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# China Report

SCIENCE AND TECHNOLOGY

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2 May 1985

# CHINA REPORT

## SCIENCE AND TECHNOLOGY

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## NATIONAL DEVELOPMENTS

### REFORM OF SCIENTIFIC RESEARCH SYSTEM OUTLINED

Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 1, Jan 85  
pp 26-28

[Article by Zhang Xicheng [1728 6932 1004]: "An Outline of Reforms of the Scientific Research System in the Machine Building Industry"]

[Text] The development of the machine-building industry manifests itself mainly in product development. Product development depends on technology which, in turn, depends on the technical departments of enterprises and special scientific research organizations of the machine-building industry. Consequently, scientific research in that industry cannot be divorced from but must revolve around products. Herein lies the major difference between scientific research in the machine-building industry and research in institutions of higher education.

#### I. The Direction of Reform of the Scientific Research System in the Machine-Building Industry

Since product development is the primary sign of progress in the machine-building industry, it follows that the principal mission of scientific research is product innovation. (Certainly other activities also revolve around product innovation, such as technology, surveying, control and components.) Let's now take an analytical look at the process whereby a product comes into existence.

| Stage I                                                                | Stage II                                                                      | Stage III                                                                                    | Stage IV                |
|------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-------------------------|
| Research of applied technology                                         | industrial development design and research                                    | intermediate testing and trial manufacturing                                                 | batch process commodity |
| Converting a theory or phenomenon into technical research              | applying the results of applied research to various industrial products       | new product goes through repeated testing and modification before examination and acceptance | commodity               |
| Example: using the interference effect of light to make interferometer | applying interferometer to the measuring and control of various machine tools | being refined into an ideal product suitable for industrial production                       |                         |

Stage I constitutes the foundation of product development, Stage II marks the creation of a product, Stage III is the product refinement process, while Stage IV involves commodity production. Of these four stages, the first stage is independent while the other three are continuous. This is the characteristic of product development.

From what I know, the bulk of industrial product development in Western nations, namely, Stages II, III and IV, take place in private corporations and companies, in line with the coherent nature of these stages. Universities and colleges are usually commissioned to undertake Stage I. As the initial design, intermediate testing and final production of a product all occur within the corporation or factory, it is easy to integrate it with the other products of the enterprise, insure its consistency with its production thrust, and, ultimately, transform research achievements into a product. Product continuity facilitates product improvement. Since the R&D department of an enterprise concerns itself only with research work pertinent to the corporation, it usually operates on a small scale within a limited sphere. Its *raison d'être* is market competition. All these characteristics comply with the principles of product development.

The scientific research system in China's machine-building industry was set up in the early years of the People's Republic by copying the Soviet model, under which product development is the responsibility of a separate scientific research system within the factory. Its main function is to assist the factory in technical development. This system proved useful in the first years of the People's Republic when much product development was imitative. But as technology develops and we go in for product innovation, this system has become unsuitable. Why? As things now stand, Stages I and II take place at colleges, universities and special research institutes whereas Stages III and IV take place in factories. This arrangement destroys the continuity of product development. Moreover, it militates against the close integration of a new product with the production focus of the factory concerned and divorces it from other existing products. As research achievements cannot progress smoothly onto Stages III and IV, scientific research and production become detached from each other. There is also the problem of waste as the Chinese Academy of Sciences, universities and research institutes in industry duplicate one another's work in Stages I and II. Such is the difficulty that exists in the scientific research system in China's machine-building industry today.

What is to be done? If we blindly follow the West and hive off research institutes to the factories, it is quite certain that product development will move ahead more quickly. But then China, with its planned economy, is different from countries in the West: our products must be developed in accordance with the national plan. Research institutes must fulfill their advisory and organizational functions towards their enterprises. In addition, they are the ones whom we depend on to mount attacks on technology. By hiving them off to factories, we will in effect be eliminating their above functions, which will work to the disadvantage of the planned economy. Furthermore, most research institutes represent a fairly considerable force, the result of many years of development. At a time when national resources are stretched to the limit, it will be a waste of human and material resources to hive them off. For all these reasons, we cannot reform our scientific research system by imitating the West.

Instead, we should set up our own product-oriented multitiered scientific research system by consulting the West's experience in the light of our special circumstances.

## II. A Reform Scheme for the Scientific Research System in the Machine-Building Industry

The basic rationale for reforming the scientific research system in the machine-building industry is product development. The following reform scheme under which functions will be performed at different tiers is proposed with the special features of a planned economy in mind.

1. Enterprises and companies are the important bases of product development. It follows that R&D should take place in factories, enterprises and companies. It conforms with objective principles to pay attention to R&D at these bases. All existing secondary research institutes, that is, factory-run institutes, should now belong to factories and will not engage in professional work. Product R&D should be entirely geared to the production needs of the factory. Factories which have the necessary financial resources can set up their own product research institute or office. Like factory-operated research institutes in the West, they should be closely integrated with their factories in terms of production and product orientation. This practice preserves the continuity of product development and trial manufacturing, and enables the factory-run research institutes to become the product development bases of the machine-building industry. Their expenses are to be borne by the factories concerned.
2. Primary research institutes attached to the Ministry of Machine Industry should associate themselves with a number of factories, companies and enterprises and set up a scientific research and production complex. As a new form of enterprise in the scientific research mode, they will mainly serve as assault troops on technology and develop products needed in key projects. To insure the continuity of research at a scientific research and production complex, it may consider narrowing its scope to an extent compatible with its capacity. Apart from scientific R&D and small-scale production, which are its major and minor functions respectively, the scientific research and production complex should also devote itself to the transfer of research achievements to factories and companies for mass production. The complex is responsible for its own profits and losses, and its main resource of revenue is the paid contracting system.
3. On the basis of the primary research institutes, the various special bureaus in the Ministry of Machine Building and industrial bureaus and provincial and municipal levels should set up an integrated research institute to do a good job in professional planning, informational gathering, standard-setting and a limited amount of applied research. Directly under the bureaus of the ministry and other industrial bureaus, it will not be involved in production per se and is one step removed from factories. Essentially it is a professional unit and its roles are those of an adviser and organizer. It derives its income from two sources, appropriations by the bureaus and the contracting system.

We thus have a three-tiered scientific research system in the machine-building industry.

|             |                                                                             |                                                             |
|-------------|-----------------------------------------------------------------------------|-------------------------------------------------------------|
| first tier  | integrated research institute                                               | advisory, organizational functions                          |
| second tier | scientific research and production complex                                  | assault troops on technology                                |
| third tier  | research offices, sections operated by enterprises, companies and factories | Developing new product quality, increasing economic results |

### III. Reform of the Internal Structure of Industrial Research Institutes

Internal structure reforms essentially cover two areas:

1. the establishment of an economic accounting system to improve the economic results of research; and
2. the establishment of a contracting system to fully mobilize the initiatives of scientific research personnel.

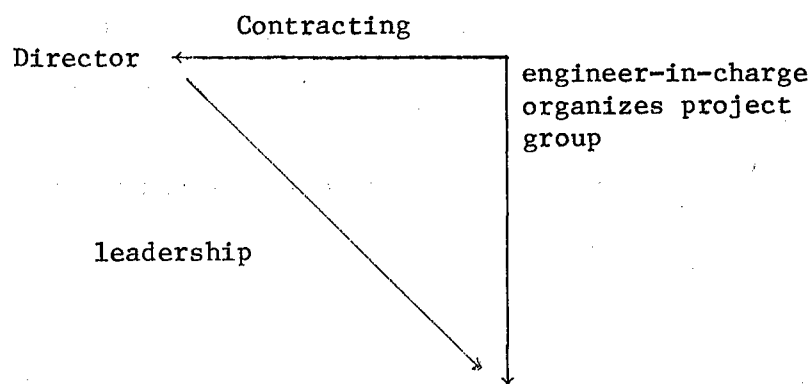
To bring about the two reforms, we have no choice but to break with tradition. By tradition, I mean the technical chief engineer responsibility system, the administrator director responsibility system and the office director responsibility system, all of which are incompatible with the economic accounting system and technical contracting system. Given today's scientific developments, there is no such person as an all-round engineer, so it is no longer practical to hold one or two people responsible for all the technical work of an institute. Instead, we should make use of the talents of more people. Factories in Western nations, for instance, do not have chief engineers and have done quite well without them. Furthermore, since the research office militates against the mobility of experts within the institute, the voluntary contracting of research work and the mobilization of individual initiative, it should be abolished and replaced by an engineer-in-chief\* contracting system. The engineer-in-charge contracts for research projects and selects engineers, technicians and support staff to participate in the projects. It is the responsibility of the engineer-in-charge to come up with the human, financial and material resources needed by a project group. The group will dissolve upon the completion of the project.

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\*The engineer-in-charge must have at least 4 years of experience and should have taken part and performed well in three medium research projects. He should also have demonstrated an ability to organize. The engineer-in-charge is appointed by the council of the institute.

The director of a research institute is to be elected by all engineers from among engineers-in-charge only. His term of office lasts 4 years.

The project group is a temporary basic contracting unit and operates flexibly with simplified procedures. As more people become engineers-in-charge, we will become better able to mobilize the talents of a larger number of experts. As engineers-in-charge are experienced in the organization and management of human, material and financial resources, the director of the institute who emerges from among them must be well-qualified for his job. In this way, we can get rid of the old director-for-life system and introduce a breath of fresh air into the stagnant world of institute management. Our reform scheme for research institutes calls for the restructuring of the technical units as follows, while leaving the finance, logistics, supply and political work units intact:



There will be three offices under the director:

1. office of engineers-in-charge, made up of engineers-in-charge, with the branch as its administrative unit;
2. office of engineers, made up of technicians, assistant engineers and engineers; with the branch as its administrative unit; and
3. scientific research office, made up of laboratory personnel and support staff, also with branch as its administrative unit.

Research projects are undertaken by temporary project groups. As the basic accounting unit, the project group facilitates the calculation of expenses and income and the summation of economic results.

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CSO: 4008/216

NATIONAL DEVELOPMENTS

GUANGMING RIBAO ON NEW TECHNOLOGICAL REVOLUTION, COMMUNIST MOVEMENT

HK100835 Beijing GUANGMING RIBAO in Chinese 1 Apr 85 p 3

[Article by Li Xiulin [2621 4423 2651]: "The New Technological Revolution and the Communist Movement"]

[Text] Since the end of the Second World War, especially the 1970s, there has been an unchecked worldwide new technological revolution. This technological revolution has had an impact on the various aspects of social life, such as economics, science, culture, public affairs, family life, and politics. In modern day politics no politician in any country does not pay great attention to the social role of the new technological revolution. By comparison, we have lagged behind in a sense, but our party and government are steadily sailing the socialist ship and catching up with others at full speed with Marxist courage and decisive spirit.

The new technological revolution is characterized by the application of micro-electronics, genetics, new materials, new energy, and fibre optics technologies. But the new technological revolution and the communist movement are absolutely not two parallel lines separated from and having no contact with one another. Their natures are linked and combined:

First, the theory of communism originates from the development of social civilization, and is the crystallization of the material and spiritual achievements of society. All of material civilization and spiritual civilization (including technology and science) are not something foreign to the communist movement, but should become the nutritious component parts and the components of the communist movement. Second, the working class--the class responsible for carrying out the communist movement, originates from the technological revolution, and will continue to grow and develop along with the technological advances. The same is true of the emergence and development of the Chinese working class. So on the basis of class, the communist movement cannot be separated from technological revolution and industrial revolution. Third, the new technological revolution has been greatly strengthening the communist front. And the new technological revolution is also the historical process leading to communism. The new technological revolution has been pushing forward the communist movement in two aspects: First, in the countries which have established the socialist system, the new technological revolution has been strengthening and consolidating the socialist victories. Second, the development of the technological revolution in the capitalist world has been pushing forward, not

destroying the communist movement in the world. The new technological revolution has made production more and more socialized. The general trend of development shows that the new technological revolution will inevitably sharpen the contradiction between the socialization of production and the private ownership of the means of production in the capitalist countries. What is more, the new technological revolution has been constantly improving the quality of the working class--the creator of the future communist society, and has been preparing the conditions necessary for the main body to realize social progress. Fourth, communist society will be built on the basis of highly developed productive forces. Without an advanced and powerful material and technological basis, there will not be real communism. The most important role of the new technological revolution in social progress is that the new technological revolution is setting up the material and technological basis for communism.

The essences of the two trends, the new technological revolution and the communist movement, cannot be separated. The trend of the historical development shows that they will eventually join together, just as the Changjiang and the Huang He eventually flow into the sea. This inevitable trend of the historical development has become a living reality in contemporary China. The technological revolution has now become an important part of the construction of the socialist modernization in China. And the technological revolution is also the practice of the communist movement in contemporary China. Here the technological revolution and the communist movement have already been combined. The technological revolution has become one of the necessary components of the communist movement. China's present reform of the economic structure may be said to be a historical trend combining both the technological revolution and the communist movement. So all communists should warmly greet it.

CSO: 4008/310

## NATIONAL DEVELOPMENTS

### BRIEFS

OFFICIAL ON SCIENCE, NATIONAL CONSTRUCTION--Speaking at a miniforum today, Hua Luogeng, newly elected vice chairman of the CPPCC National Committee, said that a scientific worker must plumb the realities of life and do his or her utmost to contribute to the motherland's construction cause. He said: As a scientific worker, my highest aspiration is to integrate science with production. The closer science and production are integrated, the faster production will develop. He said: Modern science and technology develop fast. Therefore, merely quickening our pace is not enough; we must accelerate our pace in science and technology in order to catch up with the developed nations in the shortest possible time. Hua Luogeng said: We must analyze foreign things because not all of them are good and we must have confidence in ourselves. If we do our utmost and work hard, we will surely be able to understand tomorrow what we do not understand today. We will also surely be able to catch up with others tomorrow even if we have failed to catch up with them today. Our revered Comrade Hua said: Although I am already 75 and in poor health, I will continue to work hard. In the next 5 years, I wish to accomplish two things: one is to apply science to production, and the other is to write my memoirs in compliance with Comrade Hu Yaobang's suggestion. [Text] [OW142003 Beijing Domestic Service in Mandarin 1200 GMT 11 Apr 85]

NATIONAL SCIENTIFIC ACHIEVEMENTS FAIR CONCLUDES--The first national fair of scientific and technological achievements in the chemical industry, jointly sponsored by the Ministry of Chemical Industry, the provincial Petroleum and Chemical Industries Department, and the Guangzhou Chemical Industry Corporation, concluded in Guangzhou today. Representatives from 50 units, such as chemical industrial research institutes and centers, universities, and colleges from various places throughout the country, brought 1,500 items of new scientific research achievements and sold them to some 80 units in our province. These new scientific and technological achievements include the fields of coatings, agricultural chemicals, macromolecular materials, processing, the mechanical and chemical industries, chemical fertilizers, inorganic salts, and chemical engineering. This fair of scientific and technological achievements which was sponsored by the chemical industry trade opened on 6 April. The atmosphere of the fair was lively. Many productive enterprises were greatly interested in the new scientific and technological achievements. Technological achievements have become goods in great demand. Some transactions were immediately concluded at the fair, and agreements on the sale of some of the technological achievements were initiated after talks. The units attending this

fair included state-run chemical industry enterprises in Foshan, Jiangmen, Zhanjiang, Hainan, and Guangzhou City in this province; township and town enterprises; and representatives from prefectures, cities, and counties. [Text] [HK100402 Guangzhou Guangdong Provincial Service in Mandarin 1000 GMT 8 Apr 85]

CONFERENCE STRESSES IMPORT OF TECHNOLOGY--Beijing, 15 Apr (XINHUA)--The National Technology Import Management Work Conference which ended today pointed out: In carrying out the work of importing technology, we must have a management system and management methods that meet the requirements of the new situation, raise our standards in importing technology, and rapidly heighten China's technical level through the import of technology. [passage omitted] The conference pointed out: At present China has sent out many people to observe and study technology abroad. However, their efficiency is relatively low. We must change this situation. [passage omitted] The conference stressed: In developing China's economic construction, the task of importing technology has become even more arduous, and the demands on the work of importing technology have become more pressing than ever before. The various departments concerned must adopt an overall point of view, and work with one heart and one mind. Only by doing so can we get twice the result with half the effort in doing the work of importing technology. [Excerpts] [By Yin Ke and Chen Naijin] [OW191025 Beijing XINHUA Domestic Service in Chinese 1455 GMT 15 Apr 85]

CSO: 4008/310

APPLIED SCIENCES

CHINESE CHARACTER PROCESSING SYSTEM DEVELOPED IN GUANGDONG

Guangzhou NANFANG RIBAO in Chinese 24 Dec 83 p 1

[Article by Yue Ji [4727 6060]; "A Multi-user Microcomputer With Chinese Character System, Capable of Rapid Processing of Both Chinese Characters and Most Pinyin [Alphabetic) Writing Is Developed"]

[Text] The Guangdong Provincial Computer Center, with assistance from the departments concerned, in over one year of hard work, successfully developed a 16-bit multi-user microcomputer with a Chinese character processing system (UC-01). The average age of the scientific and technical personnel who participated in this development was only 25 years.

