular conditions of the institution, refer to the model in diagram 2.

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              ┌─────────────────────────────┐
              │     National High-Tech       │
              │ Projects, Investments, Plans │
              └─────────────────────────────┘
                            │
                   Committee of Experts
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Diagram 1

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              ┌─────────────────────────────┐
              │   National and Institutional │
              │        Circumstances         │
              └─────────────────────────────┘
                            │
                            ▼
              ┌─────────────────────────────┐
              │     Managing University      │
              │ Presidents--High-Tech Committee │
              └─────────────────────────────┘
                            │
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              ┌─────────────────────────────┐
              │  High-Tech Development Program │
              └─────────────────────────────┘
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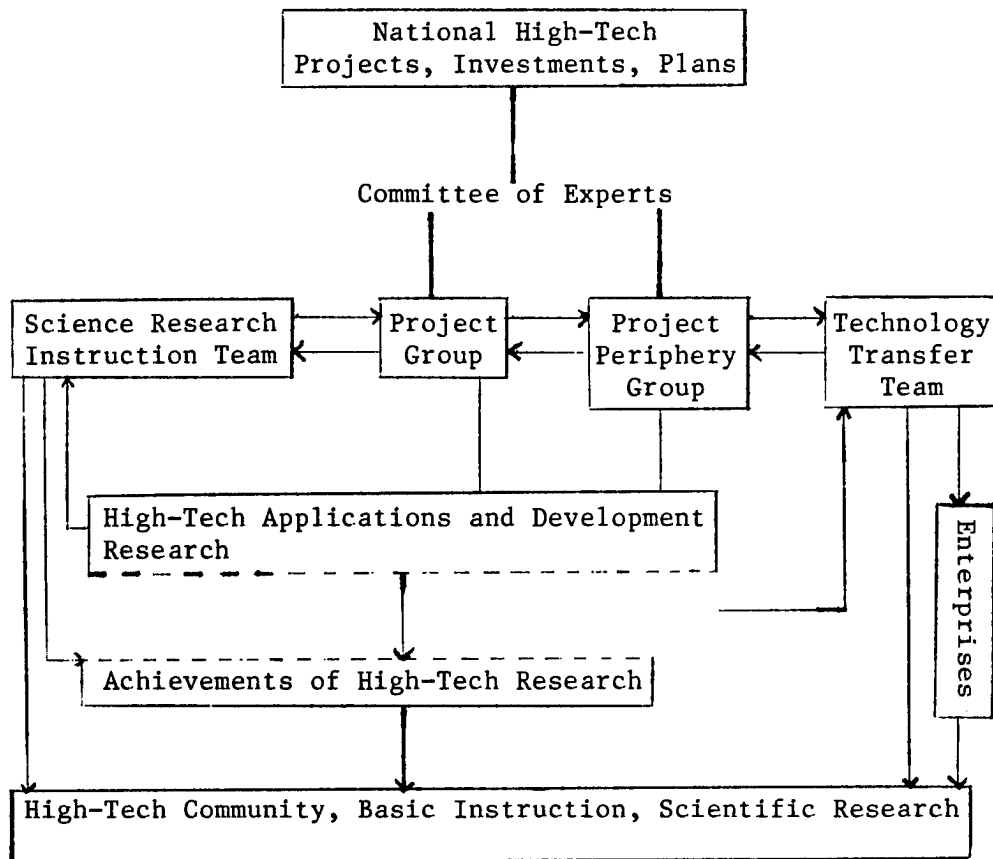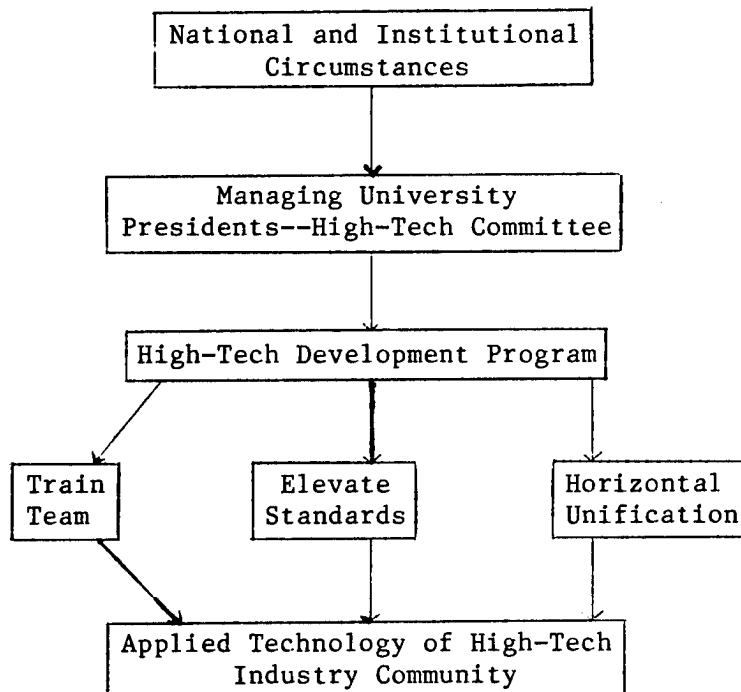
Diagram 2

Granting Research Institutes Power To Select Projects

[Article by Yi Shanfeng [2496 0810 6912] (China Geological Research Institute)]

[Summary] 1. Progress

The China Geological Research Institute (used as an example in this
article) has begun the following three reforms: 1) Reform of concepts:
Project selection will no longer depend on directives from above or
independent selection, but competition for projects will be based on
application for funding, competitive bidding on key projects and the
needs of carrying out production. 2) Reforms in the structure of
scientific research: In the "Sixth Five-Year Plan" 80 percent of the
projects were in basic or basic applications areas. This has been
changed to 50 percent in basic or basic applications areas and the
remaining 50 percent in areas directly serving national economic
construction (including manpower). 3) Reform of funding: During the
"Sixth Five-Year Plan" all funding for research projects came out of the
institute's operational funds and from funding for specialized topics
allotted from higher levels. Now, projects are funded with
appropriations apart from those allocated for administrative functions.

2. Problems

1) The research institute lacks authority to select research subjects.

A survey of 274 research institutes indicates that "the needs of
production organizations" and "the ease of obtaining funding" are the
two most important criteria in project selection. "The state of the art
in international S&T" and "the suggestions of managing departments" rank
at the bottom of the list of criteria. Because operational funding has
decreased and prices have increased, research institutes also lack the
financial ability to select projects themselves. This kind of situation
could encourage bureaucracy and pragmatism. It could also result in a
loss of initiative, foresight and diversification.

2) Investment rates are low.

Low investment rates have had the following two results: Project departments and research institutes both lack funds to upgrade instruments and renew facilities. Funding is inadequate to support the projects, forcing some S&T workers to seek new contract work to compensate. However, this increases the work-load and creates new funding deficiencies.

3) Difficulties in primary areas of concentration.

Some objectives have been set high, while financial pressure is heavy and competitive conditions are unequal. Compared with the "Sixth Five-Year Plan" the number of people apparently working on key projects during the "Seventh Five-Year Plan" has increased. But due to personnel working in other areas to compensate for funding shortages, the actual number working in key projects is only 54 percent of that during the "Sixth Five-Year Plan" period.

4) Intermediate links in development are lacking.

In order to meet the needs of reform, earning income and deregulation and to overcome shortages of funding, research institutes are utilizing some of their energies in S&T development. However, they lack the many intermediate links necessary to developing products which exploit the value of S&T. At the same time developmental personnel and funding are both inadequate.

3. Suggestions

Our institute should strive for more projects and more funding to develop the economy, science and ourselves. Simultaneously, we should concentrate on major problems in national construction which other departments have not thought of or cannot handle. Also, we should actively focus on advanced long-term development problems in science and economic construction. This should be emphasized by the leadership and actively arranged for the following reasons: 1) The Chinese Academy of Sciences has people highly skilled in development and many advanced accomplishments. 2) The funding provided to research institutes should be increased to arrange major problems and advanced projects in coordination with important missions. This can wait no longer. 3) In the "Sixth Five-Year Plan," the reforms and methods used were clearly effective.

State funding and delegation of decision-making authority to research institutes should be gradually implemented. Only in this way can the strengths of the Chinese Academy of Sciences be more fully utilized.

Study of Self-Tuning α-β Filter to Improve Tracking Accuracy of Maneuvering Targets

[English abstract of article by Liu Yongtan [0491 3057 0982], et al., of Harbin Institute of Technology]

[Text] From the point of view of engineering application, this paper proposes an approach toward designing a self-tuning α-β filter based on Reference 1. Therefore, from both aspects of filter structure and parameter matching, it successfully solves the problem of maneuvering target tracking accuracy. The simulation results achieved with an IBM/AT computer using 8087 assembly language indicate that not only is this method simple and demonstrating acceptable performance, but it also is nearly twice as accurate as the one employing the constant gains α-β filter.

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Nonlinear Time-Optimal Control of Spacecraft Large-Angle Attitude Maneuvers With Reaction Wheels

[English abstract of article by Jin Liang [6855 2733] of Beijing Institute of Control Engineering]

[Text] In this paper, the nonlinear attitude dynamic model is obtained and the dynamic equation is represented by the angular velocity and the vector of the Euler quaternion. Then, a global linearizing coordinate is transformed into an equivalent controllable linear system. The time-optimal control law for motor torques of reaction wheels is designed and the calculations of the maneuver time and system state are given. Finally, digital simulation is illustrated.

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Numerical Calculation of Hypersonic Nonequilibrium Viscous Shock-Layer Flow
Over Slender Body With Blunt Nose

[English abstract of article by Shen Jianwei [3088 1696 0251], et al., of the
National University of Defense Technology]

[Text] In this paper, the numerical method is studied to calculate the
hypersonic nonequilibrium viscous flow over a slender body with a blunt nose.
The details of solving the continuity equation and normal momentum equation
jointly are described, as well as is the mathematical method of dealing with
slip boundary conditions at high altitude. The results of the numerical
solution indicate that the method is successful for approaching the afterbody
region about 30 times greater than the nose radius.

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Optimal Guidance Law With First Order Lag Loop for Bank-to-Turn Missile

40090031d Beijing YUHANG XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 3, 31 Jul 88 pp 30-38

[English abstract of article by Luan Zewei [2940 3419 1218], et al., of Harbin Institute of Technology]

[Text] An optimal guidance law for a BTT missile based on the minimum principle is discussed in this paper. It is assumed that the kinetic characteristics of the autopilot and airframe are that of a first order lay loop. The target maneuvering and the attitude of the body are studied. The linear moving equations of the target relative to the missile are obtained by linearizing the state equations at the operating point. The quadratic performance index is the minimum miss distance and controls energy consumption.

Based on the assumptions, an optimal intercept guidance law with the pitch acceleration and roll rate as control variables for a BTT missile has been deduced.

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Difference Scheme With Autocontrol Artificial Viscosity to Predict Ablated Nosetip Shape

[English abstract of article by Yang Maozhao [2799 5399 2507] of China Aerodynamic Research and Development Center]

[Text] The triple layer explicit difference scheme, to which has been added an artificial viscosity item, is found by using filtration in the computation of the ablated nosetip shape. The scheme is of first order accuracy in regions where the shape change is wavy and of second order accuracy in regions where it is smooth. Numerical experiments show that the scheme is effective.

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Study of Pretreatment, Superplasticity of Industrial Superhigh Strength Aluminum Alloy LC9

[English abstract of article by Yang Jinfeng [2799 6855 7685], et al., of Harbin Institute of Technology; Wang Yonghai [3769 3057 3189] of Northeast Light Alloy Fabrication Plant]

[Text] Through two pretreatment methods, the industrial superhigh strength aluminum alloy LC9 demonstrated good superplasticity in a certain temperature range and at a certain strain rate. By means of thermo-mechanical treatment (TMT) and a simple forging treatment, under different optimum conditions ($T_{TMT} = 515°C$, $\dot\varepsilon_{TMT} = 1.66 \times 10^{-3}$ S^{-1}; $T_f = 405°C$, $\dot\varepsilon_f = 1.66 \times 10^{-3}$ S^{-1}), the results were as follows: elongation $\delta_{TMT} = 1300$ percent, $\delta_f = 380$ percent, flow stress $\sigma_{TMT} = 1.7$ MPa, $\sigma_T = 16$ MPa, strain rate sensitive index $m_{TMT} = 0.66$, $m_f = 0.3$. When the thermo-mechanical treatment was used, the dispersion of the η phase played an important role in obtaining a fine-grained microstructure, while the resolution of the η phase reduced the cavity sensitivity of the material and restrained the early fracture of the specimen. Through the TMT process and forging process pretreatment, the fracture forms were of the unstable cavity type and stable necking type, respectively.