In recent years, a steady stream of all kinds of high-speed, high-efficiency and comparatively practical 16-bit microcomputers are being imported into the domestic market. Hence, a technologically crucial key to propagate more extensive domestic use of these microcomputers is to adapt them for use with Chinese characters. The Chinese character processing system that has just been successfully developed, can most conveniently accept every kind of Chinese character code, can handle Chinese characters as part of the languages programmed within the various procedures of the original computer system, and is furthermore fitted with a very effective screen editing procedure for Chinese characters. As if writing with a brush, the user can move the cursor on the screen at will and thereby add, delete or perform other manipulations, can most conveniently use character-creating procedures, tabulation procedures, and also handle most pinyin [alphabetical] writing, e.g. English, Russian, Greek, etc. The system is therefore particularly suited for use in departments concerned with books, information, newspapers and periodicals and in enterprises and industrial units.

After having been experimentally used by certain units, the system passed the technological appraisal yesterday [23 Dec 83]. The specialists and users who participated in the appraisal meeting expressed the opinion: This Chinese character processing system meets advanced domestic standards in design and actual technology, is convenient in operation and use, and will play an effective role in the further spread of computer technology use in our province and throughout the country.

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CSO: 4008/259

2 May 1985

## APPLIED SCIENCES

## CHINA'S FIRST IMPORTED COMPUTER PRODUCTION LINE

Guangzhou NANFANG RIBAO in Chinese 25 Dec 83 p 1

[Article by reporter Wang Dekuan [3769 1795 1401]: "China's First Imported Computer Production Line Begins Production; These Supermini-computers are Capable of an Average of 100,000 to 1,080,000 Operations per Second. The Production Line Will Produce 400 Sets per Year"]

[Text] Yesterday morning [24 Dec 83], a ceremony for the formal testing and acceptance of China's first imported modern production line for computers was held at the Guangzhou Electronic Computer Plant, and the line was officially declared to be in operation. The ceremony was attended by Ministry of Electronics Industry advisor, Li Rui [2621 3843], provincial and municipal leaders, Liang Lingguang [2733 7227 0342], Kuang Ji [0562 0679], Liu Nianzu [0491 1819 4371] and over 300 representatives from other concerned units.

The major components of this production line were imported from France, with some domestic support. Its annual production capacity is 400 sets. The HN-3000 series of superminicomputers, which will be produced, is one of the current internationally produced superminicomputers. They achieve an average speed of 0.1 to 1.08 million operations per second, and are equipped with a Chinese character terminal system so that they can be used by persons who cannot read a foreign language. These computers can be used for the control of industrial production processes, production management, scientific research planning, university-level mathematics, military affairs and national defense, in government administrative offices, and etc. The Qinghua University, the Energy Bureau of the State Economic Commission, the PLA First Military Medical College, and the Guangzhou Satellite Observation Station have used these computers, have obtained excellent results, and do welcome them. This production line will have a very positive and stimulating effect on the development of our electronic computer industry and will accelerate the pace of progress in our entire electronics industry.

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CSO: 4008/259

APPLIED SCIENCES

COMPUTER PUTS OUT CHINESE CHARACTERS FROM PHONETIC LETTERS

Guangzhou NANFANG RIBAO in Chinese 14 Jan 84 p 1

[Article by Wen Yushan [2429 5148 1472]: "A New Type of Computer for Automatic Conversion of Chinese Pinyin (Alphabetic) Writing Into Chinese Characters Developed; the Young Technical Staff Member, Lin Caisong, Who Developed the Computer, was Promoted to Assistant Research Fellow as an Exceptional Case"]

[Text] This new type of computer which can automatically convert input as Chinese pinyin alphabet to output as Chinese characters, has now been successfully developed by Lin Caisong [2651 2088 2646], a young technical staff member, and others at the Guangzhou Institute of Electronics Technology of the Chinese Academy of Sciences. Experts consider this a breakthrough in Chinese information processing technology as well as a breakthrough in computer applications for Chinese pinyin (alphabetic) writing.

The large number of Chinese characters, their structural complexity and large information content are the cause of many technical difficulties in the course of developing the Chinese language computer. The input unit of this computer developed by Lin Caisong and his colleagues does not require coding, but merely typing Chinese in pinyin (sound, rhyme, tone) at the keyboard. If the operator is uncertain of standard Chinese pronunciation, he can hit another key and a whole series of Chinese homophones will appear on the screen, allowing him to make his selection. This computer also utilizes a small conventional keyboard with the Latin alphabet of international usage, which enables Chinese to be used on the same equipment with western languages such as English, French, German and Spanish, thus facilitating international contacts. As to output, the operator has the choice of Chinese characters, Chinese pinyin or a foreign language. The way in which the fluorescent screen will depict the size, the proportions, thick or thin strokes, distance between characters and between lines, can be adjusted at will, and characters can be inserted or deleted at will. Characters that are not stored or in the dictionary can be quickly composed. All written material input can be directly printed out on a printer, transmitted over telecommunications or stored on floppy disks. Any common home television

set can be used in place of a monitor. Lin Caisong is a 1981 graduate from the Computer Department of the South China Institute of Technology. He is 35 years of age and was last year promoted, as an exceptional case, to assistant research fellow, with a raise in salary of one rank.

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CSO: 4008/259

APPLIED SCIENCES

ANALYSIS OF DELAYED m SEQUENCE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11 No 6, Nov 83  
pp 22-27

[Article by Zhou Dahua [0719 1129 5478]]

[Text]

I. Introduction

If  $[x_0]$  is defined as the prime m sequence produced by a given shift register,  $[x_k]$  is the k-bit delayed sequence of  $[x_0]$ , then the modulo-2 sum of these two sequences is equal to another delayed m sequence.

$$[x_0] \oplus [x_k] = [x_i] \quad (1)$$

where  $k \neq 0$ ,  $i \neq 0$ ,  $i \neq k$ . The question is whether it is possible to determine  $[x_i]$  for a given  $[x_k]$ ? In summarizing about m sequences, Davies<sup>1</sup> believes that it is still not possible to derive a general theoretical formula for determining  $[x_i]$  at the present time, but it is possible to find  $[x_i]$  for each individual m sequence. His method consists of successively generating all the  $(2^n-1)$  delayed m sequences (n is the number of stages of the shift register,  $2^n-1$  is the period of this sequence); when n is large, finding  $[x_i]$  is indeed a tedious task in practice. At present, there are several unresolved problems such as: 1) For a delayed m sequence generator, what should  $[x_i]$  be if in equation (1)  $k < n$  ( $k = 1, 2, \dots, n-1$ )? 2) if the modulo-2 sum of an arbitrary number of stages of this generator yields a new delayed m sequence, then what should  $[x_i]$  be? In this article, the Walsh-Hadamard function (abbreviated W-H function) is used to study these problems. First, the latter two problems are analyzed, and a general computational method is presented. Second, by introducing the property of a delayed m sequence, simplified procedures are developed to analyze certain problems. Finally, the method of analyzing another type of delayed m sequences is introduced, and it is found that certain relationship exists between delayed m sequences with reciprocal polynomial relations.

## II. Analysis of Delayed m Sequence Generator

### 1. Representation of Shift Register Using W-H Function

Figure 1 shows an n-stage shift register. Within the range  $(0, 1, \dots, 2^n - 1)$ , the binary representation of any variable  $x$ ,  $\langle x_{n-1}, \dots, x_1, x_0 \rangle$  is denoted by  $\bar{x}$ . The  $j$ th W-H function is defined as<sup>2</sup>:

$$\text{Wal}[j, \bar{x}] = (-1)^p = (-1)^q \quad (2)$$

$$\text{where } j = \sum_{l=0}^{n-1} j_l \cdot 2^l, \quad x = \sum_{l=0}^{n-1} x_l \cdot 2^l, \quad p = \sum_{l=0}^{n-1} j_l \cdot x_l, \quad q = \sum_{l=0}^{n-1} j_l \cdot x_l,$$

$\oplus$  represents modulo-2 summation. The feedback coefficients  $a_0, a_1, a_{n-1}$  in Figure 1 are either 0 or 1, where 1 indicates a closed link. In order to insure a true n-stage shift register, we must have  $a_{n-1} = 1$ ,  $a = \sum_{l=0}^{n-1} a_l \cdot 2^l = \sum_{l=0}^{n-1} a_l \cdot 2^l$ .

The coefficients  $a_0$  through  $a_{n-1}$  which correspond to the 9th stage through the  $(n-1)$ th stage range in value from 0 to  $2^n - 1$ . The state transformation of the shift register can be expressed as

$$x_0(t) = \sum_{k=0}^{n-1} a_k \cdot x_k(t-1), \quad x_l(t) = x_{l-1}(t-1) \quad (3)$$

where  $0 < l < n$ . By multiplying  $x_0(t)$  by  $j_0$ ,  $x_l(t)$  by  $j_l$ , then computing the modulo-2 sum, we get

$$\sum_{l=0}^{n-1} j_l x_l(t) = \sum_{l=0}^{n-1} (j_{l+1} \oplus j_0 a_l) x_l(t-1)$$

Treating the above equation as the exponent of  $(-1)$ , and denoting  $\text{Wal}(j, \bar{x}(t))$  by  $X_j(t)$ , we have,

$$X_j(t) = X_{[j/2]}(t-1) [X_{j_0}(t-1)]^{j_0} \quad (4)$$

where  $1 \leq j \leq 2^n - 1$ ,  $[j/2]$  is the largest integer less than or equal to  $j/2$ ,  $j_0$  is the least significant bit of the binary representation of  $j$ , and  $X_{j_0}(t-1)$  represents the feedback connection of the shift register. Equation (4) represents the relationship between the current state and the previous state of the shift register. For ease of computation, equation (4) can be written as

$$X_{j-1} = \begin{cases} X_{j/2}, & \text{when } j \text{ is even} \\ X_{(j-1)/2 \oplus a}, & \text{when } j \text{ is odd} \end{cases} \quad (5)$$

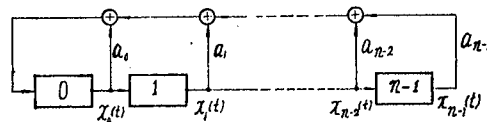


Figure 1. An n-Stage Shift Register

## 2. Analysis of a Primitive Trinomial Delayed m Sequence Generator

For the shift register shown in Figure 2, only  $a_{n-1}$  and  $a_{s-1}$  have feedback, therefore

$$a = 2^{n-1} \oplus 2^{s-1} \quad (6)$$

It generates a prime m sequence  $[x_0]$ . If any two stages of the shift register are added modulo-2 (without feeding back to the input terminal), the result must be another delayed m sequence, but what is the number of bits of delay? In the case of the prime m sequence  $[x_0]$  from the output of the 0th stage,  $a = 2^0 = 1$ . In the case of the 1-bit delayed m sequence from the output of the first stage  $a = 2^1 = 2$ . For the  $(n-1)$ -bit delayed m sequence  $[x_{n-1}]$  from the output of the  $(n-1)$ th stage,  $a = 2^{n-1}$ . For a shift register with a characteristic polynomial  $x^n + x^s + 1$ , we have

$$[x_n] \oplus [x_s] = [x_0] \quad (7)$$

From the shift-addition property,<sup>3</sup> we have

$$[x_{n+j}] \oplus [x_{s+j}] = [x_j] \quad (8)$$

where  $j$  is an integer. It is known from equation (8) that the two delayed m sequences  $[x_{n+j}]$  and  $[x_{s+j}]$  differ by  $(n-s)$  bits; the delayed m sequence  $[x_j]$  obtained from their modulo-2 sum differs from  $[x_{n+j}]$  by  $n$  bits. For a given  $[x_{n+j}]$ , one can determine  $[x_{s+j}]$ , and then  $[x_j]$  by computing the modulo-2 sum.  $[x_j]$  can be treated as the new  $[x_{n+j}]$ , and the above procedure is repeated until  $[x_j]$  becomes one of  $[x_0], [x_1], \dots, [x_{n-1}]$ . Suppose that the final  $[x_j]$  is  $[x_t]$  ( $0 \leq t \leq n-1$ ), then the number of delay bits of  $[x_{n+j}]$  is equal to the number of repetitions times  $n$  plus  $t$ . Following the above logic, one can use equation (5) to compute the delayed m sequence which is the modulo-2 sum of any two stages or of any number of stages.

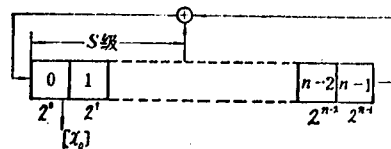


Figure 2. Shift Register Whose Primitive Polynomial Is  $x^n + x^s + 1$

For the shift register shown in Figure 2,  $n, s$  are known, find the modulo-2 sum of any two stages or of any number of stages (e.g.,  $[x_0] \oplus [x_1] \oplus \dots \oplus [x_\ell]$ ), and determine the number of delay bits between  $[x_1]$ , and  $[x_0]$ . The procedure is as follows:

$$(1) \quad a = 2^{n-1} \oplus 2^{s-1} \quad (9)$$

$$(2) \quad X_j = X_{\Sigma \oplus}, \quad \text{where } \Sigma \oplus = 2^0 \oplus 2^1 \oplus \dots \oplus 2^j \quad (10)$$

(3) Depending on whether  $j$  in  $X_j$  is even or odd, determine  $X_{j-1}$  from equation (5); then by treating it as the new  $X_j$ , determine  $X_{j-2}$  from equation (5). This operation is repeated  $(n-s)$  times to yield the result  $X_{j-(n-s)}$ .

$$(4) X_{j-n} = X_{j \oplus [j-(n-s)]} \quad (11)$$

(5) Determine if  $(j-n)$  of  $X_{j-n}$  is equal to  $2^t$  ( $t=0,1,\dots,n-1$ ); if not,  $X_{j-n}$  will be treated as the new  $X_j$  and the procedure is repeated starting from step (3). If after  $r$  repeated operations,  $(j-rn)$  of  $X_{j-rn}$  is equal to  $2^t$ , then the  $i$  in  $x_i$  is

$$i = rn + t \quad (12)$$

i.e.,  $[x_i] = [x_{rn+t}]$ . The above procedure can be carried out using an electronic computer.

[Example 1] Consider a shift register with  $n=7$ ,  $s=4$ , find  $[x_0] \oplus [x_5]$ .

Solution:  $a = 2^{7-1} \oplus 2^{4-1} = 72$ ,  $X_j = X_{20 \oplus 2^5} = X_{33}$

From equation (5), we obtain

$$\begin{aligned} X_{j-1} &= X_{(33-1)/2 \oplus 72} = X_{88} & X_{j-2} &= X_{88/2} = X_{44} \\ X_{j-3} &= X_{44/2} = X_{22} & X_{j-n} &= X_{j \oplus [j-(n-s)]} = X_{33 \oplus 22} = X_{55} \end{aligned}$$

Since 55 is not equal to  $2^t$  ( $t=0,1,\dots,6$ ),  $X_{55}$  is chosen to be the new  $X_j$ , and the above operation is repeated seven times to yield  $X_{j-7n} = X_2$ , i.e.,  $r=7$ ,  $t=1$ . Thus,  $i = rn + t = 50$ , i.e.,  $[x_0] \oplus [x_5] = [x_{50}]$ .

[Example 2] In the above example, find  $[x_0] \oplus [x_2] \oplus [x_4] \oplus [x_5]$ .

Solution: The value of  $a$  is the same as that in the above example,

$X_j = X_{20 \oplus 2^2 \oplus 2^4 \oplus 2^5} = X_{33}$ ; we can obtain  $r=12$ ,  $t=6$ ,  $i = 12 \times 7 + 6 = 90$ , i.e.

$$[x_0] \oplus [x_2] \oplus [x_4] \oplus [x_5] = [x_{90}]$$

### 3. Analysis of Delayed $m$ Sequence Generator Whose Primitive Polynomial Is Higher Than a Trinomial

Let the primitive polynomial be  $x^n + x^{\zeta} + \dots + x^{\theta} + 1$ , then

$$a = 2^{n-1} \oplus 2^{\zeta-1} \oplus \dots \oplus 2^{\theta} \quad (13)$$

where  $\oplus = S_h$ ,  $\zeta = S_{h-1}$ . For a given  $X_j$ , one can obtain from equation (5)

$$\begin{aligned} &X_{j-(n-s)}, \dots, X_{j-(n-\theta)}, \\ \text{and} \quad &X_{j-n} = X_{j \oplus [j-(n-s)] \oplus \dots \oplus [j-(n-\theta)]} \end{aligned} \quad (14)$$

Determine if  $(j-n)$  of  $X_{j-n}$  is equal to  $2^t$ ; if not, then  $X_{j-n}$  is treated as the new  $X_j$ , and the above operation is repeated; if after  $r$  operations,  $X_{j-rn} = X_s$ , then

$$i = rn + t \quad (15)$$

where  $s = 2^t$ . Thus,  $[x_i]$  can be readily obtained.