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Power Division, Optimum System Design Method of Dual-Frequency System

[English abstract of article by He Zhenghua [0149 2973 5478] of Shanghai Institute of Satellite Engineering]

[Text] The dual-frequency system consists of three subsystems, i.e., coherent dual-frequency Doppler tracking, data transmission and telemetry. It has been widely used in the field of space flight and is currently still in use. However, some parts of its theory, as well as the optimum system design as shown in this paper, have never appeared in the published literature. This paper presents the concept and equations for: (1) Composite (random) error of a dual-frequency range rate system resulting from the high frequency channel is absolutely predominant; (2) optimum power division and optimum design method of the dual-frequency range rate system, saving the precious satellite power of improving the range rate measurement accuracy; (3) optimum power division for a dual-frequency system for the same goal of saving power or improving the accuracy of the respective subsystems; (4) the optimum design method for a dual-frequency system, including a very fast and convenient graphic method.

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China Launches Its First Meteorological Satellite

40080070a Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE MAGAZINE] in Chinese
No 10, Oct 88 p 2

[Text] On 7 September, at 5:30 Beijing daylight saving time, China
successfully launched its first experimental meteorological satellite into
a near-circular sun-synchronous orbit; all equipment onboard the satellite
functioned normally.

This satellite, named "Fengyun-1," was launched from the Taiyuan Satellite
Launch Center by a "Long March-4" launch vehicle. It was the first polar-
orbit meteorological satellite built and launched by this country. The
satellite is equipped with two ultra high resolution scanning radiometers
with five detection channels. It has the capability of detecting cloud
images, ground surface images, ocean water color images, boundaries between
bodies of water, ocean surface temperatures, ice and snow cover, and
vegetation growth both in daylight and during nighttime. The satellite's
main mission is to acquire global weather information and transmit the
data to satellite ground stations around the world. In addition, it is also
capable of detecting particle contents in space to provide data for space
physics research. Since the "Fengyun-1" became operational, China's weather
forecast capability, particularly in the area of monitoring and forecasting
destructive weather movement, has been greatly enhanced. Therefore, this
satellite plays an important role in providing service to China's economic
development.

The "Long March-4" launch vehicle is a three-stage rocket which uses
conventional propellant; it is primarily used to launch large satellite
payloads into mid-to-low altitude orbits. They include sun-synchronous
satellites which are widely used for weather and ocean observations and
resource exploration. Many of China's new space technologies have been
implemented on the "Long March-4" to improve its rocket engine design,
its digital circuit design, and in its first and third sub-stages to provide
the launch capability of large-diameter satellites.

Weather Satellite Returns Photographs

40080070b Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE MAGAZINE] in Chinese
No 10, Oct 88 p 2

[Text] On 7 September, at 7:09 Beijing daylight saving time, China's weather
satellite returned its first photograph of cloud images.

It was a photograph taken above the Soviet Union and the Asian landmass.
The picture showed clearly visible details which reflects the good technical
performance of China's first sun-synchronous polar-orbit satellite. Each
day, three satellite ground stations located at Beijing, Guangzhou, and
Urumqi can receive data from the satellite during its 6 to 8 passes over
these regions. These data are processed by the Satellite Weather Center to
produce timely pictures of cloud images, cloud analysis diagrams, and surface
feature maps to the user. Such information greatly enhances China's
capability in monitoring destructive weather movement and improves the
timeliness and accuracy of weather forecast.

Scientific Probe and Technical Experiment Satellite

40080070c Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE MAGAZINE] in Chinese
No 10, Oct 88 p 2

[Text] On 5 August at 16:30, a scientific probe and technical experiment
satellite was launched from the Jiuchuan Satellite Launch Center. The
satellite was successfully injected into the designated orbit and all
on-board equipment functioned normally. After completion of its mission,
the satellite will be returned to earth as planned.

Also carried onboard the satellite were the experiments of three West
German users. This was the second time satellite service was provided to
a foreign user by a Chinese satellite since the micro-gravity experiment
conducted last August for the French Matra Company.

China's Heavy Launch Vehicles

40080070d Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE MAGAZINE] in Chinese
No 10, Oct 88 p 2

[Text] China is currently developing three new rockets of the "Long March"
family to provide greater launch capabilities. By the early 1990's, these
launch vehicles will be able to provide the service of launching various
domestic and foreign commercial satellites. This information was revealed
in late August by the director of the No 1 Research Institute of the
Ministry of Aeronautics and Astronautics, Wang Yunzi, and the chief design
engineer of the "Long March-3," Xie Guangxuan.

In order to accommodate the launch requirements of domestic and foreign
commercial satellites, the No 1 Research Institute of the Ministry of
Aeronautics and Astronautics have initiated a plan to develop new launch
vehicles and to improve existing launch vehicles.

The three new launch vehicles being developed are:

The "Long March-3A" rocket, which is based on the "Long March-3" design;
it has a geosynchronous transfer orbit (GTO) payload capability of 2,500 kg.

The "Long March-2E" rocket, which uses the new rocket strapping technology.
It consists of 4 booster rockets strapped to the main body of "Long March-2."
It has a low-orbit payload capability of 8,800 kg.

A new three-stage launch vehicle, which combines two "Long March-2E" rocket
with the third stage of the "Long March-3." It has a GTO payload capability
of 4,500 kg.

The improved launch vehicles include:

The "Long March-1D" launch vehicle, which is an improved version of the
"Long March-1"; it has a low-orbit payload capability of 700 to 750 kg.

Experts believe that based on China's current rocket technology, it is
possible to carry out the above plan without difficulty.

High-Altitude Experimental Balloons

40080070e Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE MAGAZINE] in Chinese No 10, Oct 88 p 3

[Text] After 10 years of dedicated efforts, China has now established a high-altitude scientific balloon system. It has the capability of producing and deploying balloons smaller than 200,000 cubic meters. Currently, efforts are under way to develop systems for deploying 300,000 to 400,000 cubic meter balloons.

Over the past 10 years, the Chinese Academy of Sciences has deployed 150 high-altitude balloons to conduct dozens of experiments in the areas of cosmic rays and high-energy astro-physics, atmospheric physics, space astronomy, space physics, remote sensing, and space chemistry.

In the area of high-energy celestial physics, Chinese scientists have succeeded in using high-altitude balloons to make observations of pulse neutron stars for the first time. The measured data on hard X-ray spectrum of the Cygnus X-1 have attracted considerable attention in the scientific community. In the area of infrared astronomical observations, the infrared brightness temperature of the sun was measured for the first time. In the area of space chemistry, high-altitude balloons have helped Chinese scientists obtain valuable samples of cosmic dust.

Determination of Hydrogen, Deuterium, Tritium, Helium, Oxygen, Nitrogen, Carbon Monoxide in Gas Mixture by GC-GCMS

[Article by Deng Zhongguo [6772 0022 0948], Lin Zhihao [2651 1807 6275] and Lai Yunxiang [6351 6663 7013] of the Institute of Atomic Energy, Beijing, and Jing Kangcai [5427 1660 2088] and Wu Runxian [0702 3387 0341] of P.O. Box 345, Chengdu, Xichuan: "Analysis of Hydrogen and Helium Isotopes and Oxygen, Nitrogen and Carbon Monoxide with GC-GCMS"]

[Text] This paper describes the use of capillary gas chromatography (GC) and gas chromatography - mass spectrometry (GCMS) with neon carrier gas to simultaneously analyze hydrogen and helium isotopes, oxygen, nitrogen and carbon monoxide with high accuracy. The sample size is 10 ul and the accuracy is 1.5 - 2.0 percent. The atomic to molecular ion ratios for HD, HT and DT were measured with GCMS. It was found that the atomic ion to molecular ion ratios of the isotopes are unequal. The effect of CO on the separation characteristics of the low temperature GC column was observed.

I. Analysis of Gas Mixture of Hydrogen-Helium Isotopes and Characteristics of GCMS

The difficulty in analyzing the contents of a gas mixture containing hydrogen, deuterium, tritium, helium, oxygen, nitrogen and carbon monoxide is in the determination of the hydrogen-helium isotopes. GC and MS are the primary methods used to measure these isotopes[1,2]. With GC a thermal conductivity pool gas chromatography is used and with MS either a low or high resolution mass spectrometer is required. Neither GC or MS can totally solve the analysis of these isotopes. Although the six components of the hydrogen isotopes can be separated by GC, yet the sensitivity for each component is different. A known standard is required for calibration in order to obtain quantitative results. The two helium isotopes cannot be separated GC, resulting in low sensitivity and large error. The advantages of MS include

sensitivity, accuracy, wide concentration range and identical
sensitivity to all six hydrogen isotope compositions. However, the
molecular and atomic ions of these isotopes and helium ion will form
several doublets in the mass spectrum. To analyze these doublets will
require the knowledge of thermal equilibrium constants. Some thermal
equilibrium constants cannot be accurately measured. It is also
difficult to determine precisely whether a sample is in equilibrium or
the status of the sample is altered in the analysis. Therefore, the
error associated with the thermal equilibrium constants is high.
Although a high resolution mass spectrometer (resolution > 1300) can
separate some doublets, however, certain doublets (such as $T^{-3}He$) cannot
be separated. Hence, it is very difficult to simultaneously measure the
contents of hydrogen and helium isotopes. In addition, it is relatively
complicated to prepare sensitivity curves for such mixtures using MS.
One of the difficulties in using MS alone is that the hydrogen, nitrogen
and oxygen background levels are high and they fluctuate widely in the
mass spectrometer.

Due to these reasons, we are using GC in parallel to GCMS. GCMS is used
to measure the contents of hydrogen and helium isotopes and GC is used
to determine the contents of oxygen, nitrogen and carbon monoxide. A
shunt is used to divert most of the sample to the GC to compensate for
its low sensitivity and a small amount of the sample goes into the GCMS.
Because the GC column in the GCMS can separate the six hydrogen isotope
components, the mass spectrometer is provided with a single component
sample to avoid doublets in the mass spectrum. Moreover, we can take
advantage of the mass spectrometer which has high sensitivity, accuracy
and identical response to the six hydrogen isotope components. Thus,
GC-GCMS has two outstanding advantages. The first is high sensitivity.
With a 10 µl sample, the accuracy can reach 1.5 - 2.0 percent. The
concentration range is 0.1 - 100 percent. The hydrogen background is
low. The second is that hydrogen, helium, oxygen and nitrogen can be
simultaneously measured with one sample.

II. Key Problems with GC-GCMS

Two problems must be resolved before GC-GCMS can be used to measure the
contents in the mixture. One is to develop a GC which can be linked to
a mass spectrometer and the other is to synchronize the GC peak with the
magnetic field scanning and ion beam recording of the MS.

1. Construction of the GC System

The capillary column C that is directly connected for GCMS analysis must
meet the following requirements. (1) It should use a low temperature
metallic capillary column with the proper resistance and separation
characteristics. (2) There should be no flow restriction and dead
volume between the sampling port and the ion source. (3) It should
have a good vacuum seal.

(1) Fabrication and activation of the low temperature capillary column

The direct connection of GCMS depends upon the flow restriction in the capillary column. The capillary tube should be long and filled evenly to create a large but uniform pressure drop for the carrier gas between the inlet and outlet of the tube.

The capillary tube used to separate hydrogen isotopes is a 0.4 mm inner diameter x 9 m glass capillary[7] which has good separation characteristics. A 0.4 mm inner diameter x 20 m glass capillary filled with Al_2O_3 (Fe_2O_3) was also used in this work. However, it was found to be difficult to have a vacuum connection. In addition, it breaks easily and is not suitable to analyze radioactive sample. Therefore, the low temperature GC columns were made with 0.6-0.8 mm inner diameter, 1-1.5 m long stainless steel capillary tubes.

The major difficulty in the fabrication of metallic capillary column is filling. The following method was used to fill it with 120 mesh packing material.

(a) Both ends of the tube were enlarged to facilitate the filling.

(b) The filling was done in two sections to reduce the travel distance. A 0.5 mm diameter tungsten wire was inserted half way into the column. After one half of the tubing was filled, the tungsten wire was removed to fill the other half.

(c) A vacuum pump was used to pull a vacuum in the tubing to increase the mobility of the packing material.

(d) It was filled several times with a small amount of packing material each time.

After the column was packed, the quality of the packed column was checked with the carrier gas. The GC column was activated at 200-250°C and separation characteristics of the six hydrogen isotopes were used to check and control the activation time.

(2) Flow restriction and dead volume are not permitted in the tubing.

(3) Vacuum check

The vacuum seal of the GC system was checked by a helium leak detector. If the GC system can keep a good vacuum, it is easy to connect it to a mass spectrometer.

2. Scanning and Ion Beam Collection in the MS

Since it is a quantitative measurement, the accuracy requirement is high. It is not acceptable to record a fast scanning multi-ion chromatographic spectrum. Mass pre-selectors are used and calibrated at the peaks of those molecular ions of interest. After the GC peak corresponding to a certain mass is recorded, the instrument immediately jumps to the next pre-selector to record another GC peak until all the GC peaks are recorded.

III. Experimental Apparatus and Method of Analysis

1. Experimental Apparatus
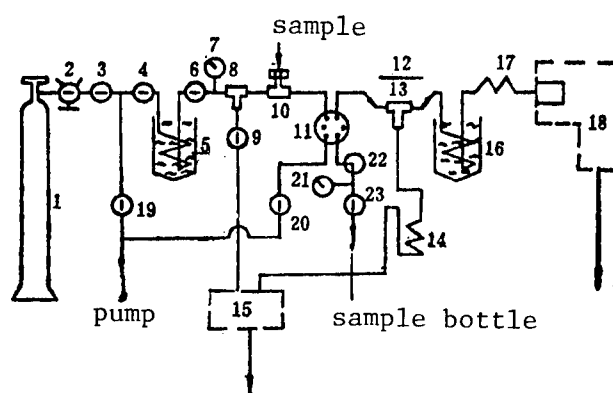
Figure 1. Flow Diagram of the GC-GCMS System

1- neon carrier gas cylinder; 2- pressure reduction valve; 3- fine adjustment valve; 4,6,19-23- two-way valves; 5- activated charcoal liquid nitrogen trap; 7- vacuum gauge; 8- carrier gas flow divider; 9- fine adjustment vacuum valve; 10- sampling port; 11- six-way valve; 12- shunt; 13- sample splitter; 14- constant temperature column; 15- thermal conductivity GC; 16- low temperature capillary column; 17- GCMS connector; 18- mass spectrometer.

The experimental apparatus and flowchart are shown in Figure 1. The operating conditions of the apparatus are briefly described as follows:

(1) Low temperature metal capillary column: spirally coiled stainless steel capillary tubes 0.8 mm ID x 1.5 mm and 0.6 mm ID x 1.0 mm.

(2) Constant temperature column: 2.0 mm ID x 1.0 m stainless steel column filled with 120 mesh 5 A molecular sieve which was activated in vacuum for 3 - 4 hours prior to use at 350°C.

(3) Sampling port: consisting of a sample injector and a six-way valve which is at 2.67 Pa in vacuum.

(4) Small thermal conductivity pool: stainless pool with a 20 μl effective volume, 100 ohm tungsten resistor, 200 μA operating current at room temperature.

(5) GCMS connector: 0.6 mm ID x 1.5 m stainless steel capillary tube.

(6) Mass spectrometer: a Model CH4 mass spectrometer is used in the GCMS with a gas source, 20 μA electron beam, 30 and 70 eV energy, 3 kV ion acceleration potential, mass pre-selector peak recorder, and Faradaic cylinder to collect static charge. A 120 1/min vacuum pump is used as the pre-pump.

2. Method of Analysis

The analysis process is shown in Figure 1. The neon carrier gas passes through the cylinder (1), pressure reducing valve (2), and fine adjustment valve (3) and enters the activated charcoal liquid nitrogen trap (5) to remove water vapor and organics from air. The purified neon passes through valve (6) and its pressure is measured by vacuum gauge (7). A flow divider (8) is used to let a portion of the carrier gas into the thermal conductivity reference cell through the fine adjustment vacuum valve (9). The other portion goes into the sampler (10). The sample is introduced through the sampler or a six-way valve (11). It goes into the sample splitter (13) with the carrier gas. When GC measurements are not made, connector (12) is added to allow most of the sample to enter the constant temperature chromatography column (14) to be measured by the thermal conductivity GC (15). A small portion of the sample flows into the low temperature column (16) and then enters the mass spectrometer (18) through connector (17). The entire analysis simultaneously determines the concentrations of hydrogen, deuterium, tritium, helium, oxygen and nitrogen with one sample.

IV. Experimental Results

1. Selection of Carrier Gas Flow Rate

Table 1 shows the relation between carrier gas flow rate, column pressure, vacuum in the ion source of the mass spectrometer, and times at which peaks for hydrogen and helium isotopes to appear. As shown in Table 1, the times for hydrogen isotopes to appear are moved forward at a higher flow rate. However, the vacuum in the ion source becomes poorer as the flow rate increases. Therefore, the carrier gas flow rate was fixed at 1.1 ml/min to ensure long term stable operation of the mass spectrometer.

Table 1. Carrier Gas Flow Rate, Column Pressure, Vacuum and Times for Hydrogen, Deuterium, Tritium and Helium Peaks

carrier flow rate ml/min	column pressure 10^5 Pa	vacuum 10^{-3} Pa	peak appearing time			
			He	H_2	HD	D_2
1.0	1.07	2.00	4' 10"	54'	69'	92'
1.1	1.17	2.93	4'	48'	67'	89'
1.2	1.37	3.33	3' 10"	44'	62'	87'

2. Separation of Hydrogen, Helium, Oxygen and Nitrogen

The GCMS carrier gas flow rate is 1.1 ml/min and the GC carrier gas flow rate is 6.0 ml/min. The results are shown in Figure 2. It was found in the separation of hydrogen isotopes that if the CO content in the sample exceeded 5 percent the activity of the low temperature chromatography column would decrease due to temporary poisoning by CO. After the sample passed by, the activity was restored. Figure 3 shows the chromatographic peaks of HT and D_2 with 5 percent CO and without CO.

3. Determination of Ratio of Atomic Ion to Its Parent Molecular Ion

The atomic ion to molecular ion ratios for the six hydrogen isotopes were measured by GCMS at 30 eV and 70 eV. The chromatographic peak of T^+/DT^+ is shown in Figure 4. The measured and theoretical results from GCMS and the MS data from abroad are shown in Table 2[2,8]. The value in parenthesis is not measured. It is calculated based on the ratios of H_2, D_2 and T_2 under the assumption that the atomic ion to molecular ion ratios for the two isotopes are identical. The D^+/DT^+ ratio in the table was measured in a high tritium content tritium/deuterium mixture where D_2 was neglected[8]. Obviously, ratios for HD, HT and DT cannot be directly measured. We also found that in HD, HT and DT the atomic ion to molecular ion ratios for any two isotopes are not equal. This is probably because the lighter atom has high mobility than the heavier one in the dissociation or ion-molecule reaction, thus producing more lighter proton clusters. The measurement of the atomic ion to molecular ion ratios for HD, HT and DT and the fact that they are unequal have not been reported in the literature to date.
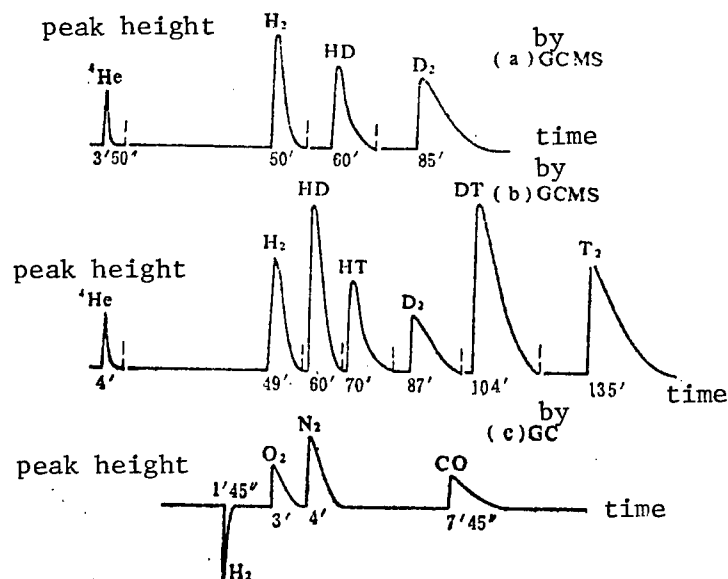
Figure 2. Separation Spectra

(a), (b) GCMS chromatographic peaks for hydrogen, deuterium, tritium and helium; (c) GC peaks for O_2, N_2 and CO.
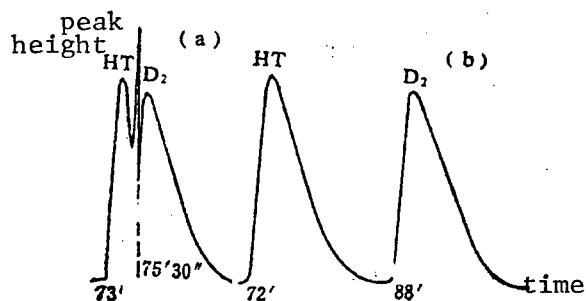
Figure 3. Chromatographic Peaks for HT and D_2

(a) Sample with 5 percent CO   (b) Sample without CO
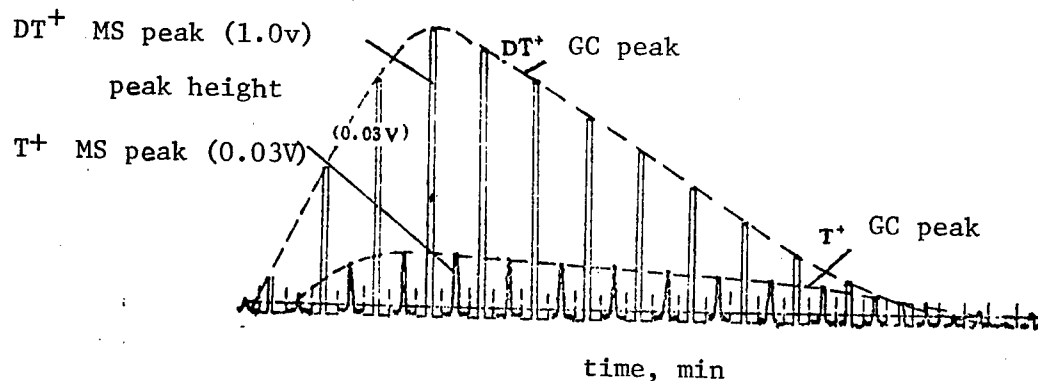
Figure 4. GCMS and GC Peaks for T^+ and DT^+

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Table 2. Atomic Ion to Molecular Ion Ratios for H_2, HD, HT, D_2, DT and T_2

electron energy, eV	method	ratio, ×10⁻²								
		$2H^+/H_2^+$	H^+/HD^+	D^+/HD^+	$2D^+/D_2^+$	H^+/HT^+	T^+/HT^+	D^+/DT^+	T^+/DT^+	$2T^+/T_2^+$
70	GCMS	1.48	·0.45	0.95	0.99	0.32	0.66	0.22	0.40	0.44
30	GCMS	1.27	0.41	0.85	0.70	0.27	0.50	0.19	0.32	0.36
30	theoretical	1.60	(0.54)	(0.54)	0.72	(0.39)	(0.39)	(0.26)	(0.26)	0.38
30	MS	1.30	(0.48)	(0.48)	0.70	(0.34)	(0.34)	(0.25)	(0.25)	0.36
30	MS							0.20		

4. Sensitivity Curves

(1) GCMS Sensitivity Curves

The sensitivity curves for various components are described as follows

(a) Sensitivity curves for samples containing H, (H,D) and H, D, T).

As shown in Figure 5, GCMS has the same sensitivity to these three types of samples. This curve can be used to calculate the abundance of hydrogen isotopes. It can also be used to determine the contents of hydrogen isotopes in a mixture. After the instrument is calibrated with a high purity hydrogen sample, the contents can then be measured.
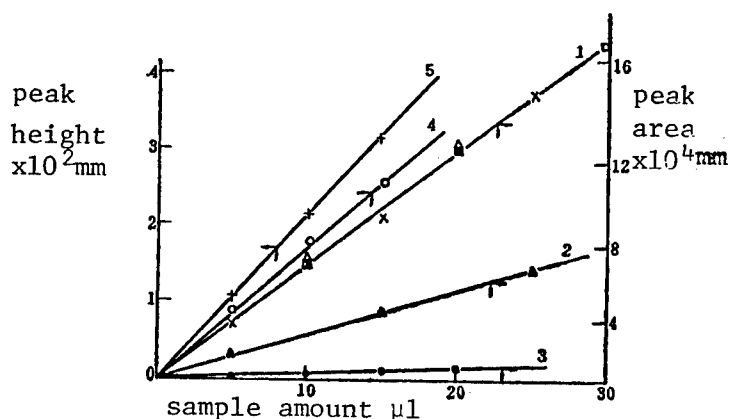
Figure 5. Sensitivity Curves in Measuring Hydrogen and Helium with GCMS and Measuring O_2 and N_2 with GC

▲, ● – He sample; x – H sample; Δ – HD sample; ▢ – HDT sample; ⊙ – O_2 sample; + – N_2 sample

(b) Sensitivity Curve for He Sample and Shunt Ratio

The sensitivity curves for the He sample were determined by GCMS before
and after the GC was connected to the GCMS, as shown in Figure 5. The
slopes of curves (2) and (3) were used to calculate the ratio of sample
going into the GC to that going into the GCMS. It was determined to be
5.1 : 1.