[Example 3] Consider a shift register whose primitive polynomial is  $x^6 + x^5 + x^3 + x^2 + 1$ , find  $[x_1] \oplus [x_2] \oplus [x_3] \oplus [x_5]$ .

Solution: From equation (5), we obtain  $a = 2^{6-1} \oplus 2^{5-1} \oplus 2^{3-1} \oplus 2^{2-1} = 54$

From equation (10)  $X_j = X_{21 \oplus 2^2 \oplus 2^3 \oplus 2^5} = X_{46}$

From equation (5)  $X_{j-1} = X_{46/2} = X_{23}$   $X_{j-2} = X_{(23-1)/2 \oplus 54} = X_{61}$

$$X_{j-3} = X_{(61-1)/2 \oplus 54} = X_{40} \quad X_{j-4} = X_{40/2} = X_{20}$$

From equation (14)  $X_{j-n} = X_{j \oplus (j-1) \oplus (j-3) \oplus (j-4)} = X_{46 \oplus 23 \oplus 40 \oplus 20} = X_5$

5 is not equal to  $2^t$ , hence  $X_{j-n}$  is chosen as the new  $X_j$ , and the above operation is repeated. After  $r=3$  operations  $X_{j-3n} = X_{16} = X_{2^4}$ , i.e.,  $t=4$ . Therefore,

$$i = rn + t = 22$$

$$[x_1] \oplus [x_2] \oplus [x_3] \oplus [x_5] = [x_{22}]$$

### III. Analysis of Delayed m Sequence

In equation (1), if  $k > n$ , what should  $[x_i]$  be? To answer this question, we first determine the structure of the delayed m sequence generator from  $(x_k)$ , i.e., we find the stages of the shift register whose modulo-2 sum is equal to  $[x_k]$ ; these stages are then summed modulo-2 with  $[x_0]$ . Based on the above generator analysis,  $[x_i]$  can be readily obtained.

[Example 4] Given  $n=7$ ,  $s=4$ , find  $[x_0] \oplus [x_{87}]$ .

Solution: From Ref. 4, one can calculate  $[x_{87}] = [x_2] \oplus [x_3] \oplus [x_4] \oplus [x_6]$

then  $[x_0] \oplus [x_{87}] = [x_0] \oplus [x_2] \oplus [x_3] \oplus [x_4] \oplus [x_6]$ ,

From the above generator analysis, we can calculate

$$[x_0] \oplus [x_2] \oplus [x_3] \oplus [x_4] \oplus [x_6] = [x_{106}]$$

$$\text{i.e., } [x_0] \oplus [x_{87}] = [x_{106}]$$

### IV. Simplification of Certain Analysis Using the Delayed m Sequence Property

If  $[x_i]$  of equation (1) has been determined, then from the shift-addition property, we have

$$[x_g] \oplus [x_{g+g}] = [x_{g+g}] \quad (16)$$

where  $g$  is a positive integer. As in example 1,  $[x_0] \oplus [x_5] = [x_{50}]$ , then from equation (16), we can get  $[x_1] \oplus [x_6] = [x_{15}]$ , etc.

For the shift register shown in Figure 2, we have

$$[x_0] \oplus [x_s] = [x_n] \quad (17)$$

By using the shift-multiplication property and the shift-division property, we have respectively,

$$[x_0] \oplus [x_{\Lambda \cdot s}] = [x_{\Lambda \cdot n}] \quad (18)$$

$$[x_0] \oplus [x_u] = [x_v] \quad (19)$$

where  $\Lambda=2Y$ ,  $u=(s+aL)/2Y$ ,  $v=(n+bL)/2Y$ ; since  $y$  is a positive integer, we should choose  $a, b$  to be  $0, 1, 2, \dots$ , so that the fraction would be a positive integer.  $L$  is the period of the sequence.

[Example 5] Consider a shift register with  $n=7$ ,  $s=4$ , and  $L=127$ .

From equation (17)  $[x_0] \oplus [x_4] = [x_7]$

From equation (18)  $[x_0] \oplus [x_8] = [x_{14}]$

From equation (19)  $[x_0] \oplus [x_2] = [x_{(7+127)/2}] = [x_{67}]$

$$[x_0] \oplus [x_1] = [x_{(67+127)/2}] = [x_{97}]$$

Applying the shift-subtraction property to equation (17), we get

$$\begin{aligned} [x_{L-s}] \oplus [x_0] &= [x_{n-s}] \\ [x_0] \oplus [x_{n-s}] &= [x_{L-s}] \end{aligned} \quad (20)$$

[Example 6] Consider a shift register with  $n=7$ ,  $s=4$ , and  $L=127$ .

From equation (20), we get  $[x_0] \oplus [x_{7-4}] = [x_{127-4}]$ ,  $[x_0] \oplus [x_3] = [x_{123}]$

From the shift-multiplication property, we get

$$[x_0] \oplus [x_6] = [x_{123 \cdot 2 - 127}] = [x_{119}]$$

This illustrates that certain computational procedures can be simplified by properly making use of equations (16)-(20).

## V. Analysis of Another Type of m Sequence

Figure 3 shows a shift register whose primitive polynomial is  $x^n + x^s + 1$ . The only difference between Figure 3 and Figure 2 is the output position of  $[x_0]$ .

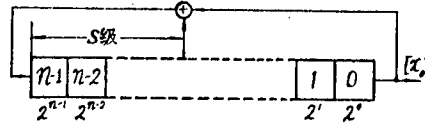


Figure 3. Shift Register Whose Primitive Polynomial is  $x^n + x^t + 1$

The delayed  $m$  sequence shown in Figure 3 can be obtained by replacing  $s$  by  $(n-s)$  and treating it as the new  $s$ , then repeating the above analysis.

[Example 7] For the shift register shown in Figure 3,  $n=7$ ,  $s=4$ , find  $[x_0] \oplus [x_5]$ .

Solution: Treating  $n-s=3$  as the new  $s$ , we obtain from equations (9)-(12) the following:  $a=2^{7-1} \oplus 2^{3-1}=68$ ,  $X_j = X_{20 \oplus 2^3} = X_{33}$

Similarly,  $X_{j-n} = X_{j \oplus (j-n)} = X_{111}$

Since 111 is not equal to  $2^t$ ,  $X_{111}$  is treated as the new  $X_j$  and the above procedure is repeated. After 11 operations, the result is  $2^5$ , hence  $i = rn + t = 82$

Therefore,  $[x_0] \oplus [x_5] = [x_{82}]$

It is clear from example 1 and example 7 that although the two shift registers have the same structures (i.e.,  $n$ ,  $s$  are identical), the delays of the respective  $[x_0]$  corresponding to the modulo-2 sums of the 0th stage and the 5th stage are different. But a definite relationship exists between the two.

For the  $n$ -stage shift register shown in Figure 2, whose primitive polynomial is  $x^n + x^s + 1$ , equation (17) holds. For the corresponding inverse trinomial,  $x^n + x^{\alpha} + 1$  ( $\alpha = s'$ ), equation (17) also holds, which gives  $[x_0] \oplus [x_{\alpha}] = [x_n]$ . Using the shift-subtraction property and subtracting  $s'$  from both sides, we get

$$\begin{aligned} [x_{L-\alpha}] \oplus [x_0] &= [x_{n-\alpha}] \\ [x_0] \oplus [x_{n-\alpha}] &= [x_{L-\alpha}] \end{aligned} \quad (21)$$

The above equation is similar to equation (20). The following relationship exists between the primitive trinomial and its inverse trinomial:  $n-s' = s$ . Thus, equation (21) can be written as

$$[x_0] \oplus [x_s] = [x_{L-s}] \quad (22)$$

The left hand sides of both equation (22) and equation (17) are equal to  $[x_0] \oplus [x_s]$ ; the right hand sides can be summed to give

$$L - s' + n = L + (n - s') = L + s$$

This procedure can be extended to the general case. If, for a shift register with primitive trinomial of the form:

$$[x_0] \oplus [x_k] = [x_i] \quad (23)$$

then for the shift register with corresponding inverse trinomial, we have

$$[x_0] \oplus [x_k] = [x_{i'}] \quad (24)$$

i.e., the following exists

$$i + i' = L + k \quad (25)$$

The expression shown in equation 23) is identical to that of example 1, the expression shown in equation (24) is identical to that of example 7; the relationship between the two is shown in equation (25). In fact, once the solution of example 1 is obtained, example 7 can be readily solved through equation (25). In example 1,  $i=50$ , thus  $i' = L+k-i = 127+5-50 = 82$ , which is identical to the solution given in example 7. Equations (23)-(25) not only provide the relationship between two types of delayed  $m$  sequences represented by Figures 2 and 3, but also give the relationship between delayed  $m$  sequences generated by two shift registers with inverse polynomial relations. Equations (23)-(25) can be extended by making use of certain sequence properties; for example, using the shift-addition property and adding 'g' to both sides of equations (23) and (24), we get

$$[x_g] \oplus [x_{k+g}] = [x_{i+g}], \quad [x_g] \oplus [x_{k+g}] = [x_{i'+g}]$$

$$\text{thus,} \quad i + g + i' + g = i + i' + 2g = L + k + 2g \quad (26)$$

$$\text{If} \quad [x_k] \oplus [x_j] = [x_i] \quad [x_k] \oplus [x_j] = [x_{i'}]$$

$$\text{then} \quad i + i' = L + k + j \quad (27)$$

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APPLIED SCIENCES

SHIFT-MULTIPLICATION AND DIVISION PROPERTIES OF DELAYED  $m$  SEQUENCES

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[Article by Zhou Dahua [0719 1129 5478] and Liu Yuqin [0491 3768 3830]]

[Text] I. Shift-Multiplication Property

1. Notation

An  $m$  sequence generated by an  $n$ -stage linear shift register has a period  $L = 2^n - 1$ . We introduce the following notations:  $[x_0]$  denotes the prime  $m$  sequence of an  $n$ -stage shift register;  $[x_k]$  denotes a  $k$ -bit delayed  $m$  sequence of  $[x_0]$ .

For convenience, we also use ' $d$ ' to represent the delayed  $m$  sequence.  $d_1 \oplus d_2$  represents the bit-bit modulo-2 addition of two delayed sequences  $d_1$  and  $d_2$ .  $d_1 + d_2$  represents the conventional addition of two integers  $d_1$  and  $d_2$ .

2. Shift-Multiplication Property for the Case Where the Multipliers Are Equal to  $2^y$

$$\text{If } d = d_1 \oplus d_2 \oplus \dots \oplus d_h \quad (1)$$

$$\text{then } 2^y d = 2^y d_1 \oplus 2^y d_2 \oplus \dots \oplus 2^y d_h \quad (2)$$

where  $y$  is a positive integer. Equation (2) is the shift-multiplication property of equation (1). The proof is as follows:

From the shift-addition property, it is known that if  $d = d_1 \oplus d_2 \oplus \dots \oplus d_h$ ,  
then  $d + j = [d_1 \oplus d_2 \oplus \dots \oplus d_h] + j$   
 $= (d_1 + j) \oplus (d_2 + j) \oplus \dots \oplus (d_h + j)$

where  $j$  is an integer. If we let  $j = d$  in the above equation, then

$$\begin{aligned} 2d &= [d_1 + (d_1 \oplus d_2 \oplus \dots \oplus d_h)] \oplus [d_2 + (d_1 \oplus d_2 \oplus \dots \oplus d_h)] \oplus \\ &\quad \dots \oplus [d_h + (d_1 \oplus d_2 \oplus \dots \oplus d_h)] \\ &= 2d_1 \oplus (d_1 + d_2) \oplus \dots \oplus (d_1 + d_h) \oplus (d_1 + d_2) \oplus 2d_2 \oplus \dots \oplus (d_2 + d_h) \oplus \\ &\quad \dots \oplus (d_1 + d_h) \oplus (d_2 + d_h) \oplus \dots \oplus 2d_h \\ &= 2d_1 \oplus 2d_2 \oplus \dots \oplus 2d_h \end{aligned}$$

By the same token,  $4d = 2(2d) = 4d_1 \oplus 4d_2 \oplus \dots \oplus 4d_h$   
 Therefore,  $2^y d = 2^y d_1 \oplus 2^y d_2 \oplus \dots \oplus 2^y d_h$

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### 3. Shift-Multiplication Property When the Multipliers Are Not Equal to $2^y$

If  $d = d_1 \oplus d_2 \oplus d_3$ , then we know from the shift-addition property that

$$\begin{aligned} 2d &= [d_1 + (d_1 \oplus d_2 \oplus d_3)] \oplus [d_2 + (d_1 \oplus d_2 \oplus d_3)] \oplus [d_3 + (d_1 \oplus d_2 \oplus d_3)] \\ &= 2d_1 \oplus (d_1 + d_2) \oplus (d_1 + d_3) \oplus (d_2 + d_1) \oplus 2d_2 \oplus (d_2 + d_3) \\ &\quad \oplus (d_3 + d_1) \oplus (d_3 + d_2) \oplus 2d_3 \end{aligned}$$

In the above equation,  $d$  is added to the left hand side to yield  $2d$ ; on the right hand side,  $d_1, d_2, d_3$  are respectively added to the terms  $d_1, d_2, d_3$  and modulo-2 operations are performed.

Similarly, from  $2d = 2d_1 \oplus 2d_2 \oplus 2d_3$ , we get

$$\begin{aligned} 3d &= [2d_1 + (d_1 \oplus d_2 \oplus d_3)] \oplus [2d_2 + (d_1 \oplus d_2 \oplus d_3)] \oplus [2d_3 + (d_1 \oplus d_2 \oplus d_3)] \\ &= 3d_1 \oplus (2d_1 + d_2) \oplus (2d_1 + d_3) \oplus (2d_2 + d_1) \oplus 3d_2 \\ &\quad \oplus (2d_2 + d_3) \oplus (2d_3 + d_1) \oplus (2d_3 + d_2) \oplus 3d_3 \end{aligned}$$

In this equation, again  $d$  is added to the left hand side, and  $d_1, d_2, d_3$  are added to the terms  $2d_1, 2d_2, 2d_3$  on the right hand side and modulo-2 operations are performed.

By repeating this process, the shift-multiplication property can be represented by a tree structure as shown in the figure. The notation " " indicates terms that have been canceled, the numbers  $u, v, w$  represent  $ud_1 + vd_2 + wd_3$ . The first row is  $d = d_1 \oplus d_2 \oplus d_3$ , and subsequent rows follow a similar pattern.

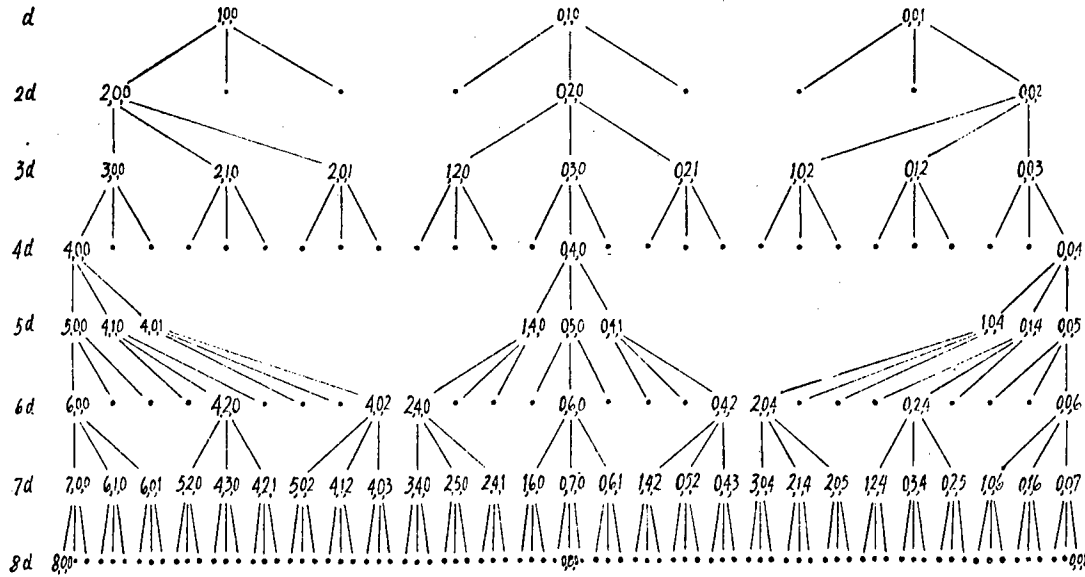
[Example 1] If  $d = d_1 \oplus d_2 \oplus d_3$ , find  $6d$ .

Solution: From the figure, one can obtain by inspection

$$\begin{aligned} 6d &= 6d_1 \oplus (4d_1 + 2d_2) \oplus (4d_1 + 2d_3) \oplus (2d_1 + 4d_2) \oplus 6d_2 \\ &\quad \oplus (4d_2 + 2d_3) \oplus (2d_1 + 4d_3) \oplus (2d_2 + 4d_3) \oplus 6d_3 \end{aligned}$$

Although the tree structure provides a direct solution, it has its limitations. To accommodate the general situation, the following mathematical formula is derived from the tree structure.