(2) Sensitivity Curves for Measuring O_2 and N_2 with GC

The sensitivity curves for measuring O_2 and N_2 with GC after the GC was
connected to the GCMS are shown in Figure 5.

(3) H to He Sensitivity Ratio

The hydrogen to helium sensitivity ratio can be calculated from curves
(1) and (2) in Figure 5, which is 2.70. The theoretical value (from
ionization efficiency) is 2.65.

5. Analysis of Hydrogen-Deuterium Samples

GCMS was used to analyze binary samples containing H and D. The results
are shown in Table 3 together with the data obtained with MS. The
accuracy of measurement is 1.5 percent and the two methods are
consistent.

Table 3. Determination of H and D Contents in Binary Samples Containing
H and D.

content, percent	GCMS value									MS value
	1	2	3	4	5	6	7	8	mean	
H	11.60	11.73	11.29	11.38	11.32	11.52	11.69	11.59	11.51±0.16	11.60±0.12
D	88.40	88.24	88.71	88.61	88.66	88.47	88.31	88.40	88.47±0.16	88.37±0.14

6. GC-GCMS Measurement of Mixed Samples

Mixed samples with hydrogen, helium and nitrogen were analyzed by the
GC-GCMS system. A 10 μl sample was introduced into the sampler. The
nitrogen content was determined by GC and the hydrogen and helium
contents were measured by GCMS. Figure 6 shows the spectra. The
contents of various components are shown in Table 4. The accuracy of
measurement is 1.5 - 2.0 percent.

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Table 4. Composition of Mixed Samples (percent)

No.	³He	H	D	T	N
80	0.94	0.51	58.65	33.44	6.50
81	1.01	0.48	58.68	33.32	6.49
82	0.96	0.49	58.53	33.62	
83	0.96	0.49	58.62	33.40	
mean	0.97±0.03	0.49±0.01	58.61±0.12	33.43±0.13	6.50
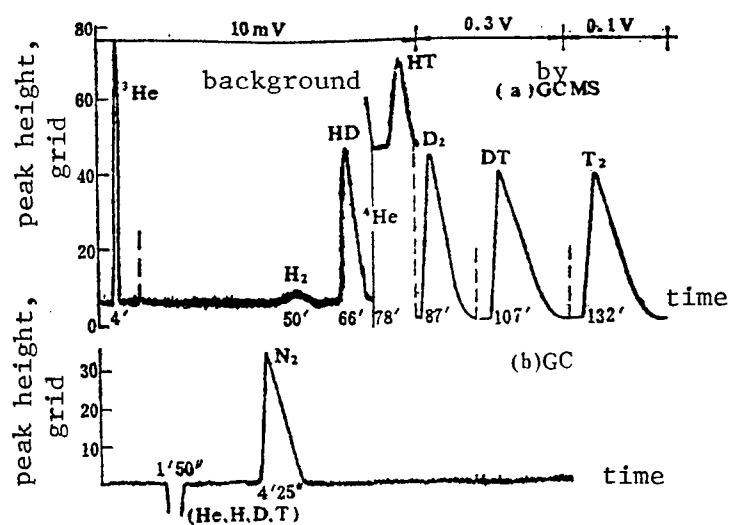
Figure 6 Chromatographic Peaks for a Mixed Sample

V. Conclusions

1. GC-GCMS is a new technique capable of determining hydrogen and helium isotopes, as well as oxygen and nitrogen, in a mixture. It requires a small amount of sample, and is accurate and reliable. In addition, it is a direct measurement.

2. The atomic ion to molecular ratios for HD, HT and DT were reported for the first time. Moreover, the ratios involving these three molecules and their corresponding two isotope atoms are not equal.

3. It was found that the $Al_2O_3(Fe_2O_3)$ low temperature chromatography column would be poisoned when the CO content exceeds 5 percent.

4. Chromatography involving the use of a small thermal conductivity pool and a capillary column was attempted.

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New HBeAg Immune Binding Sites Found by Mc-anti-HBe

[Article by Zhang Zheng [1728 2973], Li Xin-fu [2621 2450 1381], Sun Yan [1327 3508] and Tao Qi-min [7118 0366 2404], Institute of Helatology, Beijing Medical University, Beijing]

[Text] In detecting HBsAg by RIA, when Mc-anti-HBe(b) is coated on the well and radiolabled, some HBsAg positive sera show high values but other remain negative. This indicates a new binding site on HBsAg in some sera. The antigenicity of this new binding site is not as strong as that of the "b" determinant on HBsAg and shows cross reactivity with Mc-anti HBe(b), but not with Mc-anti HBe(a).

In 1982, Imai[1] acquired Mc-anti-HBs(a) and (b) cell lines immunized with free HBeAg. In 1984, Ferns and Tedder[2] also got both Mc-anti-HBe (α) and (β) cell lines. In 1986, K.S. Spiezia prepared two Mc-anti-HBe(β) cell lines. At present McAb has been widely used not only in the preparation of test kits but also in the analysis of antigenic determinants. Researchers have reported that when the same kinds of Mc-anti-HBe were coated and labeled for detection of HBsAg, HBeAg positive sera showed negative value. This might be competitively binded HBeAg epitope by coated and labeled the same Mc-anti-HBe. In the study of HBeAg, we found that when Mc-anti-HBe(b) was coated and labeled, some of the HBeAg positive sera showed high cpm values while others do not. It seems that there may be a new binding site on some HBeAg.

MATERIAL AND METHODS

Material. Mc-anti-HBe(a) and (b) were supplied by the Institute of Immunology Co. Ltd. of Japan. Human polyclonal anti-HBe (HP-anti-HBe) was purified by affinity chromatography by ourselves. The serum of patients with chronic persistent hepatitis confirmed by liver biopsy (CPH) and HBsAg carriers was collected in Beijing.

Methods. Mc-antibodies and HP-anti-HBe were labeled with ^{125}I by the chloramine T method. HBeAg was detected by sandwich RIA.

RESULTS

HBeAg was detected by different patterns of coating/labeling. Different RIA matchings were chosen. Mc-anti-HBe(a) and (b) and HP-anti-HBe were used as coating and labeling antibodies respectively. Ten samples of HBeAg positive sera were tested. The results are shown in Table 1. All tests were confirmed by neutralization.

Table 1. Detection of HBeAg by RIA

Matchings (coating/labeling)	Positive number*	Negative number
a/a	0	10(1.79)
a/b	10(84.7)	0
a/HP	10(2.73) weak	0
b/a	10(27.4)	0
b/b	2(19.3)	8(1.97)
b/HP	10(3.78) weak	0
HP/a	10(5.6)	0
HP/b	10(23.74)	0
HP/HP	10(2.98) weak	0

* P/N average value

New binding site positive rate in 100 HBeAg positive sera samples. Fifty CPH samples and 50 carrier samples were selected. All were HBeAg positive. All samples were tested by four RIA matchings. The results were shown in Table 2.

Table 2. HBeAg Detection in 100 HBeAg Positive Sera Samples by Different RIA Matchings

P/N ratio	CHP (N = 50)				HBsAg (N = 50) carrier				Total (%)			
	a/b	b/a	b/b	a/a	a/b	b/a	b/b	a/a	a/b	b/a	b/b	a/a
30	35	0	0	0	44	0	0	0	79	0	0	0
10.1-30	15	33	8	0	6	36	6	0	21	69	14	0
5.1-10	0	17	11	0	0	14	14	0	0	31	25	0
2.1-5.1	0	0	13	0	0	0	15	0	0	0	28	0
2.1	0	0	18	50	0	0	15	50	0	0	33	100

Table 2 shows the classifications according to the P/N ratios. The results showed no significant differences between the CPH and carrier groups ($P > 0.05$). By a/b matching the P/N value of 79 percent of the sera was greater than 30, whereas by b/b matching all the sera P/N value was lower than 30. In class 1 and class 2, with P/N values greater than 10, the a/a matching results were significantly higher than those of b/b matching ($P < 0.01$). By a/b matching all the sera gave negative results.

DISCUSSION

In 1975 Kohler and Milstein[4] established the hybridoma technique which greatly improved immunological detection of HBeAg of different RIA patterns. We found that there might be a new immunogenic binding site on HBeAg besides determinants (a) and (b). The characteristics of this new site are HBeAg sera with the new binding site which showed high cpm values in the b/b model, this had not been reported previously. This binding site was weaker than the b determinant in binding with Mc-anti-HBe(b). As samples with P/N values higher than 10 were much more numerous by a/b matching than by b/b matching ($P < 0.01$), it is suggested that there is cross-reactivity between the new binding site and the (b) determinant, but no evidence of sharing common antigenicity with the (a) determinant. All of the sera tested by a/a matching were negative.

There was no significant difference between CPH and HBsAg carrier groups in positive rate and antigenicity of the new binding site. This new binding site might be a subgroup of Mc-anti HBe(b) specific (b) determinant or a new determinant which shared cross reactivity with the (b) determinant. Further study is required. This new binding site may be caused by HBeAg change in conformation or repeat sequencing. Preparation of McAb specific for this new binding site and protein analysis of HBeAg with this new site will aid understanding this new determinant.

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Investigation of Prevalence of Hepatitis A Outbreak in Minhang District, Shanghai

[English abstract of article by Han Xiangyang [7281 0686 7122], et al., of the Department of Epidemiology, School of Public Health, Shanghai Medical University; Pan Zhongfang [3382 9112 5364], et al., Antiepidemic Station of Minhang District, Shanghai]

[Text] From 15 January to 15 February 1988, 2,449 cases of acute hepatitis A were reported in Minhang, Shanghai, a district of 105,476 residents. The attack rate was 23.2 per thousand population, with 41.4 per thousand among 20-29 year olds, 39.9 per thousand for those 30-39 years old, and no reports of occurrence in people any older. An investigation disclosed that the cause of the outbreak was the ingestion of the raw clam, Arca (Anadara) subcrenata. The facts confirming the source of infection were: (1) two supplies of clams preceded the two epidemic peaks by 1 month, corresponding to the incubation period of hepatitis A, and up to 27.9 percent of the people in the sample population were found to have ingested these raw clams; (2) a case-control study indicated that 94.4 percent of the hepatitis A patients had a history of eating clams, significantly higher than the percentages of the general population (27.9 percent) and the control patients (28.7 percent), and that the odds ratio (OR) was up to 72.0 (95 percent confidence level: 25.9 - 200.3), i.e., the more clams one consumed, the higher the OR value would be; and (3) a sampling survey of the population showed that the relative risk (RR) of acquiring hepatitis A infection in those who had ingested the clams was 29.37 times higher than that in those who had not, with 93.1 percent of the tot total hepatitis A cases estimated to be attributable to having eaten contaminated clams.

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Seroepidemiological Survey of Viral Hepatitis A During Epidemic in Shanghai

[English abstract of article by Wang Jianxiang [3076 0256 5046], et al., of the Department of Epidemiology, School of Public Health, Shanghai Medical University]

[Text] In order to investigate the characteristics of an epidemic of hepatitis A in Shanghai which occurred in the early spring of 1988, 1,649 residents of the Changning district were surveyed. The investigation revealed that the attack rate of hepatitis A was 5.76 percent, and the sufferers were mainly limited to the age group of 20-39, with no difference between males and females. For those who had eaten a species of clam, Arca (Anadara) subcrenata, the attack rate was 15.86 percent, while it was 0.64 percent for those who had not eaten the clam. The relative risk (RR) was found to be 24.78, the attributable risk (AR) 15.22 percent, the attributable risk percentage (AR%) 95.96, the population attributable risk (PAR) 5.12 percent and the population attributable risk percentage (PAR%) 88.89. The attack rate of hepatitis A was closely related to the quantity of clams and ways ingested ($p < 0.0001$). Blood samples of 470 of the 1,649 residents examined for anti-HA and anti-HA IgM revealed that the number of persons susceptible to hepatitis A in the population fell gradually as the age increased. The average susceptibility of this group was 30.21 percent. In the anti-HA negative group, for those who had eaten the clams the attack rate was 29.41 percent and the infective rate was 38.24 percent, while for those who had not ingested the clams the attack rate was 1.35 percent and the infective rate was 5.41 percent. The relative risk was 21.79 and 7.07, respectively. The overall inapparent infection rate of hepatitis A in this outbreak was 1.91 percent.

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Isolation, Identification of Toxins Contained in Microcystis Aeruginosa From Donghu Lake, Wuhan*

[English abstract of article by He Jiawan [0149 1367 5463], et al., of the Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan]

[Text] The eutrophication of water supplies and recreational water bodies in China has increased, causing the water bloom of blue-green algae. Studies were carried out in order to determine the presence of toxic Cyanobacteria in freshwater lakes and ponds.

In 1984-1985 during the water bloom seasons, algal cells of Mycrocystis aeruginosa were collected from Donghu Lake. Most of them were toxic. The toxin was isolated by homogenization, extraction, ultracentrifugation, and ion exchange chromatography, and purified by high performance liquid chromatography. The results showed that the toxicity of the freeze-thaw cells was 100 mg/kg for 20-25 g mice by intraperitoneal injection, with a survival time of 60-120 min (LD_{100} = 100 mg/kg). The toxicity of the purified toxin was 1 mg/kg in mice by i.p. The modes of poisoning were similar to those reported involving the hepatoxic peptides of Microcystis aeruginosa. The pure toxin had two u.v. absorbance shoulders at 230 and 240 nm, respectively, and had heat and alkaline stability. The main amino acids of the toxin were asparatic acid, glutamin acid, alanine, arginine, serine and phenylalanine. The fast atom bombardment mass spectra of the toxin showed the molecular weight to be about 937 daltons.

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Effects of Proteinase Inhibitors on Coagulative Activity of Chinese Agkistrodon
Acutus Venom

[English abstract of article by Deng Chengqi [6772 2110 4388], et al., of the
First Affiliated Hospital, West China University of Medical Sciences]

[Text] The interference of plasmic proteinase inhibition in the coagulative
activity of the Chinese agkistrodon acutus venom (CAAV) has been investigated
by fibrin coagulation, fibrin polymerization function and immunoelectrophoretic
radioautograph of ^{131}I-CAAV. The normal defibrinated plasma could inhibit the
coagulative activity of the CAAV, and its left coagulative activity was
negatively correlated with the incubation time (P < 0.001). Pure AT-III
gradually decreased the coagulative activity of the CAAV, but α_2-mG increased
the coagulative activity following incubation with the CAAV. AT-III inhibited
the fibrin polymerization induced by the CAAV, but α_2-mG increased this
reaction. The results of the immunoelectrophoretic radioautograph showed
that both AT-III and α_2-mG could make the CAAV form complexes.

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Disseminated Intravascular Coagulation-like Syndrome in Patients Envenomated by Agkistrodon Acutus Bite

[English abstract of article by Wen Shangwu [2429 1424 2976], et al., of Wannan Medical College]

[Text] A study was conducted of 11 patients envenomated by Agkistrodon acutus bites. The results showed that most of the coagulation screening tests (Fgn, PT, Plt and serum FDP) were abnormal, but plasma antithrombin-III and fibronectin levels remained in the normal range. These data suggest that there was no evidence of thrombin formation in the systemic circulation in the victims. Therefore, it was determined that the patients envenomated by Agkistrodon acutus bites had a disseminated intravascular coagulation (DIC)-like syndrome rather than true DIC.

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Studies on Protoplast Culture of Rice (<u>Oryza</u> <u>sativa</u> L.), Plant Regeneration
From Protoplast-Derived Calli

[English abstract of article by Li Liangcai [2621 5328 2624], et al., of the
Institute of Genetics, Chinese Academy of Sciences, Beijing]

[Text] Protoplasts isolated from suspension cells of a japonica rice (77-170)
and an indica variety (IR-50) were cultured in a RY-2 medium. The plating
efficiency of the 77-170 was as high as 2.5 percent. Plant regeneration was
achieved in both subspecies. Some methodological improvements are as follows:
(1) A two-step isolation procedure was used to avoid the spontaneous fusions
and to obtain high quality protoplasts. (2) Protoplasts isolated from
suspension cells cultured in an AA medium supplemented with ABA showed a
distinctly higher level of survival and division. (3) Postponing the transfer
of the embedded protoplasts into a liquid medium might be beneficial to their
survival and division. (4) Using media with relatively high osmotic pressure
in culturing protoplast-derived calli increased their plant regeneration
frequency on subsequent differentiation media. This is the first report of
plant regeneration from the protoplast culture of an indica rice. All
regenerated plants are albinos, probably due to their long-term culture
history (1 and 1/2 years).

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Induction of Dihaploid Plants From Unpollinated Ovaries of Potato In Vitro

[English abstract of article by Tao Zirong [7118 5261 2837], et al., of the Institute of Genetics, Chinese Academy of Sciences, Beijing]

[Text] The in vitro culture of unpollinated ovaries is a new approach for obtaining dihaploids in potatoes, and is of theoretical and practical significance. The authors have achieved success in the induction of dihaploid plantlets from unpollinated ovaries of potatoes, with the preliminary results having been reported in 1984. Here we will report the overall results in detail.

Calluses and dihaploid plantlets were obtained from the in vitro culture of unpollinated ovaries of two autoteraploid genotypes. The ovaries were excised when the neighboring anthers contained pollen at the uninucleate stage. They were then cultured on a Murashige and Skoog medium supplemented with different hormones and sucrose. It was found that the most suitable induction medium was the MS medium supplemented with 2,4-D 2.0 mg/l, zeation 0.1 mg/l and sucrose 3 percent. The most suitable differentiation medium was 1/2 MS medium supplemented with 2,4-D 0.5 mg/l, kin 2 mg/l, BAP 2 mg/l, GA 0.5 mg/l, zeation 0.2 mg/l and sucrose 2 percent.

Two genotypes used in the authors' experiment were able to produce calli, and the 26 green plants regenerated were derived from only two genotypes. It appears that the plantlet differentiation from the callus depended more on the genotype than on the composition of the media.

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Study of Identification of Male Sterile Cytoplasms Using Analysis of
Mitochondrial DNAs in Maize

[English abstract of article by Xie Youju [6200 0645 5468], et al., of the
School of Biology, Beijing Agricultural University]

[Text] Modified Kemble's methods were used for the identification of male
sterile cytoplasms in maize. The Xho I restriction patterns of mitochondrial
DNA from Shuang A and Tang A cytoplasms, which are used in seed production
in China, were indistinguishable from that of S cytoplasm control. Undigested
mitochondrial DNAs from Shuang A and Tang A cytoplasms also clearly showed the
S_1 and S_2 plasmid-like DNAs characteristic of the S cytoplasm group. These
data indicate that Shuang A and Tang A cytoplasms belong to the S cytoplasm
group. A comparison of the restriction patterns of mitochondrial DNAs from
Y cytoplasm, which was discovered several years ago, with those of T cytoplasm
indicate that Y cytoplasm belongs to the T cytoplasm group. These results
will be helpful in the reasonable arrangement of male sterile cytoplasm in
seed production in China. The identification methods of male sterile cytoplasm
in maize are discussed.

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Study of Breeding, Cytogenetics of Octoploid <u>Triticales</u> With Different Cytoplasms

[English abstract of article by Wang Guizhi [3769 2710 5347], et al., of Harbin Normal University]

[Text] The stability of the meiosis seed-set rate and plumpness of kernels might be changed when the cytoplasm of a <u>triticale</u> is changed. The wheat variety "Chinese Spring" with different alien cytoplasms was crossed with rye, and the F_1 plants were treated with colchicine for chromosome doubling. Octoploid <u>triticale</u> with different alien cytoplasms were different in seed-set rates, heading rates and plant forms. Some demonstrated weak growth, or their anthers were not dehiscent, or their stamcus became pistillate. Different cytoplasms had apparent effects on chromosome pairing, as was shown by the univalent frequency at the metaphase of the first meiotic division. Certain effects of the D-type plasm can perhaps improve the seed-set rate of octoploid <u>triticale</u>.

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Structural Variance Analysis of Mitochondria COI, COII Genes From Normal, Cytoplasmic Male-Sterile Varieties of Rice (Oryza sativa)

[English abstract of article by Liu Yansheng [0491 3508 3932], et al., of the Institute of Genetics, Fudan University, Shanghai; Zhuo Degen [0587 1795 5327] of Hunan Academy of Agricultural Sciences, Changsha]

[Text] The authors analyzed the mtDNAs (mitochondrial DNAs) and ctDNAs (chloroplast DNAs) isolated from fertile (Zhenshan 97B) and male-sterile (Zhenshan 97A) cytoplasms by using the restriction endonuclease PstI, HindIII and BamHI. The results show that mtDNAs from Zhenshan 97A and 97B cytoplasms were distinguishable. Southern hybridization, using labeled mt genes (cytochrome C oxidase subunit I, II, COI, COII) of rice, did not indicate the presence of a mtDNA-homologous region on the ctDNA fragments, but showed the structural difference of COI, COII genes between the fertile and male-sterile cytoplasm lines. It has not been demonstrated whether different mtDNAs of normal and male-sterile cytoplasms of rice are associated with cytoplasmic male sterility.

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Synthesis, Cloning of Lengthy cDNA Segments of 3'-Poly(A) RNA Virus

[English abstract of article by Xu Naizheng [1776 0035 2973], et al., of the Institute of Genetics, Chinese Academy of Sciences, Beijing]

[Text] To synthesize lengthy cDNA segments of the 3' region of the RNA virus genome (Dengue fever virus II) without poly (A) in the 3' end, the authors joined poly (A) < 50 bp-pCp to the 3' end of the virus RNA by RNA ligase and constructed a virus RNA-poly(A)-pCp template that can use oligo (dT) as a primer for the synthesis of cDNA. Using this template, the authors synthesized lengthy cDNA segments which contain the complete 3' region of the virus RNA. The cDNA $\geq$ 5kb. It is advantageous for analyzing the structure-function of large RNA viruses and for researching infection of virus cDNA copy.

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Significance, Measurements of Areas, DNA Contents of Micronucleus Induced by Different Mutagens, Spindle Poisons

[English abstract of article by Cao Jia [2580 0163], et al., of the Department of Hygiene, Third Military Medical College, Chongqing]

[Text] The authors measured the areas and DNA contents of a micronucleus (MN) by an image processing system. Four mutagens and spindle poisons were used to induce the MN of RBCs in mouse bone marrow. The results show that almost 100 percent of the MN areas induced by mutagens was in the range of $0.5-4\mu^2$, with about 80-90 percent of the MN having a DNA content in the range of 0.5-6 percent of the G_1 nucleus. About 15-25 percent of the MN areas induced by spindle poisons was larger than $4\mu^2$, and about half of all MN has a DNA content larger than 6 percent of the G_1 nucleus. Mutagens and spindle poisons were probably separated by selecting the area of $4\mu^2$ and the DNA content of 6 percent of the G_1 nucleus. The authors also discuss MN formation in chromosome aberration types.

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Detection of Salmonella Typhi Vi-Antigen by Chemiluminescent Immunoassay.
I. Solid Phase Chemiluminescent Immunoassay

[English abstract of article by Qian Weihua [6929 4850 5478], et al., of the Capital Institute of Medicine; Ji Guoxin [6060 0948 2946], et al., of the National Institute for the Control of Pharmaceutical and Biological Products]

[Text] A new method for solid phase chemiluminescent immunoassay (Sandwich method) for the quantitative detection of the S. typhi Vi-antigen has been established. The method includes the use of: (1) the rabbit polyclonal antibody (IgG) to the Vi-antigen as the coating antibody, (2) luminol-labeled monoclonal antibody (IgM) to the Vi-antigen as the detecting antibody, (3) horseradish peroxidase and H_2O_2 as the luminescent system. The experiment showed that the detection limit and detection range of the method were 0.024 ng/ml and 0.0061-400 ng/ml, respectively. The sensitivity of this method is 41 times higher than that of ELISA, as reported in the literature. The results of healthy and mimic blood and urine specimens tested by the method are also reported in this paper.

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Investigation of Methods of Detection, Quality Control of HBsAg RIA Kit
Prepared With Monoclonal Antibodies

[English abstract of article by Guo Wei [6753 3837], et al., of the National
Institute for the Control of Pharmaceutical and Biological Products, Beijing]

[Text] Through a series of experiments involving the wide screening of the
10 strains of anti-HBs monoclonal antibodies established by the authors'
laboratory, three strains suitable for the coating and labeling of HBsAg RIA
Kit were selected. A comparative study was carried out between this kind of
RIA Kit (COMRIA-5) and Abbott's AUSRIA-II, and their sensitivities for
assaying adr, adw and ayw subtypes were similar. Both could detect as little
as 0.5 ng/ml and had good linear reactions. As for employing the COMRIA-5
Kit to identify the nine different HBsAg subtypes, it was shown that all the
antigen-antibody reactivities were very good. The radiolabeled antibody does
not inhibit the binding of the antigen to the solid-phase antibodies. There-
fore, the one-step two-step assay was developed. This assay has the same
sensitivity as Abbott's AUSRIA (two-step) Kit. A collection of 103 specimens
was tested with the two Kits, and the correlation rate was found to be
100 percent.