If  $d = d_1 \oplus d_2 \oplus \dots \oplus d_h$ , find:  $bd$  ( $b$  is a positive integer). The binary representation of  $b$  is  $(b_2) = b_k, \dots, b_t, \dots, b_1, b_0$ . Let the symbols  $a_k, \dots, a_t, \dots, a_1, a_0$  represent the weighted values of  $b_k, \dots, b_t, \dots, b_1, b_0$ ; if there are  $q$  '1's in  $(b_2)$ , then one can choose any  $h$  numbers from the  $(q+1)$  numbers  $0, 1, \dots, q$ , allowing repetition, such that the sum of the  $h$  numbers is equal to  $q$ . There are  $p$  such combinations. Let  $e_{ij}$  ( $i=1, 2, \dots, p$ ;  $j=1, 2, \dots, h$ ) be one of the numbers, then the following relation exists:



Tree Structure of the Shift-Multiplication Property

$$A(\Sigma C_{ij}^{e_{ij}}, \Sigma C_{ij}^{e_{ij}}, \dots, \Sigma C_{ij}^{e_{ij}})$$

(3)

where  $\Sigma C_{ij}^{e_{ij}}$  denotes the summation of the  $e_{ij}$ 's taken from the weighted values  $a_t$  which correspond to the  $q$  non-zero  $b_t$ ,  $A(z_1, z_2, \dots, z_h)$  represents the total permutation, allowing identical elements, with respect to each set of  $h$  numbers; there are  $h^q$  permutations. Each set of  $h$  numbers after permutation are expressed as coefficients of  $d_1, d_2, \dots, d_h$ , and are summed to form a modulo 2 number; i.e.,  $bd$  is formed from modulo 2 of  $h^q$  numbers.

Note: (1) The meaning of combinatorial sum is as follows: In choosing two numbers from the three numbers 1,2,4, there are  $C_3^2 = 3$  combinations. The combinatorial sums are  $1+2=3$ ,  $1+4=5$ ,  $2+4=6$ . (2) The total combinatorial sum of each set of  $h$  numbers is necessarily equal to  $b$ . (3) Repetitions should be avoided in calculating combinatorial sums and permutations.

[Example 2] Given that  $d=d_1 \oplus d_2 \oplus d_3$ , find  $20d$ .

Solution:  $h=3$ ,  $(20)_2=10,100$ ,  $b_4$  and  $b_2$  are 1, i.e.,  $a_4=16$ ,  $a_2=4$ ;  $q=2$ . Choose three ( $h=3$ ) numbers from 0,1,2, allowing repetition, such that the sum of these numbers equals  $q=2$ ; we have two such combinations: 0,0,2; 0,1,1; i.e.,  $e_{ij}$  ( $i=1,2$ ;  $j=1,2,3$ ). For the combination  $e_{11}=0$ ,  $e_{12}=0$ ,  $e_{13}=2$ ,  $\Sigma C_2^0=0$ ,  $\Sigma C_2^2=20$ , hence the three permutations of  $A(0,0,20)$  are: 20,0,0; 0,20,0; 0,0,20. For the combination  $e_{21}=0$ ,  $e_{22}=1$ ,  $e_{23}=1$ ,  $\Sigma C_2^0=0$ ,  $\Sigma C_2^1=16$ ,  $\Sigma C_2^2=4$ , hence the six permutations of  $A(0,16,4)$  are: 0,16,4; 0,4,16; 16,0,4; 4,0,16; 16,4,0; 4,16,0; and there are a total of  $h^q=3^2=9$  combinations.

$$20d = 20d_1 \oplus 20d_2 \oplus 20d_3 \oplus (16d_2 + 4d_3) \oplus (4d_2 + 16d_3) \oplus (16d_1 + 4d_3) \\ \oplus (4d_1 + 16d_3) \oplus (16d_1 + 4d_2) \oplus (4d_1 + 16d_2)$$

[Example 3] If  $d = d_1 \oplus d_2$ , find  $11d$ .

Solution:  $h=2$ ,  $(11)_2 = 1, 0, 1, 1$ ,  $q=3$ ,  $a_3=8$ ,  $a_1=2$ ,  $a_0=1$ . Choose two numbers from the four numbers  $0, 1, 2, 3$ ; we have  $0, 3$ ;  $1, 2$ ;  $e_{ij}$  ( $i=1, 2$ ;  $j=1, 2$ ). From equation (3), we obtain:  $11, 0$ ;  $0, 11$ ;  $10, 1$ ;  $1, 10$ ;  $9, 2$ ;  $2, 9$ ;  $3, 8$ ;  $8, 3$ ; there are a total of  $h^q = 2^3 = 8$  combinations. Therefore,

$$11d = 11d_1 \oplus 11d_2 \oplus (10d_1 + d_2) \oplus (d_1 + 10d_2) \oplus (9d_1 + 2d_2) \\ \oplus (2d_1 + 9d_2) \oplus (3d_1 + 8d_2) \oplus (8d_1 + 3d_2)$$

#### 4. Application

The computation of delayed  $m$  sequences, particularly long sequences, is in general very tedious. However, it can be greatly simplified by using the shift-multiplication property. Example 2 of Ref 3 is used to illustrate this procedure.

[Example 4] The number of shift registers  $n$  is 25, the number of feedback connections  $S$  is 18,  $[x_{600}]$  is

$$[x_{600}] = [x_{23}] \oplus [x_{22}] \oplus [x_{21}] \oplus [x_{19}] \oplus [x_{18}] \oplus [x_{16}] \oplus [x_{15}] \\ \oplus [x_{13}] \oplus [x_{11}] \oplus [x_9] \oplus [x_8] \oplus [x_2]$$

To find  $[x_{1200}]$ , we again invoke the shift-multiplication property

$$[x_{1200}] = [x_{46}] \oplus [x_{44}] \oplus [x_{42}] \oplus [x_{38}] \oplus [x_{36}] \oplus [x_{32}] \oplus [x_{30}] \\ \oplus [x_{28}] \oplus [x_{22}] \oplus [x_{12}] \oplus [x_{10}] \oplus [x_4] \\ = [x_{24}] \oplus [x_{17}] \oplus [x_{14}] \oplus [x_{13}] \oplus [x_{11}] \\ \oplus [x_9] \oplus [x_8] \oplus [x_1]$$

This illustrates that the computation of  $[x_{1200}]$  is much simpler by using the shift-multiplication property than using a formula directly.

#### II. Shift-Division Property

In ordinary division operation, when the divider is greater than 1, the quotient is necessarily smaller than the dividend. But for a delayed  $m$  sequence, the quotient is not necessarily smaller than the dividend because it is periodic, as indicated by the following expression:

$$d + gL = d \quad (4)$$

where  $g$  is 0 or a positive integer,  $L$  is the period of the sequence. Dividing  $d$  by a positive integer is equivalent to dividing  $(d+gL)$  by the same integer. In either case the quotient should be a positive integer or zero; therefore, it may be larger than dividend  $d$ .

It is known from equation (2) that if  $2^Y d = 2^Y d_1 \oplus 2^Y d_2 \oplus \dots \oplus 2^Y d_h$ , dividing both sides by  $2^Y$  gives  $d = d_1 \oplus d_2 \oplus \dots \oplus d_h$ . From the periodicity of the delayed  $m$  sequence indicated by equation (4), the above equation can be generalized as follows:

If

$$d = d_1 \oplus d_2 \oplus \dots \oplus d_h$$

$$\frac{d+aL}{2^r} = \frac{d_1+bL}{2^r} \oplus \frac{d_2+cL}{2^r} \oplus \dots \oplus \frac{d_h+iL}{2^r} \quad (5)$$

where  $a, b, c, \dots, i$  are chosen to be  $0, 1, 2, \dots$  so that the corresponding fraction is either zero or a positive integer. Equation (5) can also be written as:

$$[x_Q] = [x_{Q_1}] \oplus [x_{Q_2}] \oplus \dots \oplus [x_{Q_h}] \quad (6)$$

where  $Q = (d+aL)/2^r$ ,  $Q_1 = (d_1+bL)/2^r$ ,  $Q_2 = (d_2+cL)/2^r$ ,  $Q_h = (d_h+iL)/2^r$ .

Equation (5) or equation (6) is the shift-division property of the delayed m sequence.

[Example 5] Consider a shift register with  $n=7$ ,  $S=4$ , then the modulo-2 connection with delay  $d$  is

$$[x_{57}] = [x_0] \oplus [x_1] \oplus [x_2] \oplus [x_4] \oplus [x_5]$$

From equation (6) we obtain  $[x_{(57+127)/4}] = [x_0] \oplus [x_{(1+127)/4}] \oplus [x_{(2+2 \cdot 127)/4}] \oplus [x_1] \oplus [x_{(5+127)/4}]$

$$[x_{46}] = [x_0] \oplus [x_{32}] \oplus [x_{64}] \oplus [x_1] \oplus [x_{35}]$$

$$= [x_0] \oplus [x_2] \oplus [x_3] \oplus [x_4]$$

Thus, a 46-bit delayed m sequence can be obtained by taking modulo-2 of the 0th, 2d, 3d and 4th stages.

[Example 6] Consider a shift register with  $n=28$ ,  $S=25$ , the modulo-2 connection with 28-bit delay can be easily obtained  $[x_{28}] = [x_3] \oplus [x_0]$ ,  $L=2^{28}-1 = 268435455$ . From the shift-division property, dividing both sides by 2 gives

i.e.  $[x_{14}] = [x_{(L+S)/2}] \oplus [x_0] = [x_{134217729}] \oplus [x_0]$

$$[x_{134217729}] = [x_{14}] \oplus [x_0]$$

The modulo-2 sum of the 14th stage and the 0th stage is the 134217729-bit delayed m sequence.

By shift-dividing the above result, i.e., dividing both sides by 2, one obtains

$$[x_{(134217729+L)/2}] = [x_7] \oplus [x_0]$$

$$[x_{201326592}] = [x_7] \oplus [x_0]$$

i.e., the modulo-2 sum of the 7th stage and the 9th stage is a 201326592-bit delayed m sequence. To compute such a long delay would be very tedious by any other method, but it is so simple using the shift-division property.

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APPLIED SCIENCES

DOUBLE TEARING MODE IN PLASMA WITH MAGNETIC BRAIDING

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[Article by Dong Jiaqi [5516 1367 7871] of the Southwest Institute of Physics]

[Text]

I. Introduction

Due to the presence of low-amplitude magnetic disturbances in a magnetically confined plasma, the magnetic lines are often twisted into a braid, called magnetic braiding. This type of braided magnetic field structure has been under extensive investigation<sup>2-5</sup> because it is considered to be the possible cause for many phenomena observed in a Tokamak plasma (e.g., anomalous electron heat conduction, fracture instability and the behavior of escaped electrons).

If magnetic braiding is a result of quasi-steady low-amplitude disturbances, then it may cause not only anomalous electron heat conduction, but also anomalous transport of electron momentum in a direction parallel to the equilibrium magnetic field, which leads to anomalous increase in the coefficient of viscosity of the electrons.<sup>1,2</sup> In this case, the parallel electron viscous terms in the broad-sense Ohm's law cannot be neglected. In this article, the effect of a braided magnetic field is assumed to be manifested by the anomalous electron coefficient of viscosity. On this basis, the double tearing mode which is unique to plasma with magnetic braiding is deduced and its linear behavior is discussed.

The resistance tearing mode is a mode which has been widely observed in Tokamak discharge; it plays a very important role in the behavior of a Tokamak plasma. In-depth and extensive studies of this mode have been carried out in the past. These studies show that the linear growth rate of the resistance tearing mode for  $m \geq 2$  is related to the resistivity of the plasma as follows:  $\gamma_r \propto S^{-3/5}$ , where  $S = \tau_r / \tau_H$  is the magnetic Reynolds number of the plasma,  $\tau_r = 4\pi^2 / c\eta$  and  $\tau_H = a / C_A$  are respectively the resistance diffusion time and the Alfvén time of the plasma with linearity  $a$ ,  $\eta$  is the resistivity of the plasma; the linear growth rate of the double tearing mode for  $m=1$  is  $\gamma_r \propto S^{-1/3}$ . The so-called double tearing mode is the tearing mode which occurs when two neighboring rational surfaces satisfying the condition  $k \cdot B = 0$  exist simultaneously in

the carrier plasma. A study of the linear behavior of resistance double tearing mode can be found in Ref. [6].

Research efforts have been carried out to study the tearing mode caused by anomalous electron viscosity as a possible cause of fracture instability. It has been found that the linear growth rates of the electron viscous tearing mode for  $m \geq 2$  and  $m=1$  vary according to the rules  $\gamma \propto R^{-1/3}$  and  $\gamma \propto R^{-1/5}$  respectively, where  $R = \tau_V/\tau_H$  is the hydrodynamic Reynolds number,  $\tau_V = 4\pi\alpha^2(n_e e)^2/c^2\nu_c$  is the characteristic time of viscous diffusion of the plasma current,  $\nu_c$  is the electron coefficient of viscosity parallel to the equilibrium magnetic field. In this paper, the method of Ref. [6] is used to study the linear behavior of the double tearing mode caused by electron anomalous viscosity. Because of the complexity of the resulting equations, only an approximate solution is obtained. From this approximate solution, a comprehensive discussion of the key aspects of the problem is presented. The results show that the double tearing mode caused by viscosity has similar linear behavior as the resistance double tearing mode. When two rational surfaces with  $k \cdot B = 0$  are very close to each other, double tearing occurs, and its linear growth rate varies as  $\gamma \propto R^{-1/5}$ ; if the two rational surfaces are farther apart, double tearing does not occur, and the mode grows according to  $\gamma \propto R^{-1/3}$ . The transition between the two cases takes place approximately at the point  $\alpha x_s \propto (\alpha^4/R)^{1/15}$ , where  $\alpha$  is the disturbance wave number;  $2x_s$  is the distance between the two rational surfaces.

## II. Equilibrium Configuration and MHD Equations

We consider a carrier plasma plate with equilibrium plasma velocity  $V_0 = 0$ , and equilibrium magnetic field

$$B_0(x) = B_{0y}(x)\hat{y} + B_{0z}(x)\hat{z}, \quad (1)$$

where  $B_{0y}(x)$  is zero at  $x=\pm x_s$ , and the plasma current is in the  $z$  direction. The characteristic linearity of the plasma plate in the  $x$  direction is  $\propto x$ . Assume that the plasma is incompressible, then we can introduce the magnetic flux function  $\psi(x,y,t)$  and the velocity potential function  $\phi(x,y,t)$  which are defined by the following equations respectively:

$$B_\perp = \nabla\psi \times \hat{z} \quad (2)$$

$$V_\perp = \nabla\phi \times \hat{z}. \quad (3)$$

Taking into account electron viscosity, the Ohm's law can be written as

$$E = \eta j - \frac{1}{c} V \times B - \frac{\nu_c}{(en_e)^2} \nabla^2 j. \quad (4)$$

From this equation and equation (2), and Faraday's electromagnetic induction law, one can readily obtain its  $z$  component as

$$\frac{\partial\phi}{\partial t} = -V \cdot \nabla\psi + \frac{c^2}{4\pi} \eta \nabla^2\phi - \frac{\nu_c c^2}{4\pi(en_e)^2} \nabla^4\phi. \quad (5)$$

The z component of the equation of motion of the plasma gives

$$\frac{\partial}{\partial t}(\nabla^2 \phi) = -(V \cdot \nabla) \nabla^2 \phi + \frac{1}{4\pi\rho} \{ \nabla(\nabla^2 \phi) \times \nabla \phi \} \cdot \nabla. \quad (6)$$

Equations (5) and (6) are the main equations that will be used in this analysis. Let the disturbance be of the form  $f(x) \exp(iky y + \gamma t)$ , then the linearized equations (5) and (6) are of the form:

$$\gamma \phi_1 = V_x B_{0y}(x) + \frac{c^2}{4\pi} \eta_0 \left( \frac{\partial^2 \phi_1}{\partial x^2} - k_y^2 \phi_1 \right) - \frac{c^2 v_x}{4\pi(n_e c)} \left( \frac{\partial^4 \phi_1}{\partial x^4} + k_y^4 \phi_1 \right), \quad (7)$$

$$\rho \gamma \left( \frac{\partial^2 \phi}{\partial x^2} - k_y^2 \phi \right) = -\frac{i}{4\pi} k_y B_{0y}'(x) \phi_1 + \frac{i k_y}{4\pi} B_{0y}(x) \left( \frac{\partial^2 \phi_1}{\partial x^2} - k_y^2 \phi_1 \right), \quad (8)$$

where  $\eta$  and  $\rho$  are constants. By choosing  $x$ ,  $B_0$ , and  $\tau_H = \sqrt{4\pi\rho_0}/B_0$  as the non-dimensionalization parameters for length, magnetic field, and time, respectively, equations (7) and (8) become:

$$\gamma \tau_H \phi_1 = \gamma \tau_H \xi B_{0y}(x) + \frac{1}{S} \left[ \frac{\partial^2 \phi_1}{\partial x^2} - \alpha^2 \phi_1 \right] - \frac{1}{R} \left[ \frac{\partial^4 \phi_1}{\partial x^4} + \alpha^4 \phi_1 \right], \quad (9)$$

$$(\gamma \tau_H)^2 \left( \frac{\partial^2 \xi}{\partial x^2} - \alpha^2 \xi \right) = \alpha^2 B_{0y}'(x) \phi_1 - \alpha^2 B_{0y}(x) \left[ \frac{\partial^2 \phi_1}{\partial x^2} - \alpha^2 \phi_1 \right], \quad (10)$$

where  $\alpha = ky$ ,  $\xi = \frac{iky}{\gamma} \phi$ ,  $S = \tau_r/\tau_H$ ,  $R = \tau_v/\tau_H$ ; from equation (5) it is easy to see that  $\tau_v = 4\pi\eta^2/(\eta_e e)^2/\nu_c c^2$ , which is the characteristic time of the viscous diffusion of the magnetic field on the plasma plate.