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Establishment of Hybridoma Cells Producing Monoclonal Antibody to Pre-S (2) Epitope of HBV, Its Preliminary Clinical Use

[English abstract of article by Han Fenglian [7281 7685 6647], et al., of the Immunology Laboratory, Hospital No 302, PLA]

[Text] HBsAg containing pre-s (2), purified by affinity chromatography with pHSA coupled to CNBr-activated sepharose 4B, was ussed as the immunogen to immunize in vivo the spleens of BALB/C female mice. The spleen cells from the immunized mice were fused with mouse myeloma cells (SP2/0-Ag). Clones producing the antibody were screened by serial enzyme immunosorbent assay, and subclone cultures were isolated by limiting dilution. Finally, three clones, which were positive for the anti-pre-s (2) antibody, were selected. The clones were still stable by several passages. They were injected i.p. to prime-treated BALB/C mice to produce ascitic fluid. The titers of anti-pre-s (2) antibodies in the ascitic fluid were above 10^5.

Isotype analysis revealed that all immunoglobulins were of the IgG1 mouse subclass. The purified McAb for pre-s (2) conjugated with horseradish peroxidase was used to develop a sandwich-type assay (ELISA). Using the assay, pre-s (2), the receptor for pHSA, was detected in the sera of patients with HBV infection. The assay method was more sensitive, specific, reproducible and reliable. The assay may be practical in routine hepatitis B immunodiagnosis, and merits further clinical trial.

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New AI Tool for Combat Command Described

[Article by Wang Junling [3769 6511 3781] and Gao Guangfeng [7559 1639 1496], General Staff Institute No 61: "KAT, A Knowledge Acquisition Tool for the IBM-PC"]

[Text] **Abstract:** This paper is primarily a description of a practical and effective knowledge acquisition tool, KAT, that runs on the IBM-PC. By helping the user set up a "knowledge tree," this system generates a knowledge structure, and this knowledge structure with its linear retrieval and chained elements can help experts in a field to share knowledge with a computer and to establish knowledge bases.

I. Preface

As people develop expert systems or other knowledge engineering [projects] based upon knowledge systems, knowledge acquisition is the most vital and also most difficult step, which to a very great degree reflects system performance and the speed of system creation. This is because in the creation of a new expert system the knowledge engineer must always relearn expert knowledge. Not only must he read through many books and materials, but he must also be in close coordination with experts, to the greatest extent possible reorganizing the knowledge and experience of experts. Experience has shown that it is never easy whatever the source of expert knowledge. Because the specialized knowledge of experts has accumulated over a long period of life experiences, this knowledge has not usually been organized or structured in their minds. Generally speaking, experts are good at presenting examples, but they are not accustomed to providing the details of such knowledge. In addition, the knowledge provided by experts is generally incomplete, imprecise, and sometimes self-contradictory. This means that the knowledge engineer must do a great deal of hard work to extract that knowledge from experts and to index it through organization and restructuring according to definite forms as he establishes a knowledge base. For these reasons, knowledge acquisition has been publicly recognized as the "bottleneck" problem in the development process of expert systems, and it continues to receive much attention from researchers in artificial intelligence both here in China and abroad. This paper concentrates on describing a practical, effective knowledge acquisition tool developed by

the authors and called KAT, as well as its design philosophy and functional characteristics.

II. The KAT System, A Practical Knowledge Acquisition Tool

KAT is a knowledge acquisition tool directed toward experts in any given field. It uses a teaching learning method to help such experts set up knowledge bases, and to a certain degree, this system serves as a knowledge engineer.

KAT was written in the Sinicized compiler-type Prolog language. The system has been used to establish such military expert systems on mid-sized and mainframe computers as the "Tianshan No 1 Combat Command Decision Making System" and the "Army Campaign Mobile Support Expert System."

2.1 The Knowledge Acquisition Modes of the KAT System

The KAT system generates a knowledge structure by helping the user set up a "knowledge tree," and uses this structure in linear retrieval and chaining to help experts transmit knowledge and to build the knowledge base. This method can serve as a bridge for the acquisition of various knowledge structures. The concept of a "knowledge tree" can be abstracted from the process by which a typical expert system development tool does knowledge acquisition, and we can see that this concept reflects an essential manifestation of knowledge acquisition. For example there is the concept of an "upper and lower tree" in the EMYCIN system. Generally speaking, logical representations and rule representations, as well as process representations, naturally form knowledge trees. The semantic network representation also takes the "tree" as its central knowledge structure. Frame representations that are as different as is possible, the understanding of this concept of "tree" will differ widely, but structurally they cannot depart from the "tree" structure. The KAT system focuses upon this essential mode of knowledge acquisition to build a "tree" system. This system not only manifests the hierarchical relations within knowledge, but also manifests the inference relations within knowledge. What we mean by inference relations among knowledge nodes are the logical relations between those nodes and each subnode. For example, each subnode can independently lead to the node, the group thereby constituting an 'OR' relation; it might be necessary for several subnodes to simultaneously infer that node, in which case this makes up an 'AND' relation. These relations permit degrees of confidence. See the AND/OR chart in Figure 1, which forms the inference relations between nodes. The nodes with single lines indicate the 'AND' relations, and all others make up the 'OR' relation. The system can automatically generate 'IF-THEN' rule sets for these inference relations in accordance with the user's prompt.

2.2 A real example of the generation process for a field knowledge tree

In creating the military combat command expert system, we have chosen the conditional determinative portion, specifically the process of forming the "tree" for determining the nature of enemy artillery groups as an example,
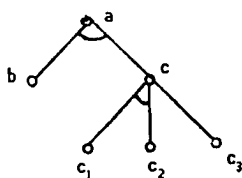
Figure 1. AND/OR Chart

to which we have added explanation of the particular methods for arranging knowledge.

How are we to determine the nature of the presence of the deployed enemy artillery groups? This involves several problems. The central one is under what conditions can we determine that an enemy artillery group is involved? There are several channels of intelligence sources. One is reports on the enemy situation as provided by higher authorities, and another is the result of reconnaissance efforts at various levels, both of which might generate the following facts: there are attacks from artillery, artillery troops are occupying territory, enemy troops are engaged in building artillery works, large-caliber artillery has been discovered, and prisoners have identified the artillery group, etc. The conditions just described are all used to determine whether the observed phenomena are the particular characteristics of artillery groups, and they are used to arrange a tree structure, as shown in Figure 2.
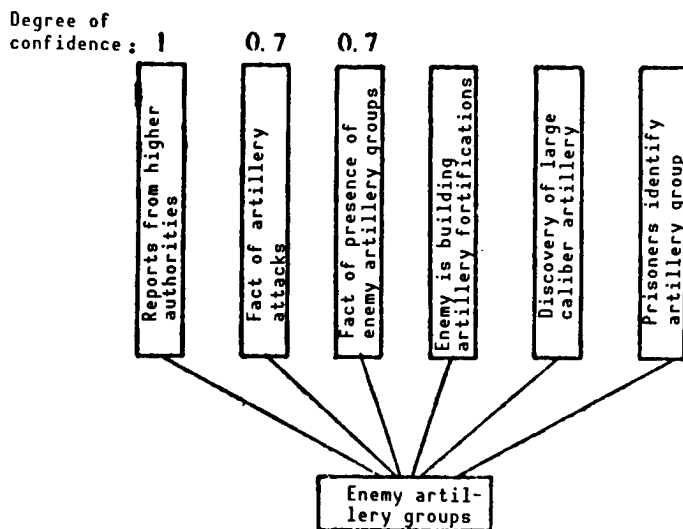

Figure 2.

When a particular area has been determined to be an artillery group, then what level artillery group is it? Within enemy defensive positions it is possible to find divisions of artillery, or regiments of artillery, or even army groups of artillery, so this tree grows longer, as shown in Figure 3.
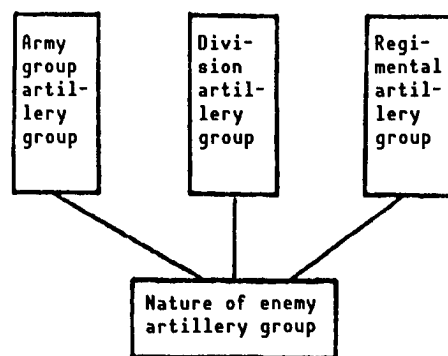
Figure 3.

From here on, we determine the nature of the enemy artillery group according to the basic battlefield position of the enemy, as well as from particular conditions that have been learned. The basic position of enemy division artillery groups within the enemy battle formation is a position 6-13 km from their front lines, or between the second and third positions of its deployment, or in the second position; this, while regimental artillery groups are in positions 2-6 km behind their lines, or are between the second and third positions; army groups of artillery are behind the artillery divisions, or are behind the third positions, or are more than 20 km behind the front lines. With this knowledge as the conditions, the "tree" blossoms, as shown in Figure 4.
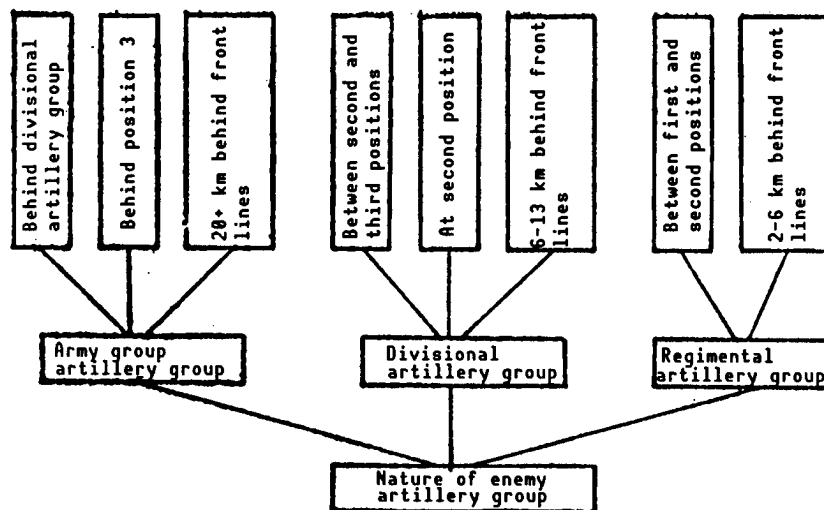

Figure 4.

Combining the two portions just described, a knowledge tree for determining enemy artillery groups is basically complete, and we will now consider the inference relations among the nodes, which can be arranged as follows: (see Figure 5)
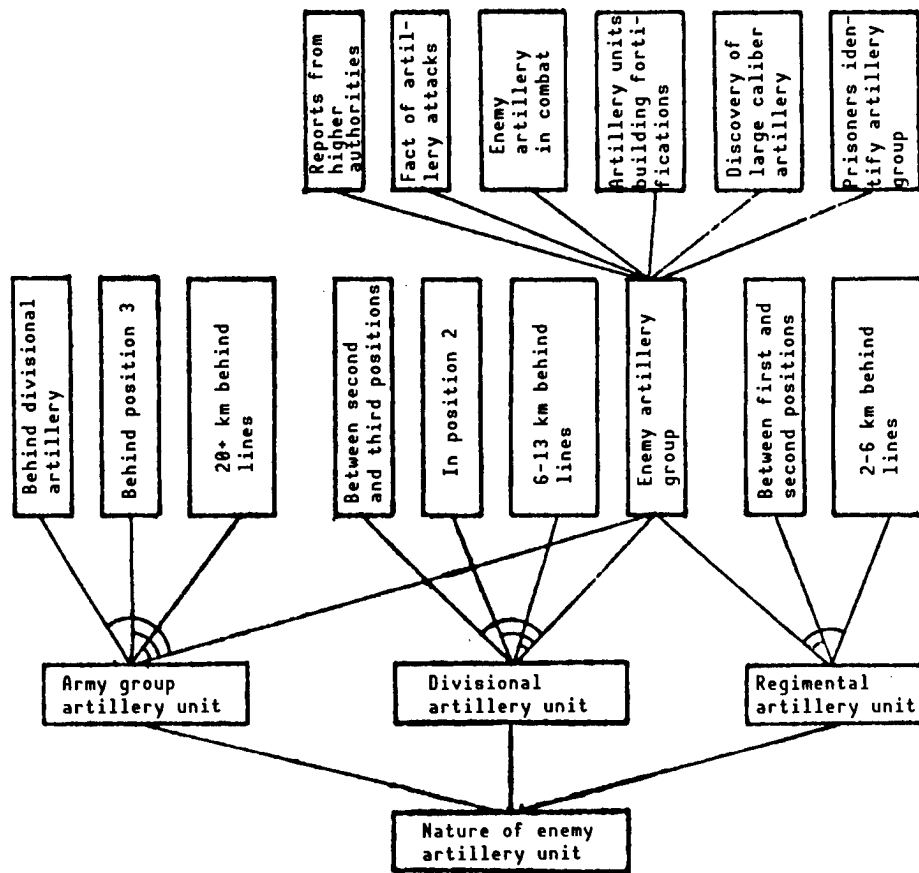
Reports from higher authorities

Fact of artillery attacks

Enemy artillery in combat

Artillery units building fortifications

Discovery of large caliber artillery

Prisoners identify artillery group

Behind divisional artillery

Behind position 3

20+ km behind lines

Between second and third positions

In position 2

6-13 km behind lines

Enemy artillery group

Between first and second positions

2-6 km behind lines

Army group artillery unit

Divisional artillery unit

Regimental artillery unit

Nature of enemy artillery unit

Figure 5. Knowledge Tree for Determining Nature of
an Energy Artillery Group

2.3 The functional characteristics of the system

Generally speaking, the knowledge acquisition process is one of expansion, and it is a process in which the knowledge base continues to grow and mature, so the system provides a convenient and flexible means to continually expand the knowledge base.

2.3.1 I/O modes

An excellent I/O environment will make the system feel smooth to the user, which is an advantage for the field expert to teach knowledge to the computer. The KAT system provides many function commands to the user. This command mode is far more flexible and convenient than the traditional menu mode. The commands include: system commands, inquiry commands, debugging commands, and check commands. The field expert and system dialog use natural language exclusively.

2.3.2 The debugging function

The KAT system is similar to other knowledge base management systems in its add, edit, and save functions for the knowledge base, which aids in the
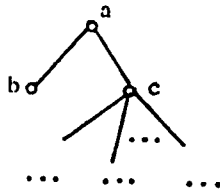
Figure 6.

maintenance and renewal of knowledge. Also, because of the hierarchical nature of the knowledge structure, these functions are implemented more easily (Figure 6). When using the delete command to delete node "c," that node and its sublevel nodes are completely eliminated. The inference relations for these nodes are also completely deleted.

2.3.3 The inquiry function

The system provides a group of knowledge base static inquiry commands for the ease of the user in querying the knowledge base, in understanding the internal structure of the knowledge base, and also to allow on-line printing. At the same time, the system also provides several commands by which to interpret the knowledge structure:

The 'How' command: explains how the knowledge at a particular node can be inferred.

The 'Why' command: explains why the knowledge at a particular node was established.

The 'What' command: interprets the knowledge concept of a particular node.

2.3.4 The check function

It is hard to avoid incorrect input of data during the knowledge acquisition process. Therefore, during the knowledge acquisition process the KAT system provides parsing prompts and checks on input data in a timely fashion, and it also provides data on deficiencies and to help with interpreting.

The system can also do a simple redundancy check on data being input. If newly input knowledge already exists in the knowledge base, the system will not accept it and will issue an error message. The system also provides complete check commands used to statically check whether the knowledge base is complete or whether the logical relations among the knowledge nodes have been established.

III. Conclusions

We have only discussed here some of the typical functions of the system. An excellent knowledge acquisition tool is a powerful aid to people who are developing knowledge-based systems. The KAT system uses the instructive learning mode, and the method that helps the user establish a "knowledge tree" generates a knowledge structure that can then be a linear retrieval

and chaining help to the expert in imparting knowledge and for establishing a knowledge base. Because of its practicality and efficiency, this system has been effectively used in creating various expert military systems, especially for the process of medium-to-large-scale military expert systems.

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Experimental Investigation of Compton Free Electron Laser

[Article by Fu Ensheng [0265 1869 3932], Wang Zhijiang [3769 0037 3068], Wang Bing [3769 0365], Chen Lei [7115 4320], Shie Peisheng [4258 1014 0581], and Zhou Huifen [0719 1979 5358] of the Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Shanghai, and He Duohui [0149 1122 1979], Wang Fuhua [3769 1788 5478], Pei Yuanji [5952 0337 0689], Jia Qika [6328 0683 0595], Liang Ruzhen [2733 3067 3791], and Yan Yan [1438 1750]]

[Text] Abstract: Experimental results of a Compton free electron laser are reported. Free electron radiation with an average power of 1.4W at 10 μm was obtained when a 22MeV relativistic electron beam was injected into the $SmCo_5$ permanent undulator with a 3 cm period for a total of 98 periods by a linear accelerator.

This paper describes the research experiments of China's first Compton free electron laser. The laser is based on a 30MeV linear accelerator, equipped with an electron beam transport system, a constant period magnetic undulator, and optical system. The output radiation has a wavelength of 9 to 11 μm. In November 1986, 10 μm radiation at an average power of 1.4W was obtained on this system. The experimental, setup of the Compton free electron laser is shown in Fig. 1. The linear accelerator (not shown) injects a beam of 22 MeV electrons into the electron transport system. The electron beam transport system consists of deflecting magnets, a beam control slit (23), quadupole magnets, beam monitor (9), fluorescent screens for observing the electron beam (3,7), vacuum pumps and an insert plate valve. Through the transmission line, a high quality electron beam of about 1 percent energy dispersion and 5π·mm·m rad divergence is injected into the vacuum chamber of the magnetic undulator (5). The device may be used as a free electron laser amplifier or oscillator. So far only the free electron spontaneous radiation output experiments have been performed.

Tables I and II list the characteristic parameters of the electron beam and the undulator parameter, respectively. The two ends of the undulator are equipped with 1/8 period magnets to bring the magnetic

field strength smoothly to zero. Figure 2 shows the structure of the vacuum chamber and the undulator of the free electron laser. One undulation period consists of four $SmCo_5$ permanent magnets, and the dimension of a magnet is 35x12x7.5 mm^3. Measurements show that the total integrated field strength is less than 88 G.cm, which satisfies the experimental requirements.
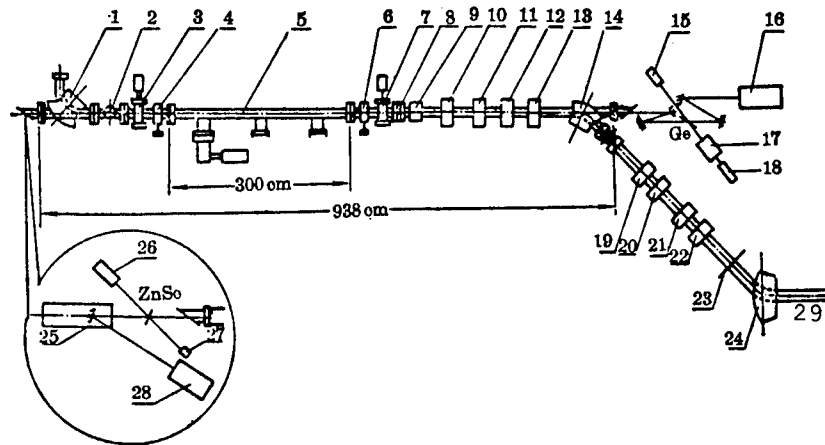

Fig. 1. Experimental setup of the Compton free electron laser

1,14,24 -- Deflecting magnets; 2 -- Sputtering ion pump;
3,7 -- Fluorescent screen plug; 4,6 -- Insert board valve;
5 -- Undulator and vacuum chamber; 8 -- Ripple tube;
9 --- Beam monitor; 10-13, 19-22 -- Quadrupole magnets;
15 -- Photon drag or TeCdHg detector; 16 -- TEA CO_2 laser;
17 -- Beam spreading telescope; 18,26 -- He-Ne laser;
23 -- Slit; 25 -- Step motor controlled reflecting mirror;
27 -- Bolometer or TeCdHg detector; 28 -- Spectrometer
29 -- Electron beam

Table I. Electron beam parameters

Electron energy	20-40 MeV
Average current	5-7 mA
Duty factor	1.4×10^{-2}
Peak current	0.35-0.5 A
Macroscopic pulse width	1 µs
Micropulse width	5 ps
Repetition rate	50 Hz
Energy dispersion	~1%
Divergence	~5 $\pi \cdot$ mm $\cdot$ m rad
Radiation frequency	2856 MHz

Table II. Undulator parameters

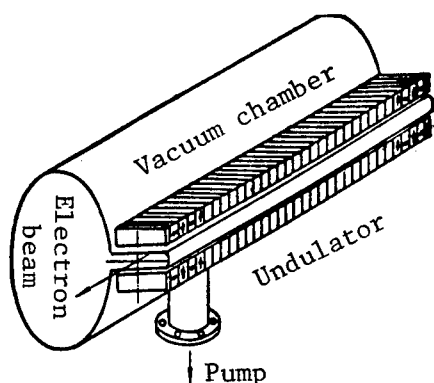|	
Period length	3 cm
Central peak magnetic field	0.28 T
Magnet gap	15 mm
Length	294 cm
Number of periods	98
Undulator parameter K	0.79

Fig. 2. Vacuum chamber and undulator of free electron laser

At the two vacuum sealed ends of the undulator there are a pair of 10 µm NaCl windows at the Brewster angle to allow almost lossless passage of parallel electric vectors. Relativistic electron beam is deflected 90° by the undulator and the dipole magnets to the fluorescent screen target outside the vacuum system. A television camera is used to observe the beam intensity and pattern on the fluorescent screen target. At about 10 cm from the NaCl Brewster window and on the axis of the transport system are a bolometer and an amplifier in a shielded box.

The detected signals are brought to an oscilloscope outside the experimental hall via shielded cables. When the electron beam energy and the transport system are properly matched, the oscilloscope will show a spontaneous radiation signal of 20 ms period at a beam repetition rate of 50 Hz. When the electron beam repetition rate is varied in the 25-60 Hz range, the period of the observed signal also varies accordingly. A set of pictures such as those shown in Fig. 3 was taken with an oscilloscope camera. Based on the response rate of the model RD-L bolometer and the gain of the amplifier, the average power of the 10 μm radiation in the 1 μs macroscopic electron beam pulse is computed to be 1.4 W. When the radiation output is obtained, the undulator was removed from the beam path without changing anything else, then the signals disappeared. This further proved that the observed radiation is coherent Compton scattering caused by the interaction of the magnetic field of the undulator and the relativistic electron beam. This radiation is hundreds of times stronger in intensity and tens of thousands times greater in brightness than the usual synchrotron radiation[1]. In 1975 it was first reported that the peak power of the spontaneous radiation of a Compton free electron laser was $15 \times 10^{1-5}$ W and the average power was 15×10^{-19} W. The peak power of the stimulated emission is 15 W, which is 10^5 times greater[2] than the peak power of the spontaneous radiation.

[Figure 3 on following page]

It was discovered in the experiments that Bremsstrahlung X-ray has a large effect on the detection of the radiation, and may cause an indication of 100 mV on the oscilloscope. Using 4 cm thick lead shields, we eliminated the X-ray interference, reduced the noise level to below 10 mV and detected the radiation output of the free electron laser.

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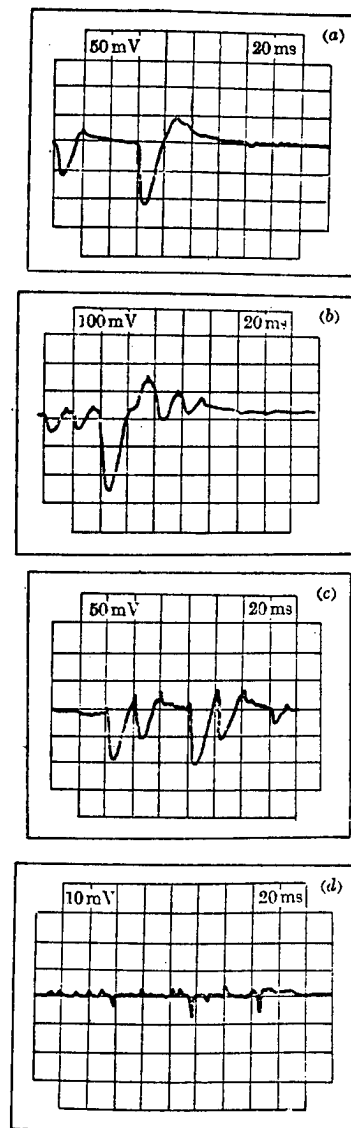2. L. Elias, et al., Phys. Rev. Lett., 36, 717 (1976).

Fig. 3. Output waveform of Compton free electron laser

(a), (b) and (c) are three photographic records, in (b) the highest output
power is 270 mW. (d) shows the detector noise level, about 10 mV.

Two-Wave Mixing Gain Enhanced in Photoconductive Photorefractive Materials With Alternating Electric Fields--A New Approach

[Article by Ye Shounian [5509 7445 1628] and Xu Gan [1776 3227] of Beijing Institute of Aeronautics and Astronautics; and Sun Yinguan [1327 1377 1351] of Beijing Normal University]

[Abstract] At present, photorefractive crystals are the principal nonlinear optimal materials for optical signal data processing and computation for many kinds of optical signals by using low power continuous-wave lasers.