### III. Partitioned Treatment

Equation (9) shows that the effect of dissipation is important only within a thin layer next to the surface  $B_{0y}(x) = 0$ ; away from this surface, the last two terms on the right-hand side of equation (9) can be neglected compared to the first term, i.e., the effect of dissipation is sufficiently small to be ignored. Therefore, in solving equation (9) inside the region next to the singular surface  $B_{0y}(x) = 0$  (called the inner region or the dissipation layer), we use the method of partitioned treatment which is often used in analyzing the resistance tearing mode. In the region away from the singular surface (called the outer region or ideal hydromagnetic region), we seek a solution of the ideal MHD equation which is obtained by letting  $S \rightarrow \infty$ ,  $R \rightarrow \infty$  in equation (9). Then the dispersion relation is obtained by matching the solutions of these two regions at the boundary.

First, we consider the ideal hydromagnetic case, equation (9) gives

$$\phi_1 = B_{0y}(x) \xi,$$

Substituting into equation (10) yields

$$\frac{d}{dx} \left\{ [(\gamma \tau_H)^2 + (\alpha B_{0y}(x))^2] \frac{d\xi}{dx} \right\} = \alpha^2 [(\alpha_{0y}(x))^2 + (\gamma \tau_H)^2] \xi, \quad (11)$$

Comparing with the term  $\alpha B_{0y}(x)$  and omitting the inertial term, we obtain:

$$\frac{d}{dx} \left[ (\alpha B_{0y}(x))^2 \frac{d\xi}{dx} \right] = \alpha^4 B_{0y}^3(x) \xi. \quad (12)$$

If  $\xi$  is expanded in terms of the parameter  $\alpha^2 x_s^2$  (assume  $\alpha^2 x_s^2 \ll 1$ ):

$$\xi = \xi_0 + \xi_1 + \dots,$$

then the zeroth order term of equation (12) is

$$\frac{d}{dx} \left\{ [\alpha B_{0y}(x)]^2 \frac{d\xi_0}{dx} \right\} = 0. \quad (13)$$

Since the displacement  $\xi_0$  is symmetric about the surface  $x=0$ , and  $|x| = x_s$  is a singular surface, the solution of equation (13) can be written as<sup>9</sup>

$$\begin{aligned} \xi_0(x) &= \xi_{00} = \text{const.} \quad |x| < x_s; \\ \xi_0(x) &= 0 \quad |x| > x_s. \end{aligned} \quad (14)$$

This is the ideal hydromagnetic instability which corresponds to double tearing--typical displacement of double twisting.<sup>6</sup> The first order solution is given by the following equation:

$$\begin{aligned} \frac{1}{\xi_{00}} \frac{d\xi_1}{dx} &= \left( \frac{\alpha}{B_{0y}(x)} \right)^2 \int_0^x B_{0y}^3(x') dx' \quad |x| < x_s, \\ \frac{1}{\xi_{00}} \frac{d\xi_1}{dx} &= \left( \frac{\alpha}{B_{0y}(x)} \right)^2 \int_0^{x_s} B_{0y}^3(x') dx' \quad |x| \geq x_s. \end{aligned} \quad (15)$$

In the vicinity of the surface  $x=x_s$ , we expand  $B_{0y}(x)$  in a power series and omit the two terms on the right-hand side of equation (11) to arrive at a solution which joins with equation (14):

$$\xi = \frac{1}{2} \xi_{00} \left\{ 1 - \frac{2}{\pi} \arctan [\alpha B_{0y}'(x - x_s) / \gamma \tau_H] \right\}, \quad (16)$$

where  $B_{0y}' = B_{0y}'(x_s)$ . Now, by equating  $d\xi/dx$  obtained from equation (16) in the limit  $\alpha B_{0y}'(x - x_s) / \gamma \tau_H \rightarrow -\infty$  with  $d\xi_1/dx$  given by equation (15) in the limit  $x \rightarrow x_s^-$ , we can obtain the rate of growth of the double twisting mode:

$$\gamma_H \tau_H = - \left( \frac{\pi \alpha^3}{B_{0y}^3} \right) \int_0^{x_s} B_{0y}^3(x') dx', \quad (17)$$

This is a measure of the pure MHD drive energy. Since  $\gamma_H < 0$ , the double twisting mode in the plate configuration is stable. But the right-hand side of equation (17) is proportional to  $(\alpha x_s)^3$ ; in the limit  $x_s \rightarrow 0$ , the double twisting mode becomes marginally stable. The dissipation effect can stabilize this double twisting mode to produce a double tearing mode. Considering the effect of dissipation, in the outer region we use the ideal MHD equation and the corresponding solution given by equations (14) and (15). In the inner region, by comparing with  $d^2/dx^2$ , omitting  $\alpha^2$  and expanding  $B_{0y}(x)$  in a power series in the neighborhood of the surface  $x=x_s$ , equations (9) and (10) become

$$(\gamma r_H)^2 \xi'' = -\alpha^2 B'_{0y}(x - x_s) \phi_1', \quad (18)$$

$$(\gamma r_H) \phi_1 = \gamma r_H B'_{0y}(x - x_s) \xi + \frac{1}{S} \frac{\partial^2 \phi_1}{\partial x^2} - \frac{1}{R} \frac{\partial^2 \phi_1}{\partial x^4}, \quad (19)$$

where double prime represents the second derivative of  $x$ .

By introducing the transformations  $x - x_s \rightarrow x$ ,  $\psi_1/B'_{0y} \rightarrow \psi_1$ ,  $\xi \rightarrow \xi$  equations (18) and (19) become

$$\xi'' = \frac{x}{\lambda} \phi_1', \quad (20)$$

$$\phi_1 = -x\xi + \frac{\varepsilon}{\lambda} \phi_1'' - \frac{\sigma}{\lambda} \phi_1^{(4)}, \quad (21)$$

where  $\lambda = \gamma r_H / \alpha B'_{0y}$ ,  $\varepsilon = 1/S\alpha B'_{0y}$ ,  $\sigma = 1/\alpha B'_{0y} R$ . These are the equations which must be solved for the inner region; the boundary conditions are obtained by matching the outer solution at  $|x| \rightarrow \infty$ . This set of equations can be reduced to a sixth order equation in  $\xi$ :

$$-\lambda\sigma \left[ \frac{24}{x^5} \xi'' - \frac{24}{x^4} \xi^{(3)} + \frac{12}{x^3} \xi^{(4)} - \frac{4}{x^2} \xi^{(5)} + \frac{1}{x} \xi^{(6)} \right] + \lambda\varepsilon \left[ \frac{2}{x^3} \xi'' - \frac{2}{x^2} \xi^{(3)} + \frac{1}{x} \xi^{(4)} \right] - 2\xi' - \left( x + \frac{\lambda}{x} \right) \xi'' = 0, \quad (22)$$

Equation (22) should have six linearly independent solutions. It is not difficult to see that in the limit  $|x| \rightarrow \infty$ , one of the solutions has an asymptotic form  $\xi = \text{const}/x$ , i.e.,  $d\xi/dx = \text{const}/x^2$ . This solution matches well with the outer solution. It can be expressed as

$$\xi = \frac{1}{2} \xi_\infty + \xi_{\text{odd}}(x). \quad (23)$$

The outer solution (15) can be written as

$$\frac{1}{\xi_\infty} \frac{d\xi}{dx} = -\frac{\lambda_H}{\pi} \frac{1}{x^2}, \quad (24)$$

then

$$\lambda_H = -\pi \frac{\alpha^2}{B_{0y}^2} \int_0^{x_s} B_{0y}^2(x') dx'. \quad (25)$$

The boundary condition to be satisfied by  $\xi_{\text{odd}}(x)$  in equation (23) is

$$\frac{x^3}{2} \frac{d}{dx} (\ln \xi_{\text{odd}}) = -\frac{1}{\pi} \lambda_H \quad x \rightarrow -\infty \quad (26)$$

or

$$\frac{x^3}{2} \frac{d}{dx} (\ln \xi_{\text{odd}}) = \frac{1}{\pi} \lambda_H, \quad x \rightarrow \infty$$

Since  $\xi_{\text{odd}}$  is an odd function of  $x$ ,  $x \rightarrow -\infty$  and  $x \rightarrow \infty$  represent the singular surfaces moving away from  $x=x_s$  in the directions of decreasing  $x$  and increasing  $x$  respectively.

For given values of  $\lambda$ ,  $\sigma$  and  $\varepsilon$ , and given the conditions of equation (26) and  $\xi_{\text{odd}}(0)=0$ , as well as the boundary condition imposed on  $\psi_1$ , equation (20) and (21) can be solved numerically to provide the dispersion relation between  $\lambda$  and  $\lambda_H$  for given values of  $\varepsilon$  and  $\sigma$ . However, this is beyond the scope of this paper. In this paper, we are only concerned with the double tearing mode caused by the electron viscosity of the plasma and we are interested in analyzing the linear behavior of this mode.

If we let  $\varepsilon = 0$  in equations (20) and (21), then

$$\xi'' = \frac{x}{\lambda^2} \phi_1, \quad (27)$$

$$\phi_1 = -x\xi - \frac{\sigma}{\lambda} \phi_1^{(4)}. \quad (28)$$

To solve this set of equations, we follow an approach similar to that of Ref. [9] by introducing the function

$$\chi(x) = x\phi_1' - \phi_1 = \lambda^2 \frac{d\xi}{dx} + \chi_\infty, \quad (29)$$

Then equations (27) and (28) can be combined into a single equation

$$\sigma\lambda \left[ \frac{d^4\chi}{dx^4} - \frac{4}{x} \frac{d^3\chi}{dx^3} + \frac{8}{x^2} \frac{d^2\chi}{dx^2} - \frac{8}{x^3} \frac{d\chi}{dx} \right] + (\lambda^2 + x^2)\chi = x^2\chi_\infty, \quad (30)$$

where  $\chi_\infty$  is a constant which can be determined from the asymptotic behavior of the solution in the following manner.

From equation (28) we get

$$\begin{aligned} \xi &= -\frac{\phi_1}{x} - \frac{\sigma}{\lambda} \frac{1}{x} \frac{d^4\phi_1}{dx^4} \\ &= -\frac{1}{x} \chi(x) + \int_x^\infty \frac{1}{x} \frac{d\chi}{dx} dx - \frac{\sigma}{\lambda} \frac{1}{x} \left[ \frac{2}{x^3} \frac{d\chi}{dx} - \frac{2}{x^2} \frac{d^2\chi}{dx^2} + \frac{1}{x} \frac{d^3\chi}{dx^3} \right]. \end{aligned}$$

When  $x \rightarrow -\infty$ ,  $\xi \rightarrow \xi_\infty$ , hence

$$\xi_\infty \simeq \int_{-\infty}^\infty \frac{1}{x} \frac{d\chi}{dx} dx \simeq 2 \int_0^\infty \frac{1}{x} \frac{d\chi}{dx} dx.$$

When  $x \rightarrow -\infty$ ,  $d\xi/dx \rightarrow \text{const}/x^2$ ; by defining  $d\xi/dx|_{x \rightarrow -\infty} = -\chi_\infty/x^2$ , and comparing this with the following expression given by equation (26)

$$\begin{aligned} \frac{x^2}{2} \frac{d}{dx} (\ln \xi_{\text{odd}}) \Big|_{x \rightarrow -\infty} &= \frac{x^2}{2} \frac{1}{\xi_{\text{odd}}} \frac{d\xi_{\text{odd}}}{dx} \Big|_{x \rightarrow -\infty} = \frac{x^2}{2} \frac{1}{\xi_\infty} \frac{d\xi}{dx} \Big|_{x \rightarrow -\infty} \\ &= -\frac{1}{\pi} \lambda_H \end{aligned}$$

we obtain

$$\chi_\infty = \frac{1}{\pi} \lambda_H \xi_\infty \simeq \frac{2\lambda_H}{\pi} \int_0^\infty \frac{d\chi}{dx} \frac{dx}{x}. \quad (31)$$

This is the boundary condition that must be satisfied by the solution of equation (30).

Now let us discuss the solution of equation (30). In the case of the ideal hydromagnetic limit,  $\sigma \rightarrow 0$ , the solution of equation (30) is

$$\chi = \frac{x^2}{\lambda^2 + x^2} \chi_\infty, \quad (32)$$

Substituting equation (31) gives

$$\lambda = \lambda_H,$$

which represents the ideal hydromagnetic mode.

In the case where the ideal hydromagnetic mode is marginally stable,  $\lambda_H = 0$ ,  $\chi_\infty = 0$ , equation (30) becomes

$$\sigma \lambda \left[ \frac{d^4 \chi}{dx^4} - \frac{4}{x} \frac{d^3 \chi}{dx^3} + \frac{8}{x^2} \frac{d^2 \chi}{dx^2} - \frac{8}{x^3} \frac{d\chi}{dx} \right] + (\lambda^2 + x^2) \chi = 0. \quad (33)$$

To an accuracy of the order of  $x^3$ , the solution of equation (33) is given by

$$\chi = A \exp[-x^2/2^{6/5} \sigma^{2/5}], \quad \lambda = \sigma^{1/5}/2^{1/5}. \quad (34)$$

The constant A can be determined by substituting equation (31), and we get

$$\chi = -\frac{\xi_\infty \sigma^{1/5}}{\sqrt{\pi} x^{2/5}} \exp[-x^2/2^{6/5} \sigma^{2/5}]. \quad (35)$$

Equation (34) gives the rate of growth of the double tearing mode caused by electron parallel viscosity under the condition that the ideal hydromagnetic mode is marginally stable:

$$\gamma = \frac{1}{2^{2/5}} (\alpha B'_{0y})^{4/5} \frac{1}{r_H^4 r_V^{1/5}}, \quad (36)$$

This is identical to the rate of growth of the mode  $m=1$ .<sup>7</sup>

In order to obtain a general solution of equation (30), we introduce the following transformations:  $\zeta = x^2/\lambda^{1/3}\sigma^{1/3}$ ,  $\hat{\lambda} = \lambda/\sigma^{1/5}$ , hence equation (30) reduces to

$$\zeta^2 \frac{d^4 \chi}{d\zeta^4} + \zeta \frac{d^3 \chi}{d\zeta^3} - \frac{1}{4} \frac{d^2 \chi}{d\zeta^2} + \frac{1}{16} (\hat{\lambda}^{5/3} + \zeta) \chi = \zeta \chi_{\infty}. \quad (37)$$

We shall now seek an approximate solution of this equation. First, by comparing with equation (34), the term containing  $\zeta^2$  can be eliminated. Next, we assume that the approximate solution is of the form:

$$\chi = A \left\{ 1 + B \int_0^1 t^l (1+t)^m \exp \left[ -\frac{\zeta}{\alpha'} \left( \frac{1-t}{1+t} \right) \right] dt \right\}, \quad (38)$$

Substituting it into equation (37) to determine the constants A, B, l, m and  $\alpha'$ , we get

$$A = \chi_{\infty}, \quad B = -\frac{\hat{\lambda}^{5/3}}{2^{m+1}\alpha'}, \quad l = \frac{\hat{\lambda}^{5/3}}{3\alpha'} - \frac{13}{12}, \quad m = \frac{\hat{\lambda}^{5/3}}{3\alpha'} + \frac{5}{4}, \quad \alpha' = 2^{4/3}. \quad (39)$$

By substituting this approximate solution into equation (31), we obtain the following dispersion relation

$$\lambda = \lambda_H \left\{ \frac{\hat{\lambda}^{5/2}}{16 \cdot 2^{(\frac{\hat{\lambda}^{5/3}}{3\alpha'} + \frac{1}{4})}} \cdot \frac{\Gamma\left(\frac{\hat{\lambda}^{5/3}}{6\sqrt[3]{2}} - \frac{1}{12}\right)}{\Gamma\left(\frac{\hat{\lambda}^{5/3}}{6\sqrt[3]{2}} + \frac{17}{12}\right)} \cdot F\left(-\frac{\hat{\lambda}^{5/3}}{6\sqrt[3]{2}} - \frac{3}{4}, \frac{\hat{\lambda}^{5/3}}{6\sqrt[3]{2}} - \frac{1}{12}, \frac{\hat{\lambda}^{5/3}}{6\sqrt[3]{2}} + \frac{17}{12}, -1\right) \right\}, \quad (40)$$

where F is the hypergeometric function:<sup>10</sup>

$$F(a, b, c, z) = \frac{\Gamma(c)}{\Gamma(a)\Gamma(b)} \sum_{n=0}^{\infty} \frac{\Gamma(a+n)\Gamma(b+n)}{\Gamma(c+n)} \frac{z^n}{n!}.$$

It is not difficult to show that the function F in equation (40) is absolutely convergent. The approximate dispersion relation between  $\hat{\lambda}$  and  $\hat{\lambda}_H$  is shown in Figure 1. It can be seen from Figure 1 that for small  $\hat{\lambda}$  values, the approximate results obtained here are in good agreement with the numerical solution for the mode  $m=1$ ; for larger values of  $\hat{\lambda}$ , the two solutions begin to diverge, but the general trends of variation in the two cases are consistent. Small values of  $\lambda$  correspond to the condition  $\hat{\lambda}_H < 0$  or  $\lambda_H \approx 0$ , i.e., the conditions for which the ideal hydromagnetic double twisting mode is stable or nearly stable. These are precisely the conditions which are important for the study of double tearing mode caused by dissipation effects. Therefore, the approximate solution presented here is appropriate for studying the double tearing mode caused by electron viscosity.