By theoretical analyses and experiments, it was shown that in two-wave mixing in photorefractive crystals of the photoconductive type, the alternating electric field approach has several advantages over the dc electric field and moving grating methods: higher gain, less sensitivity to external vibrations, automatic optimization of operating conditions, and structurally simple devices, among other advantages. Thus, applications can be expected in fields such as coherent light amplification, real-time optical signal processing, and optical phase conjugations. Four figures show the time-based property of the $\pi/2$ phase shift component of the modulating oscillation amplitude of the space charge field, the light path of the alternating electric field method, curves plotted from experiments, and waveforms of signal light intensity. References: 6, in English. The paper was received for publication on 27 March 1988.

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Fast Q Switch Theory Tested Experimentally

[Article by Wu Hongxing [0702 7703 5281], Li Yongping [2621 3057 1627] and Wang Shengbo [3769 5116 3134] of Department of Physics, China University of Science and Technology]

[Abstract] The authors present a wide-ranging discussion of theory of Q switching rate; the theory is divided into two categories: fast Q-switch and slow Q-switch. They pointed out that all stably changing Q-switches can be described in terms of fast Q-switches, and all instantaneously changing Q-switches can be described by utilizing the fast Q-switch theory. Under the definition of the fast Q-switch, the authors detected experimentally the output of a Q-switch laser given the condition of different switching times and functions; the fast Q-switch theory thereby was proved.

The experiment arrangement is shown in the diagram below.
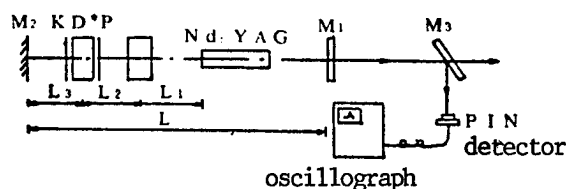
Two following figures show hot (at left side) and cold (at right side) cathode thratron switch circuits:
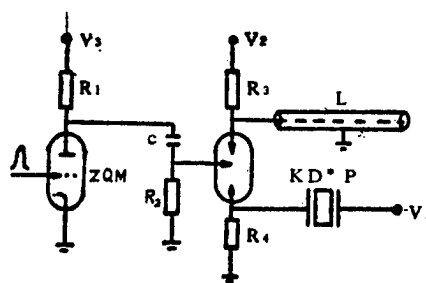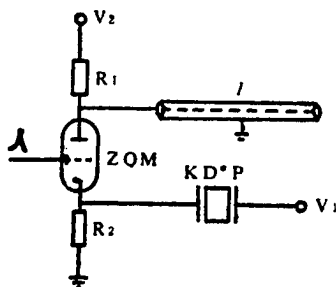
Three other figures show laser outputs of different Q-switches, observation on the switching time lag, and leading-edge waveforms of the two different switches. One table lists data of the output pulse parameters of the different Q switches. References: 2, in Chinese.

Branch-Selected CO-CO$_2$ Compound Laser

[English abstract of article by Gui Zhenxing [2981 2182 5281], et al., of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] In this paper the authors report a new type of sealed-off branch-selected CO-CO$_2$ compound laser operating at room temperature for the first time. Approximately 200 lasing lines were obtained in the region of 5.2-6.3 μm and 9.2-10.8 μm, with the highest output power of the stronger lines being about 2.5 W (CO) and 10 W (CO$_2$). The influence of CO$_2$ concentration in the gas mixture, discharge current and pressure on the power distribution of the CO and CO$_2$ lasing spectra was investigated experimentally. The excitation processes for CO and CO$_2$ molecules in the compound laser have been analyzed.

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Seven-Channel FIR HCN Laser Interferometer for Determining Electron Density
Profile on HT-6M Tokamak

40090028b Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 8 No 10,
Oct 88 pp 933-939

[English abstract of article by Tong Xingde [4547 5281 1795], et al., of the
Institute of Plasma Physics, Chinese Academy of Sciences, Hefei]

[Text] In this paper, the principle of interferometry for determining the
electron density of plasma is presented. The structure of the seven-channel
interferometer and its measurement results on the HT-6M Tokamak are described.
The light source used in the interferometer is a c.w. glow HCN laser with
cavity length of 3.4 M and power output of about 100 mW at 337 μm. The
averaged electron density of seven probing chords can be given simultaneously.
The detectable sensitivity is 1/15 frige with a temporal resolution of 0.1 ms.
Through asymmetrical Abel inversion from the line integrals of the phase
shift of seven chords, the electron density profile at different times or
a three-dimensional diagram of space-time distributions of the electron density
can be obtained.

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Second Harmonic Space Resolved Spectrum Initiated by Laser Produced Plasma Filament

[English abstract of article by Gu Min [7357 2404], et al., of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] Space resolved spectra with both high spectral resolution ($\sim$0.2 Å) and spatial resolution ($\sim$2 μm) of the second harmonic emission scattered at 90° to the laser axis were observed when both narrow band and broad band laser beams were adopted in an Al planar target experiment. After analyzing many phenomena, it has been proved that the second harmonic emission observed at 90° to the laser axis is initiated by the interaction of the laser with plasma filaments other than those of a planar wave with plasmas. The theory is in agreement with the experimental results on the whole.

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Optical Investigation of InGaAs-GaAs Strained Layer Quantum Well Structures

[English abstract of article by Xu Zhongying [1776 0112 5391] et al. of the Institute of Semiconductors, Chinese Academy of Sciences, Beijing, and by T. G. Andersson and Z. G. Chen of the Department of Physics, Chalmers University of Technology, Goteborg, Sweden]

[Text] Detailed investigations of optical properties were carried out on InGaAs-GaAs strained layer quantum well structures. Photoluminescence peak energies of structures are in agreement with the Kronig-Penny analysis combined with the effect of strain in the InGaAs layer. Hot carrier photoluminescence measurements demonstrate that photoinduced carrier heating in an InGaAs-GaAs strained quantum well is substantially increased as compared to the bulk and shows indium composition dependence. The critical layer thickness obtained from photoluminescence can be described with the mechanical balance model.

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Briefs

Fiber-Optic Communications Pilot Projects—At the National Conference on Fiber-Optic Communications held 11-14 September [1988], 15 pilot projects in fiber-optic communications engineering were commended [see JPRS-CST-88-021, 10 Nov 88, p 129]. Of these, seven are part of the posts & telecommunications system. They are: the Hefei-Wuhu [Anhui Province] Public Network primary trunkline project, using 140Mbps [DS4] single-mode optical cable, total length 146 kilometers, with a first-phase capacity of 1920 voice circuits and an eventual capacity of 3x1920 circuits; the Jiangsu [Province] Yangzhou-Gaoyou Public Network secondary trunkline project, using China's first all-domestically-made 34Mbps [DS3] single-mode overhead optical cable, total length 62 kilometers; the Chengdu-Guan Xian [Sichuan Province] Public Network secondary trunkline project, using 34Mbps single-mode optical cable, total length 64.6 kilometers; the Wuhan-Jingzhou [Hubei Province] Public Network secondary trunkline project, using 34Mbps multimode optical cable, total length 244.86 kilometers [see JPRS-CST-88-016, 29 Aug 88, p 105]; the Wuhan Municipality local telephone repeater project, using 140Mbps single-mode optical cable, total length 37 kilometers, with an initial installed capacity of 60+60 circuits and an ultimate capacity of 1920+90 circuits; the Shanghai Municipality local telephone repeater project, using 140Mbps single-mode optical cable, total length 34 kilometers; and the Tianjin Municipality local telephone repeater project, using 140Mbps single-mode optical cable. [Text] [40080103a Beijing DIANXIN JISHU [TELECOMMUNICATIONS TECHNOLOGY] in Chinese No 11, Nov 88 p 47]

New All-Solid-State Satcom Station Equipment—The all-solid-state 6-m satellite communications station equipment developed and manufactured by Research Institute 4 of the Institute of Posts & Telecommunications Science in Tibet—the first of its kind developed in China—recently passed a State Satellite Communications Station joint technical group acceptance check [see also FBIS-CHI-88-224, 21 Nov 88, pp 56-57]. The system equipment includes new technologies such as a field-effect-transistor solid-state power amplifier and a fault self-diagnostic display. [Summary] [40080103b Beijing DIANXIN JISHU [TELECOMMUNICATIONS TECHNOLOGY] in Chinese No 11, Nov 88 p 47]

New Digital Microwave Project—Construction for China's first domestically made unattended 34Mbps [DS3] digital microwave project—the Shanghai Power Industry Bureau's Shanghai-to-Jinshan digital microwave power loop network communications project—has been completed and the network is now operational. Investment for the communications equipment for each of the stations in this project came to only one third of what an imported system would have cost. Operational data

have shown that this project meets international standards for similar systems; the complete reliance on imported systems of like kind has therefore been overcome. [Text] [40080103c Beijing DIANXIN JISHU [TELECOMMUNICATIONS TECH-NOLOGY] in Chinese No 11, Nov 88 p 47]

New DMW Communications System--China is now developing a 6GHz 1920-line high-capacity digital microwave (DMW) communications system. The "Overall Design Plan for a 6GHz 1920-Line High-Capacity DMW Communications System" drafted by Research Institute 4 of the Ministry of Posts & Telecommunications' Institute of Posts & Telecommunications Science has undergone examination and approval. Proposed design principles, component technology requirements, system structure, and all subsystem functions--as well as plan options and assignment of system technological targets--all comply with CCIR, CCITT, and corresponding domestic standards. [Text] [40080112a Beijing DIANXIN JISHU [TELECOMMUNICATIONS TECH-NOLOGY] in Chinese No 12, Dec 88 p 47]

Statistics Released on Optical Cable--It has been learned from the National Conference on Fiber-Optic Communications held in September 1988 in Beijing [see JPRS-CST-88-021, 10 Nov 88, pp 128-129] that, as of the end of this year, according to still incomplete statistics, 36 cities are now using optical-cable transmission systems for municipal telephone communications, with a total of 2041 kilometers of optical cable laid; and seven provinces have built long-distance optical cable communications lines, totaling 1098 kilometers in length. It is estimated that, by the end of the Seventh 5-Year Plan, this amount will reach 7000 kilometers. Following is a breakdown of the statistics for optical cable laid for various provinces and municipalities in the posts& telecommunications system: Beijing [Municipality], 259.6 km; Tianjin [Munici-pality], 142.2 km; Hebei [Province], 49.6 km; Shanxi [Province], 11 km; Liaoning [Province], 240 km; Jilin [Province], 11.3 km; Heilongjiang [Province], 322 km; Shanghai [Municipality], 239 km; Jiangsu [Province], 166.8 km; Zhejiang [Prov-ince], 34.5 km; Anhui [Province], 6.3 km; Fujian [Province], 197.6 km; Ningxia [Hui Autonomous Region], 20 km; Jiangxi [Province], 159 km; Shandong [Province], 255.7 km; Henan [Province], 7 km; Hubei [Province], 484.6 km; Hunan [Province], 50 km; Guangdong [Province], 715.4 km; Guangxi [Zhuang Autonomous Region], 4 km; Sichuan [Province], 108.4 km; Yunnan [Province], 76 km; Shaanxi [Province], 22.4 km; Gansu [Province], 23.1 km; and Qinghai [Province], 38.5 km. [Text] [40080112b Beijing DIANXIN JISHU [TELECOMMUNICATIONS TECHNOLOGY] in Chinese No 12, Dec 88 p 47]

Military Tactical Communications Equipment--According to a report in ZHONGGUO DIANZI BAO, the new vehicle-mounted short-wave 100W single-sideband transceiver and automatic antenna tuning system developed by the state-run Fenghuo ["Beacon"] Radio Plant recently passed national-level technical accreditation and has been put into batch production. The transceiver uses all-solid-state components. Outside of China, only a small number of foreign countries--Japan, the FRG, and the U.S.--produce this high-precision, technologically complex equipment. [Text] [40080103d Beijing ZHONGGUO JIXIE BAO in Chinese 8 Dec 88 p 2]

Fiber-Optic Industry Develops Rapidly--China has opened or planned to open 112 optical cable lines with a total length of 4342 kilometers. So far, 36 cities have adopted fiber-optic telecommunications technology in telephone networks, and eight provinces have constructed optical-cable lines for long-distance communications service. Besides meeting the domestic needs for fiber-optic raw materials, there is surplus for the foreign market. China is now able to manu- facture 14,000-16,000 kilometers of optical cable each year and over 50 kinds of opto-electronic devices. They can be used for telecommunications, broad- casting, television, railway, military, computer, transport, and other purposes. [Text] [40100031 Beijing CEI Database in English 27 Jan 89]

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