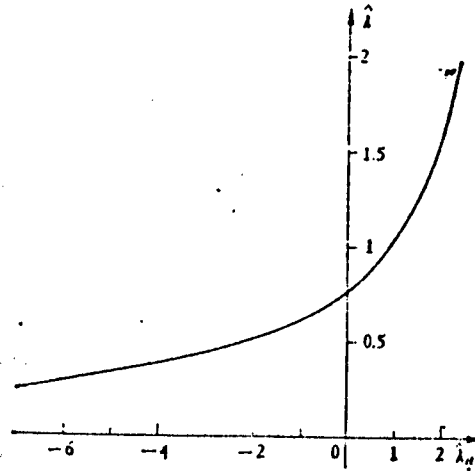


Figure 1. Dispersion Curve Obtained From Equation (40)

The dispersion relation (40) can be further written in the following approximate form:

$$\lambda = \lambda_H \left\{ \frac{\hat{\lambda}^{5/2}}{16 \cdot \sqrt[3]{2} \left( 1 + \frac{\hat{\lambda}^{5/3}}{6 \sqrt[3]{2}} \ln 2 \right)} \left[ 1 + \frac{\left( \frac{\hat{\lambda}^{5/3}}{6 \sqrt[3]{2}} + \frac{3}{4} \right) \left( \frac{\hat{\lambda}^{5/3}}{6 \sqrt[3]{2}} - \frac{1}{12} \right)}{\frac{\hat{\lambda}^{5/3}}{6 \sqrt[3]{2}} + \frac{17}{12}} \right] \right. \\ \left. \times \frac{\Gamma \left( \frac{\hat{\lambda}^{5/3}}{6 \sqrt[3]{2}} - \frac{1}{12} \right)}{\Gamma \left( \frac{\hat{\lambda}^{5/3}}{6 \sqrt[3]{2}} + \frac{17}{12} \right)} \right\}. \quad (41)$$

From this equation we can examine two special cases:

1) If  $\lambda_H = 0$ , then  $\hat{\lambda} = 1/2^{2/5}$

i.e.,  $\lambda = \sigma^{1/5}/2^{2/5}$

which is identical to equation (34).

2) If  $\hat{\lambda}_H < 0$ , and  $|\hat{\lambda}_H| \gg 1$ , then one can see from the dispersion curve that  $\hat{\lambda} < 1$ , in this case equation (41) gives

$$\lambda = \text{const} \cdot \sigma^{1/3} / \lambda_H^{2/3} \quad (42)$$

Now let us examine the condition under which the tearing mode follows equation (34) and the condition under which transition from equation (34) to equation (42) takes place. To proceed, we differentiate equation (27) twice and get

$$\xi^{(4)} = \frac{\pi}{\lambda^2} \phi_1^{(4)} + \frac{2}{\lambda^2} \phi_1^{(3)}.$$

By substituting  $\psi_1^4$  from equation (28) into the above equation, we get

$$\xi^{(4)} = \frac{x}{\lambda\sigma} [-\phi_1 + x\xi] + \frac{2}{\lambda^2} \phi_1^{(3)}.$$

Comparing terms of  $\xi$  on both sides of the equation, one can readily calculate the thickness of the dissipation layer to be:

$$\Delta \cong (\lambda\sigma)^{1/6} \cong [\gamma\tau_H/(\alpha B_{oy}')^2 R]^{1/6}. \quad (43)$$

It must be pointed out that the dispersion curve obtained previously is valid only under the condition  $\Delta \ll x_s$ , because only then can we match the solution of the dissipation layer with the solution of the outer region given by equation (15). Furthermore, it is important to remember that the outer solution is obtained under the assumption  $\alpha x_s \ll 1$ .

By definition

$$\hat{\lambda} = \frac{\lambda}{\sigma^{1/5}} = \gamma\tau_H (R/\alpha^4 B_{oy}')^{1/5}, \quad (44)$$

$$\hat{\lambda}_H = \lambda_H/\sigma^{1/5} = \gamma_H\tau_H (R/\alpha^4 B_{oy}')^{1/5}, \quad (45)$$

Based on equation (17) and the discussion following it, when  $|x_s| \ll 1$ ,  $|\hat{\lambda}_H| \ll 1$ , therefore,

$$\hat{\lambda} = \frac{1}{2^{2/5}}$$

In this case, one obtains from equation (43)

$$\gamma\tau_H \cong 0.8(\alpha^4 B_{oy}'^4/R)^{1/5}, \quad (46)$$

thus, the rate of growth varies as  $R^{-1/5}$ .

From the conditions  $|\hat{\lambda}_H| \ll 1$  and  $\Delta \ll x_s$  (assume  $B_{oy}'=1$ ), we get

$$\left(\frac{\alpha}{R}\right)^{1/5} \ll \alpha x_s \ll \left(\frac{\alpha}{R}\right)^{1/15}. \quad (47)$$

When  $x_s \gg 1$ , we have  $|\hat{\lambda}_H| \gg 1$ , and  $\hat{\lambda} \ll 1$ , hence

$$\gamma\tau_H = (\dots)/(\gamma_H\tau_H)^{2/3} (\alpha^4 B_{oy}'^4/R)^{1/3}, \quad (48)$$

i.e., the rate of growth varies as  $R^{-1/3}$ .

From the conditions  $|\hat{\lambda}_H| \gg 1$  and  $\alpha x_s \ll 1$ , we get

$$\left(\frac{\alpha}{R}\right)^{1/15} \ll \alpha x_s \ll 1. \quad (49)$$

This shows that the transition from  $R^{-1/5}$  variation to  $R^{-1/3}$  variation approximately takes place at the point  $\alpha x_s \sim (\alpha^4/R)^{1/15}$ .

In addition, we can estimate the time required for the viscosity-induced current diffusion to pass through the tearing layer to be:

$$\tau_\Delta \simeq \frac{\Delta^4}{\eta_c} = \Delta^4 \tau_H R, \quad (50)$$

the result is

$$\gamma \tau_\Delta = \gamma (\gamma \tau_H / \alpha^2 B_0^2 R)^{1/3} \tau_H R = \hat{\lambda}^{1/3}.$$

If the MHD mode is marginally stable,  $\hat{\lambda} \sim 1$ , the time required for the current diffusion to pass through the tearing layer is of the same order of magnitude as the growth time of the tearing mode. In this case, the approximation that  $\psi_1$  in the tearing layer is a constant is no longer applicable; the rate of growth of the mode is given by equation (46). If the MHD mode is stable, then  $\hat{\lambda} \ll 1$ , or  $\gamma \tau_\Delta \ll 1$ , the characteristic time of the growth of tearing mode is much greater than the time required for the current diffusion to pass through the tearing layer, and  $\psi_1$  in the tearing layer can be approximated as a constant. In this case, the rate of growth is given by equation (48).

#### IV. Conclusion and Discussion

The above analysis shows that in the equilibrium configuration considered in this paper, there are two different tearing modes caused by electron parallel viscosity; their rates of growth vary as  $R^{-1/5}$  and as  $R^{-1/3}$ , respectively. Strictly speaking, only the former mode is the so-called double tearing mode. It is developed from the mutual enforcement of disturbances on two rational surfaces which are in close proximity and satisfy the condition  $\mathbf{A} \cdot \mathbf{B} = 0$ ; its rate of growth is higher than the ordinary tearing mode and its mode structure is different from that of ordinary mode. In the case of the latter mode, while there are disturbances on two neighboring rational surfaces, the two disturbances do not interfere with each other; each disturbance develops according to the structure and growth rate of ordinary tearing mode. Exactly which mode develops is determined by the distance between the two singular surfaces. The transition from one mode to the other occurs approximately at the location

$$\frac{x_f}{a} \sim (k_y a)^{-11/15} R^{-1/15}$$

If the distance between the two singular surfaces is much smaller than this value, then double tearing mode will develop; otherwise, only ordinary tearing mode will appear.

The time required for the electron viscosity-induced current diffusion to pass through the tearing layer is of the same order of magnitude as the double tearing growth time; therefore, the development of double tearing is closely related to the failure of the approximation of constant  $\psi$  in the tearing layer.

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3012

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APPLIED SCIENCES

BRIEFS

GUANGZHOU TRAINS COMPUTER PERSONNEL--Beginning October of last year, the Science and Technology Consultative Committee and the Federation of Industry and Commerce of Guangzhou Municipality have jointly sponsored 3 sessions of technical training classes in the use of microcomputers. A total of 163 students from these classes are already actively and effectively promoting the use of microcomputers in various production, scientific research and educational departments. The students who have attended these three training classes come from Guangzhou municipality's more than 90 different units such as industrial and commercial enterprises, communications and transportation, city construction, banking, post and telecommunications, foreign trade, and education. Some students were entirely exempted from regular work and studied for 25 days consecutively, others were on half-time duty, for 2 1/2 months. By the end of their training, they would have gained a fundamental knowledge and the uses of computers. An engineer of the aquatic products organization learned that microcomputers are used abroad as a technique to control oil consumption, and he planned to use microcomputers to control oil consumption on the motorized junks of his organization. So far, 10 microcomputers have been bought and tests for the techniques for oil conservation have been started. A technician of a rubber organization also plans to use two microcomputers in the control and management of the production process. The Science Consultative Committee and the Association of Industry and Commerce of Guangzhou Municipality are now summing up their experiences in the training courses and will continue the computer training classes. The fourth term will start on 22 February and the fifth term is scheduled for 1 March. [Text] [Guangzhou NANFANG RIBAO in Chinese 1 March 84 p 2] 9808

RADIO PLANT EFFECTIVELY PROMOTES MICROCOMPUTER USAGE--The Shaoguan Radio Plant in our province [Guangdong], specially designated as a microcomputer manufacturing plant, is actively promoting microcomputers. Last year, they sold over 20 8-bit and 16-bit microcomputer systems to domestic users, who use them in various sectors of the national economy, such as scientific research, education, shipbuilding design, environmental monitoring, monitoring textile spinning and weaving, earthquake data processing and personnel administration, achieving excellent economic results. This plant has decided to expand its production this year, and has already signed over 30 delivery contracts since January. At

the beginning of last year, this plant transferred some of its engineers and skilled workers to form a team for the promotion of microcomputer uses. They began production by boldly importing key components and parts of 8-bit and 16-bit microcomputers. They assembled complete sets by designing their own computer cabinets, brazing, loading, debugging, implementing monitoring and operating systems and the BASIC language, and then put them on the market. In order to promote the use of microcomputers more effectively, the Shaoguan Radio Plant began user training classes, microcomputer technology lectures and recounted work experience for the benefit of its customers. These moves were highly appreciated by the users. [By Luo Jinmen [5012 6855 7024] [Text] [Guangzhou NANFANG RIBAO in Chinese 4 Mar 84 p 2] 9808

CSO: 4008/259

LIFE SCIENCES

STATUS, PROGRESS OF HEMATOLOGY DISCUSSED

Tianjin ZHONGHUA XUEYEXUE ZAZHI [CHINESE JOURNAL OF HEMATOLOGY]  
in Chinese No 6, 30 Dec 84 pp 361, 366-368

[Article by Chen Wenjie [7115 2429 2638], president of the Institute of Hematology, Chinese Academy of Medical Sciences and chairman of the Society of Hematology, Chinese Medical Association: "The Current State of Hematological Research in China and Abroad and the Direction of Our Efforts"]

[Excerpts] The 12th Party Congress of the Communist Party of China pointed out the various tasks involved in initiating a comprehensive new phase in China's socialist modernization. It formulated strategic goals and a series of general and specific policies for Chinese economic construction by the year 2000, and therein it was particularly pointed out that to carry out the four modernizations is to modernize science and technology.

Medicine is a component part of scientific and technological work. As far as overall socialist economic construction is concerned, medicine is also a service category that has the basic mission of preventing and curing illnesses, safeguarding the health of the people and improving the quality of our national life. Hematology, which is a branch of medicine, must also abide by this guiding ideology and reflect medicine's basic mission.

This article intends to suggest some views and provide comrades with some references on the current state of hematological research in China and abroad, the objectives of our struggle and the problems we are having in our efforts to initiate a new phase in Chinese hematology.

The Status and Progress of Chinese Clinical and Experimental Research in hematology.

Since the 3d Plenum of the 11th CPC Central Committee, Chinese hematology has developed quite rapidly and the hematological contingent has continued to mature and strengthen. In particular, young and middle-aged technological mainstays have matured rapidly and become the nucleus of this contingent. Simultaneously, the various provinces, municipalities and autonomous regions have all established clinical and experimental research bases such as research institutes, offices groups and so forth, and on this basis have actively launched work in clinical areas, scientific research and education.

In the past few years, Chinese clinical research in hematology has been quite extensive, diagnostic and therapeutic levels have improved greatly and we have made several achievements. Experimental research has also developed quite rapidly, we have initiated work in several fields and achieved some positive results.

The major achievements and advances in Chinese hematology are as follows:

#### I. Clinical Hematological Research:

A. Clinical Research in Leukemia: 1) China has done a great deal of work in clinical research on leukemia. A retrospective survey of deaths nationwide between 1973 and 1975 reveals that the incidence of leukemia was 2.52 per 100,000 people. Some provinces and municipalities have also conducted clinical surveys. For example, the city of Pingdingshan in Henan conducted a continuous 10-year survey from 1974-1983 and found that the average incidence of leukemia was 4.33 per 100,000 people. 2) Based on the particulars of clinical, hemographic and bone marrow changes, we proposed the existence of a subacute granulocytic type of leukemia. 3) We were the first to use tricuspid ester alkali [sanjiansha zhijian] [0005 1423 2619 7927 4354] to treat acute nonlymphocytic leukemia, and the overall remission rate using the HOAP program tricuspid ester alkali [sanjiansha zhijian], vincristine, cytosine arabinoside and prednisone) was 27.4-60 percent. In hematological research the use of pills made from Angelica sinensis root sinensis and aloe to treat chronic granulocytic leukemia has had some curative effects, and we have also further sifted out and purified the active principles of indirubin. We have artificially synthesized two types of indole medications, verified their antileukemic properties and carried out some research into their curative principles. Hainan Armed Forces Hospital has used intravertebral injections of tricuspid ester alkali [sanjiansha zhijian] to prevent the occurrence of central nervous system leukemia. We have begun to try out small doses of Ara-C to treat acute granulocytic leukemia, with fairly good results. 4) We have paid serious attention to the abnormal syndromes of leukemic prophase and myelosis and their apparent trend toward increased incidence. Many units have formulated or tried out typing and diagnostic standards based on their own experiences. 5) We have made some progress with the initiation of allogeneic bone marrow transplants or the injection or transplantation of fetal hepatic cells to treat acute monocytic leukemia, acute lymphocytic leukemia and chronic granulocytic leukemia. Of the three successful cases at Beijing Hospital's Hematology Research Institute, one case has survived for more than 2 and 1/2 years. 6) There has been an increase in the number of long-term survival cases: nearly 150 cases have survived for more than 3 years, 50-plus cases have survived for more than 5 years and the longest-lived are approaching 16 years.

B. Iron-Deficiency Anemia: 1) In 1982 pediatricians in Chinese provinces and municipalities conducted a survey of the incidence of iron-deficiency anemia in infants and children under 7 years of age. The results demonstrated a 25-65 percent incidence in urban areas and a 37-87 percent incidence in rural areas, with rates as high as 95 percent in one or two rural areas.

There were also reports of combined anemia in a minority of gynecological and obstetric patients. Some regions have initiated preventive measures with use of iron fortified cereals for children under 7. For example, in a commune in Jiangxi's Duanjin County the incidence of iron-deficiency anemia fell from 81.9 percent to 36.7 percent over the course of a year's observation. 2) There are some domestic units that have purified ferritin and produced a specific antiserum from it, and have also established serum ferritin assay methods for use in early diagnosis. Some regions have also developed a general check for serum iron and ferritin in healthy individuals and discovered ferritin abnormalities in 10.4-33.4 percent of normal females. The incidence of simple iron deficiency is far higher than that of iron-deficiency anemia, and this has begun to attract some serious attention. Health infirmities, slow physical and mental development and behavioral abnormalities due to iron deficiency are prevalent.

C. Nutritional Megaloblastic Anemia: This hemopathy does not occur frequently nationwide, but in a few regions, such as certain areas of Shanxi, Shaanxi, Sichuan and so forth, it is relatively common and its incidence is higher than that of iron-deficiency anemia. According to survey data from a Shanxi test site, as much as 24.2 percent of that population may have megaloblastic anemia and suspected folic acid or B<sub>12</sub> deficiency, and the rates may be as high as 59 percent among women and 55 percent among rural students. Xi'an Medical College detected 39 cases in general checkups on 5,091 students. According to the survey, megaloblastic anemia in high-incidence areas is primarily due to poor dietary habits, insufficient consumption of fresh vegetables, fruits, meats and eggs, unsuitable cooking methods and so forth, and it also has an indefinite association with household economic status.

D. Aplastic Anemia: 1) The incidence of this disease is higher in China than in Europe and the United States, but we still lack reliable nationwide figures. According to surveys in a few regions (such as the city of Mudanjiang in Heilongjiang and the city of Pingdingshan in Henan) its incidence is slightly lower than that of leukemia and, as far as etiological aspects are concerned, secondary aplastic anemia is more common than it was in the past. Combining the clinical data on 2,810 cases from various regions, more than 70 percent of the cases afflicted young patients and the proportion of acute to chronic cases was 1:4.6. 2) In clinical research, China first differentiated between acute and chronic types of aplastic anemia at the beginning of the 1960's. We used clinical manifestations, hemographs and multilocational myelographs as the primary indicators and discovered that the two types were notably divergent in their hematopoietic and immune functions. The intervening 20-plus years of experience verifies that typing standards are specific and applicable in more than 95 percent of all cases. However, they are of significant reference value for guiding treatment and theoretical research. 3) We have also conducted relatively systematic observation on hematopoietic functions and other experimental research areas. In particular there have been many reports from various regions on aspects of bone marrow stem-cell cultures, and these are of some significance in developing pathogenetic principles, diagnosis and treatment. Shanghai Second Medical College discovered the existence of inhibitors to normal bone

marrow CFU-C in the serum and lymphocytes of some patients. Some units have begun to use nuclein  $^{99m}\text{Tc}$  to carry out general bone marrow scans and radioautographs for observation of the state of bone marrow hematopoiesis. 4) In treatment, China has achieved notable success using traditional Chinese doctors and medicine or a combination of Western and traditional Chinese medicine to treat this disease, and has also summarized some patterns. According to the reports of 10 to 20 provinces and municipalities, the cure rate for chronic aplastic anemia is 42.9-89.3 percent. Several areas have developed androgen and assimilative hormones, as well as selective splenectomy, to treat aplastic anemia, achieving notably improved results. China has also begun to use neural stimulant treatments (such as strychnine and securinine) and has achieved a certain success. A few units that use bone marrow transplants, fetal liver infusions and antithymocyte globulins to treat acute cases have reported successful results.

E. Paroxysmal Nocturnal Hemoglobinuria: The incidence of this disease seems to be higher in China than in Europe or the United States. We have done a great deal of work on its clinical characteristics, its typing, its association with and differential diagnosis from aplastic anemia and other areas. We have also made some observations of erythrocytic ultrastructural organization, membranes, acetylcholinesterase and 2,3-DPG sialic acid SH base, and we consider this disease to be a defect in the erythrocytic membrane and a sensitivity to complement. With respect to treatment, we are exploring a therapy of combined Western and traditional Chinese medicine and have obtained some initial feedback.

## II. Areas of Recent Rapid Progress in Chinese Hemoglobin Disease Research

A. We have conducted an epidemiological survey of abnormal hemoglobin in the 28 provinces, municipalities and autonomous regions and among the 30-plus minority nationalities nationwide. The particulars of this survey are as follows: The hereditary genes for hemoglobin abnormalities are widely dispersed. The adjusted rate of occurrence is 0.309 percent, with a higher rate in southern than in northern areas. A further series of structural analyses was conducted on the hemoglobin abnormalities discovered, and among them there were 10 new types that had never before been reported in the literature. We have produced a map depicting the epidemiological distribution of hemoglobin abnormalities in China, and this provides invaluable data for anthropology, studies of population movements and eugenics. B. We have surveyed the incidence of thalassemia in 18-20 provinces, municipalities (and autonomous regions) and have preliminarily ascertained the distribution and conditions under which thalassemia occurs in China. We have also identified the areas of high beta thalassemia occurrence, such as Yunnan, Fujian, Sichuan, Guizhou, Guangdong and Guangxi. We are currently initiating an analysis of the gene atlas for alpha thalassemia hemoglobin and have provided the characteristics and basic conditions for alpha thalassemia genetic organization in China. This marks the beginning of gene-level molecular genetic research in China. In addition, we are also applying restricted isoelectric focusing and rapid trace-DNA molecular hybridization techniques to carry out prenatal diagnosis and provide effective measures for the treatment of this disease. C. We have attained some

experience with splenectomy to treat HbH patients and have advanced a formula that can predict the effectiveness of patient splenectomy.

We have conducted a survey of glucose-6-phosphate dehydrogenase deficiency disease in the 20-plus provinces, municipalities and autonomous regions nationwide, and have identified Guangdong, Guangxi and Sichuan as areas of high incidence. We have also begun to study the variability of this enzyme. We have advanced our own view of the pathogenesis, pathophysiology and clinical typing of the associated favism and have launched preventive and therapeutic work, attaining fairly good results.

III. On Aspects of Hematopoietic Stem-Cell Cultures: A. We have established several kinds of hemocytic parent-cell cultures but have not yet launched clinical and experimental work on some of them. B. We have made rather wide use of CFU-S, CFU-D, CFU-C and CFU-F cultures and have clinically assayed CFU-C changes in hemopathic patients (such as leukemia and aplastic anemia patients, etc.). At the same time, we have observed the association between CFU-C changes and prognosis. C. We have used CFU-D to screen Chinese herbal medicines, and from among medications for reinforcing the vital energy of the kidney we have found some that stimulate CFU-D growth. We have also used CFU-S, CFU-D, CFU-ED and CFU-C cultures to observe the principles of 'securinine's curative effects. D. We have observed the proliferation and specific properties of differentiation in hematopoietic stem cells (CFU-S).

IV. Research on Thrombosis and Hemostasis: Most of our research is at approximately the level of research abroad in the 1960's, and the majority is limited to clinical observation. Due to the lack of reagents, our methods are backwards and we still have problems in the diagnosis of many hemorrhagic disease patients. Some coagulant-factor or thrombocytic congenital defects that have been reported from abroad have not yet been reported domestically. We have begun to direct serious attention to the reasons for the frequent occurrence of non-thrombocytopenic purpura, and have launched research into the immune mechanism. We have verified that thrombocyte surface conjugated antibodies show a negative correlation to thrombocyte count. We have done some initial work in surveying associated hemophilia and conducting social psychological surveys on its carriers. In studying agents to prevent thrombocytic aggregation, in the past few years China has sorted out the active principles of several Chinese medicines, such as the acid and sodium in *Resinae Ferulae*, the piperazine in *Rhizoma Ligustici Chuanziong* and so forth. We are currently conducting research into thrombocyte releasants and thrombocyte monoclonal antibodies. We have achieved some success using cicen [0459 0639 Stichopodidae (?) acid mucopolysaccharides to diagnose defects in thrombocyte functions and treat thrombotic illnesses, and in using components of the venom of the Pallas pit viper to treat thrombotic illnesses.

V. Aspects of Experimental Leukemia Research: At present, China has more than 12 strains of mouse leukemia models that can be divided into virally induced (such as T638 and L6565), chemically induced (such as L7811) and radiation-induced (L801) types. Based on their cell types, there are

lymphatic cell types (the vast majority of them are T-cells) and granulocytic cell types. As far as growth patterns are concerned, there are general infiltrative types, sarcomas and hydroperitoneal types. We are using the various kinds of mouse leukemia models to launch basic theoretical research into many areas. For example, we are isolating and extracting viruses, assaying the activity of reverse transcriptase and we have identified the various chromosome markers. We have had some success in studying nucleic acid metabolism, cell membrane composition, various biological characteristics of cells, the process by which leukemia cells infiltrate the body and cell dynamics. We have discovered the existence of specific antigens in mouse leukemia cells. In addition, by using mouse models we have screened large quantities of synthetic drugs, Chinese herbal medicines and traditional folk medicines, and integrated experimental therapeutic studies from applied medicine and immune therapy.

VI. HLA Work: China lagged behind the rest of the world by more than 10 years in initiating HLA work, but due to concerted efforts and cooperation nationwide, our progress is quite rapid. A. With regard to HLA antigens, in addition to the admittedly few units developed at D-sites, the majority of antigens have been detected at A, B, C and DR sites. B. Ten Chinese units have screened out 11 kinds of antiserum for A-site antigens and 23 kinds for B-site antigens. We have only been able to screen out HLA-CSH antiserum for C-site antigens. C. In studying the association between HLA and disease, China has surveyed more than 30 diseases, such as chronic granulocytic leukemia, nephritis, diabetes mellitus and nasopharyngeal carcinoma. D. We have accomplished compatible typing in almost 100 cases of transplant HLA typing for medullary, renal, pancreatic and testicular transplants.

VII. Biological Research into Hemocytic Elements: At present we are still doing little work in this area. In the past few years quite a few localities have studied changes in erythrocyte and leukocyte membranes in various kinds of hemopathies. A. We have observed erythrocyte membrane abnormalities and hemolytic mechanisms in PNH patients. For example, we have conducted experimental research on the activation of complementary sensitivity to C-membranes, the reaction of the membrane to the external introduction of agglutinin, membrane lipid peroxide and the protective functions of aluminum ions and some medications (such as blood-activator medications) for the structure of cell membranes, and closely studied the associations of these aspects with the blood infiltration mechanism. B. We have studied growth abnormalities in the erythrocyte membranes of patients with favism, hereditary spherocytosis and thalassemia, and we have assayed membrane protein composition, phospholipid classification, membrane lipid mobility and other areas. We have launched research into leukemia cell plasmalemma isolation and identification and the relevant membrane markers in order to look for the biochemical characteristics and specific markers of leukemia cell membranes. D. We have observed the electrophoretic action of erythrocytes, lymphocytes, thrombocytes and so forth, as well as the association between surface charge and the genes concerned.

LIFE SCIENCES

PRC HEALTH MINISTRY SAYS NUMBER OF PRIVATE DOCTORS UP

HK200349 Beijing CHINA DAILY in English 20 Apr 85 p 3

[Text] More than 80,000 private doctors are practicing in China this year--an increase of 63 percent over a year ago--according to the Ministry of Public Health.

The number of private practitioners more than doubled in seven provinces, including Shaanxi, Hebei, Guizhou, Anhui, Shandong, Jiangxi and the Inner Mongolia Autonomous Region in the same period.

The rate of increase, which has been encouraged by the ministry as a part of an overall reform in the country's public health system, is much slower in the cities than in the rural areas. In rural areas the majority practice traditional medicine while in cities most retired doctors of Western medicine.

There are now only about 9,000 self-employed physicians in the cities--only a fraction of what is needed by the urban population, according to "JIAN KANG BAO" (the HEALTH NEWS).

However, the limited number of private doctors are already playing vital roles in diverting patients from the overtaxed public hospitals in Beijing and Wuhan.

In Beijing the 200 private practitioners in the city's West City and Xuanwu districts treated more than 400,000 cases last year, while the 433 private doctors in Wuhan City, Hubei Province, dealt with 385,000 patients in the same period--equivalent to the capacity of a public hospital receiving 1,000 outpatients a day in each city.

In Wuhan and some other cities, a number of private physicians have launched maternity wards, first-aid stations or small private hospitals with inpatient wards.

Some local health authorities have awarded contracts to private medical professionals such regular jobs as inoculation of residents or extermination of rats.

Encouraged by the Ministry of Public Health, the health departments in the cities are speeding the registration procedure for private doctors. In

Shanghai, the city government has announced that retired medical professionals who worked for the State will continue to enjoy their retirement benefits after they take up self-employed medical practices.

According to policy recently made public, a qualified private doctor may operate his own clinic or join with other private doctors to run a partnership clinic or hospital. A private physician may run his own pharmacy counter, while a veteran traditional Chinese physician may take pupils, the HEALTH NEWS said.

In a commentary on Tuesday, the HEALTH NEWS urged the cities to speed up their urban health reform in encouraging more private doctors to take up practices.

They should supervise and administer the private medical profession to see they abide by health regulations. But this does not mean they should restrict the growth of private medical services. On the contrary, they should encourage and guide the service to develop, it added.

CSO: 4010/130

LIFE SCIENCES

BRIEFS

LARGE RADIATION CENTER BUILT--Lanzhou, April 15 (XINHUA)--A radiation center for civil use, China's largest of its kind so far, is being built in Lanzhou, capital of Gansu Province. Medical equipment, fur and herbal materials will be disinfected, vegetables, fruit, meat and eggs kept fresh, and farm crops bred through cobalt 60 radiation at the center, which will go into operation in July 1986. Effective and safe measures will be taken to control the gamma rays released, according to center officials. Radiation techniques for civil use are spreading in Gansu, Henan, Shaanxi, Sichuan Provinces and Shanghai. [Text] [OW150928 Beijing XINHUA in English 1901 GMT 15 Apr 85]

SHANGHAI NEIGHBOURHOOD HOSPITALS--Shanghai, March 28 (XINHUA)--More neighbourhood hospitals have been built to aid ailing residents of Shanghai, according to officials here. The East China municipality now has 104 local hospitals with 1,120 beds. The facilities treat nearly half of Shanghai's outpatients. Nearly all the hospitals have departments of internal medicine, surgery, obstetrics, pediatrics, traditional Chinese medicine, ophthalmology and acupuncture. Some also have departments of tumors, lungs, orthopedics and stomatology. They are also involved in disease prevention, vaccination and public hygiene programs, and dispatch local medics to treat aged, disabled or chronically ill patients at home. The neighbourhood hospitals are given medical and management aid by city and district level hospitals. The higher-level facilities also help local clinics set up special wards to suit neighbourhood needs. In the Jiaxing Road neighbourhood hospital, an 18-bed rehabilitation ward was set up for wholly or partially paralysed patients convalescing from brain surgery. The hospital uses both Chinese and Western medicines, doctors said. [Text] [Beijing XINHUA in English 0655 GMT 28 Mar 85 OW]

COMPUTERS DIAGNOSE CEREBRAL BLOOD DEFICIENCY--Taiyuan, April 17 (XINHUA)--Computers are now being used at the Shanxi Medical College's No 1 Hospital to aid in early diagnosis of a cerebral blood deficiency which mainly affects elderly patients. By entering the results of six blood tests into the computer, doctors can determine if the patient is suffering from ischemic cerebrovascular disease (apoplexy) in its early stage. If the disease can be diagnosed, it is possible to take preventive measures against cerebral thrombosis. [Text] [OW171230 Beijing XINHUA in English 1031 GMT 17 Apr 85]

CSO: 4010/130

## ENVIRONMENTAL QUALITY

### ENVIRONMENTAL IMPROVEMENT WORK REPORTED

#### Environmental Beautification in Tianjin

Beijing RENMIN RIBAO in Chinese 7 Apr 84 p 1

[Article by Xiao Huo [5135 3752]: "Tianjin Engages in Major Greening and Beautification To Change the Appearance of the City; Green Willows and Blooming Flowers Dot River Banks"]

[Text] With real, visible and tangible success, greening and beautification work in the Tianjin metropolitan area is winning the respect of visitors from other regions and has stirred the enthusiasm of the entire citizenry. At present, 26 parks and green zones have been established and overall construction work has begun.

In the past, the level of greenery in Tianjin was quite low. According to incomplete 1982 statistics, the metropolitan area possessed only 900,000 trees, greenery coverage was only about 8 percent and per capita public parkland was only 1.5 square meters.

Since the development of a people's volunteer tree-planting campaign, however, the municipal government of Tianjin has ranked the greening and beautification of the city as one of its own key tasks and has made a breakthrough in changing the face of the city. In the course of the year, 1.28 million people participated in volunteer labor, 1.1 million trees were planted in the metropolitan area and new public and specialized green zones numbered 200, with a total of over 900,000 square meters. The survival rate for planted trees reached 93.6 percent, exceeding the highest historical level.

The work of beautifying and greening the Tianjin Municipality concentrates its energies on attention to key issues. The rivers running through the metropolitan area form the central scenic axes of Tianjin and for many years their banks had been a chaotic jumble of debris. At the end of 1982, the municipal government called on the masses to "start working for their own welfare," and a total of 65,000 people participated in volunteer labor to complement teams of experts in construction work. In a mere 10 and 1/2 months, they cleared away all the debris and built riverside parks consisting of a nearly 20-kilometer belt of trees and tracts of

blooming flowers and green willows. By way of praising League members and youths who played a leading role, comrade Deng Yinzha0 [6772 4481 6389] wrote the name "Youth Park" when he came on a visit of inspection.

Another feature of the Tianjin Municipality's beautification and greening project in the metropolitan area is expressed in the phrase, "add greenery wherever there is room." The parks department is complementing the greening of residential districts with tree-planting and construction of the "three minis" (mini streetscapes, mini green zones and mini parks), as well as adapting its projects to local conditions and "sticking in a needle wherever there is room" [making every available use of space]. These "three minis," which range in size from over 100 square meters to over 10,000 square meters, come in every shape and style and are pleasing both to the eye and to the mind. At present, public green zones amount to 5.5 million square meters throughout the city, a 51.1 percent increase over 1978. A garden-style residential area that has begun to take shape on Xianyang Bei Lu in the Hongqiao district has won the praise and admiration of visitors from all regions with its trees and grasses planted among flowers, complemented by pavilions, galleries, gates, walls, ponds and raised flower beds scattered here and there on different levels.

Tianjin Municipality's greening and beautification project is taking firm charge of the greening and beautification of factories, companies, official institutions, army units and schools. Last year, emphasis was given to 1,000 key sites in the city and as many as 100 experts were organized to go to these sites and give practical assistance. Of the sites, there have already been 100 "advanced green sites." Forty percent of the total area occupied by the Tianjin Railway Car Manufacturing Plant has been planted with trees and one army post hospital has reached the point where "no bare dirt sees the sky."

#### Successful Zhejiang Land Management

Beijing RENMIN RIBAO in Chinese 7 Apr 84 p 2

[Article: Zhejiang Province Land Management Project Is Successful--Yearly Use of Urban and Rural Cultivable Land for Construction Falls from 110,000 Mu to 30,000 Mu"]

[Text] Editor's note: Valuing every inch of land and using that land efficiently constitutes a basic national policy in China. In heavily populated Zhejiang Province, an enhanced land management project has reversed a large-scale decline in cultivatable land. This illustrates a point: All that is needed for this type of project to be successful is the conscientious implementation of relevant party and people's government policies and strict and impartial adherence to regulations.

In recent years, Zhejiang Province has resolutely implemented the basic national policy of valuing and using efficiently every inch of land and,

using a variety of measures to stop unhealthy tendencies toward the misuse and the indiscriminate use of land, has economized on lands used for urban and rural construction, and the yearly encroachment on cultivatable land has dropped from 110,000 mu to 30,000 mu.

#### Enact Laws and Regulations, Implement Management Measures

The "Accord on Managing Lands for Urban and Rural Construction" issued by the provincial party standing committee last year provided rigorous procedures for the requisition of cultivatable land and for the examination and approval of noncultivable land. Commune members building houses must adhere to the program and, insofar as it is possible, use residential areas, barren slopes and hillsides and not occupy cultivatable land. The accord also stipulates limits on plot sizes for the dwellings of commune members. This year, the extent of sanctioned encroachment on cultivatable land in the province was further reduced and restrictive quotas were issued to each municipality and county.

#### Firmly Implement a Program To Link Land Use and Land Reclamation

Last year, the province as a whole received a total of nearly 2 million yuan in land reclamation funds in accordance with regulations. After receiving its funds, the city of Hangzhou implemented the reclamation of 1,000 mu of new grain fields and 420 mu of new vegetable plots, thus compensating for 90 percent by area of lands appropriated for construction. In addition, it has recently been ruled in the province that areas and counties in which there is no land that can be reclaimed may extract a specified percentage of land requisition funds and use it to reclaim unproductive fields or to establish the original vegetable plots.

#### Set Up Sound and Unified Land Management Organizations

At present, regional (city) and county (city and district) agricultural bureaus have basically established land management centers, departments and sections. A majority of communes and brigades have set up leading groups for land management (or village and town plans), and some have provided for commune land specialists.

#### Mulan Xi Pollution Survey

Fuzhou FUJIAN RIBAO in Chinese 6 Apr 84 p 1

[Article by Chen Zhengji [7115 2398 1015] and Zhang Lixing [1728 4409 1840]: Provincial Construction Office Reacts to National People's Congress Resolution--Leaders Survey Problem of Pollution in Mulan Xi]

During the Second Session of the Sixth People's Congress, representatives from Putian city vigorously demanded that pollution in the Mulan Xi be brought under control. Immediately after the conclusion of the session, the provincial urban and rural construction and environmental protection department joined with the provincial economic committee and the provincial

department of light industry and studied relevant materials. From March 28th to the 30th, departmental leaders led nine engineers and technicians from the two departments and one committee to Putian and Xianyou to conduct an on-site survey. Nan Tiaoshan [0589 2742 1472] of the Provincial People's Congress Standing Committee responded to an invitation to participate in the survey.

After their investigations and on-site observations, our comrades in the survey group feel that Mulan Xi pollution is serious and that firm measures must be adopted to remedy the problem. For this reason, they have proposed that a comprehensive control plan be studied in the near future. They also made the following suggestions: undertaking yearly plans; raising a portion of the funds for a comprehensive solution by enacting management regulations and, first of all, imposing across-the-board fines for pollution, thereby encouraging enterprises to deal with the problem; and proposing deadlines for controlling critical outbreaks of pollution.

The leadership of Putian city is of the opinion that the survey group's proposals are feasible. The task of controlling pollution is a formidable one--easy at first and more difficult later--but if we can find a consensus, then water quality in the Mulan Xi will surely gradually change for the better.

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CSO: 4008/275

ENVIRONMENTAL QUALITY

HEBEI GRASSLANDS MANAGEMENT REGULATIONS

Text of Regulations

Shijiazhuang HEBEI RIBAO in Chinese 13 Apr 84 p 2

[Text of provisional grasslands management regulations issued by the Standing Committee of the Hebei Province Sixth People's Congress on 11 April 1984]

[Text] Section I: General Principles

Article 1: Grasslands are an important national resource which can be renewed and used indefinitely, they form the physical basis for the growth of livestock industries and they are a critical element in preserving ecological balance and in promoting national economic expansion. In order to give full play to the economic and ecological benefits of grasslands, these regulations have been specially formulated in accordance with the Constitution of the People's Republic of China and relevant national laws and rules and in light of conditions in Hebei province.

Article 2: The management and development of grasslands must be enhanced at all levels of the people's government. Resource studies and overall surveys should be carried out and a comprehensive plan should be formulated in accordance with policies of conscientious protection, enhanced management, positive development and rational exploitation and use.

Article 3: The protection and development of grasslands are duties that should be fulfilled by every citizen. Those who contribute to the protection and development of grasslands will be rewarded and those who violate these regulations will be punished.

Article 4: All grasslands, grassy hills, grass plots, grass clearings, barren hills and sands suitable for grasses, man-made lawns and semi-artificial lawns are collectively referred to as grasslands and all fall under the jurisdiction of these regulations.

## Section II: Rights of Ownership and Rights of Usage

### Article 5: Grassland Ownership Rights

All undeveloped grasslands, grasslands which have already been transferred in accordance with the law to state-run agricultural and livestock enterprises or institutions, and other grasslands not belonging to collectives belong to the socialist people as a whole.

Grasslands regularly used by collective organizations, including district rural communes, village brigades and agricultural and livestock production collectives, belong collectively to the socialist working masses.

### Article 6: Grassland Usage Rights

In accordance with national and collective arrangements, the right to use undeveloped grasslands is possessed in perpetuity by whomever plants grasses or trees on such grasslands and this right is inheritable.

For all publicly used grasslands owned by the people, plans should be unified, boundaries set, amounts fixed, grazing systems determined and methods for setting up grazing lands established in order to regularize natural village management and to contract land to households for periods of 20 or 30 years.

The management of collective grasslands may be contracted to households or to organized cooperatives, with contract terms of 15 or more years and, according to actual conditions, a certain portion can be permanently divided into private grass plots.

The system of contracting grasslands requires that contracts be signed and profits be divided on resource fees to be handed over. Grasslands may be transferred with the agreement of the collective economic organization, and when usage rights are transferred, the new contractor must pay the original contractor reasonable compensation. The collective has the right to recover land and, at its own discretion, seek financial compensation from those who violate contracts by seizing land and by causing grasslands to drop in soil fertility or to suffer damage.

Article 7: After grasslands usage rights have been determined, no individual or institution may violate a "certificate of grasslands use" issued by a county people's government.

Article 8: No individual or institution may occupy or damage state-run pasture property.

On state-run pastures, the development of grasslands must be enhanced and management must be improved, and specialized contracts may be implemented to increase economic benefits continuously.

Article 9: After usage rights have been determined, grasslands remain the property of the nation or of collectives and cannot be bought, sold, rented or leased.

National development works or collectively initiated projects requiring the use of grasslands must undergo examination and approval procedures in accordance with stipulations of the "Regulations Governing the Appropriation of Lands for National Development." No unsanctioned land use by any individual or organization is permitted.

The temporary use of grasslands must be sanctioned by the competent county authorities and reasonable compensation must be paid to grasslands administrators. At the conclusion of such use, the occupying party should bear the responsibility for promptly cleaning the site.

Article 10: Disputes which arise involving grasslands ownership rights or usage rights will be resolved by means of consultations with the parties concerned. When agreement is not reached, such disputes will be adjudicated by the next higher level of the people's government.

Until grasslands disputes are resolved, the status quo must be strictly maintained and none of the parties concerned may use any pretext to provoke an incident.

Article 11: When mediation or adjudication of grasslands rights is in dispute, situations involving disputes arising because of unclear boundaries are, in general, to be handled in accordance with the following principles:

1. Between counties within the province, boundaries fixed at the time of land reforms are to be taken as legitimate.
2. Between collective economic organizations, boundaries fixed at the time of collectivization are to be taken as legitimate.
3. Between the people as a whole, collectives and individuals, boundaries fixed through legally sanctioned procedures are to be taken as legitimate.
4. For cases which have already been adjudicated by the people's government above the county level, previously adjudicated boundaries are to be taken as legitimate.

Article 12: Once grasslands disputes have been adjudicated, rulings must be strictly enforced. In the event of noncompliance, petitions for reconsideration can be directed to the next highest level of the people's government or suits can be filed in local courts within a fixed time. If the time limit is exceeded and no petition for reconsideration has been submitted or suit filed, the ruling acquires the force of law. Responsibility will be investigated and assigned in the case of a refusal to implement a ruling.

### Section III: Development and Management

Article 13: Every level of the people's government should include grasslands development in national economic plans and should enact regional plans for planting grasses and trees. They must adhere to the principle of the mutual linkage of "grasses, irrigation and trees" and adapt to local conditions in arranging for percentages of land to be occupied by grasses and trees and for planting patterns. Land resources should be used fully, with grasslands given over to grazing first and then to forestry, and with woodlands given over to forestry first and then to grazing. In conformity with local conditions, grasses and trees shall be planted under the technical guidance of forestry and livestock farming authorities on private hills and on grasslands contracted to households in the context of the three stabilizing actions (stabilization of mountain and forest rights, designation of private hill lands and determination of systems of responsibility for forestry production). Public education to promote respect of the national "forest law" should be carried out regularly so that grazing and the elimination of grasses are not permitted to damage forests.

Article 14: Enhance the basic development of grasslands. At the same time that the preservation of water and land is enhanced, there should be planned development of water conservancy resources and continuous enlargement of the area of irrigated grasslands. Self reliance will play the principal role in terms of development investments, with necessary support provided by the state.

Article 15: In accordance with national unified regulations and under the guidance of grasslands management authorities, users of grasslands must, on the basis of different conditions, establish improvement measures such as the use of artificial planting of grasses, the reseeding of forage grasses, the closing off of mountains and sandy areas to facilitate the re-establishment of grasses, and the rotation of closed off areas, so as to increase gradually the area of artificial and semi-artificial plots and to increase coverage rates and the proportion of good pasturage.

Article 16: Under the guidance of livestock authorities, owners and users of grasslands must periodically inspect sites and measure grasses and, based on grasslands type and grass production amounts, determine suitable grazing loads, prevent overgrazing and gradually allow available grass to determine herd sizes, so that the two are in balance.

Article 17: No organization or individual may arbitrarily open up and plant grasslands. Slopes of 25 degrees and more already opened to cultivation and all field unsuitable for farming may, subject to plans drawn up by county and township People's Governments, be withdrawn from cultivation and planted with grasses and trees within a specified period of time.

Article 18: Cutting sod or digging up grass by the roots on grasslands are strictly prohibited. Such activities as digging and hauling earth on grasslands must receive the consent of the grasslands' owners or users, must be submitted to the township people's government for approval and

must be carried out within specified limits. Digging medicinal materials on state-run livestock farms and on grasslands contracted to others requires the consent of the holders of usage rights, the protection of vegetation and the filling in of hollows and pits created.

Article 19: Rodent and insect infestations must be actively eliminated, and grasslands protected, through a program of joint implementation of chemical and biological prophylaxis and treatment based principally on biological prevention and treatment. The hunting of beneficial birds and animals is prohibited.

Fires should be prevented by the establishment of sound grasslands fire prevention systems, of public pledges to protect grasslands and of strict management.

Article 20: Every region should, in accordance with local conditions, establish a forage grass seed base for the active development and support of households specializing in forage grass seed production and to improve seed quality. State enterprises, collectives and individuals may engage in producing forage grass seeds. The introduction of forage grass seeds required stringent experimentation, quarantining and regional trials before widespread applications.

#### Section IV: Management Organizations

Article 21: Livestock management authorities at all levels are responsible for grasslands management. Their duties are:

1. thorough implementation of applicable laws and regulations and the development of public information and education projects;
2. the surveying of grasslands resources and the enactment of plans for the exploitation and use of grasslands;
3. the guidance and supervision of grasslands users;
4. the joint handling of arrangements pertaining to rewards and punishments with the authorities concerned.

Article 22: Sound scientific and technological organizations should be set up to enhance the work of scientific research and the spread of technology.

Article 23: All public security organs should strengthen grasslands security management and, where appropriate, punish criminal elements who damage grasslands.

#### Section V: Rewards and Penalties

Article 24: Moral or material encouragement shall be granted to organizations or individuals who conscientiously implement these regulations

and produce notable achievements and who possess one of the following qualifications:

1. notable achievement in grasslands protection, management, development and use;
2. notable achievement in grasslands scientific research, resource surveys and technology popularization projects;
3. outstanding action in combating all behavior violating these regulations;
4. devotion to work and a record of at least 8 years' continuous engagement in grasslands development.

Article 25: Those who violate these regulations through any of the actions below will, according to the seriousness of the case, be accorded criticism and education, administrative disciplinary measures or economic sanctions. The responsibility for investigating criminal cases involving those who violate criminal law rests with judicial organs.

1. the infringement of the lawful rights and interests of the owners or users of grasslands;
2. the provocation of an incident or the causing of serious damage in the settlement of grasslands disputes;
3. the destruction of the fruits of either development or of scientific research, including artificial grass plantings or irrigation facilities;
4. the buying, selling, renting or leasing of grasslands;
5. the setting of fires in violation of grasslands fire prevention regulation;
6. the unauthorized cultivation, occupation or destruction of grasslands;
7. other actions violating these regulations.

#### Section VI: Amendments

Article 26: These regulations are in force from the day that they are made public.

Article 27: Provincial livestock and aquatic product bureaus may enact detailed implementation rules and regulations based on these regulations, submit them to the provincial people's government for approval and enforce them.

Shijiazhuang HEBEI RIBAO in Chinese 13 Apr 84 p 2

[Editorial: "Implement Regulations to Strengthen Grasslands Development"]

[Text] The "Hebei Province Grasslands Management Regulations (draft)" are based on the lessons of long years of experience and formulated in light of present conditions. They possess critical significance with respect to resolving current important issues involved in developing grasslands, to strengthening the development of grasslands and to developing livestock farming.

In the past, because of the influence of "leftist" errors, we committed many stupid acts regarding the development of livestock farming, acts violating objective law, and these caused some of the historically traditional grasslands in our province to suffer serious damage. Since the 2d Plenary Session of the 11th party Central Committee, a system of responsibility has been in effect in which the raising of livestock is contracted to households and livestock farming has seen rapid recovery and expansion. Yet right up to the present, a number of barren hills and sands suitable for grasses and public grazing lands have not been developed or used rationally because there have been no clear rights of ownership or use. For the same reason, a number of collective grasslands are overloaded and overgrazed, giving rise to the potential problem of a vicious circle. In terms of grasslands management, use is stressed over development. The promulgation of the "Hebei Province Grasslands Management Regulations (draft)" will be effective in promoting the solution of these problems and will put grasslands development and livestock farming production in our province on the track of robust development.

Now that the grasslands "Regulations" have been made public, each locale should intensify its work in disseminating them and should mobilize the masses to conscientiously implement them. As quickly as possible, all levels of the people's government should, through thoroughgoing and painstaking work, put grasslands usage rights into effect, determine the limits of usage and make long-term arrangements to bring about the simultaneous developments of contracting grasslands to households and of contracting the raising of livestock to households. Usage rights will be legally protected when it is clear who may use lands, who may develop them and who receives the benefits. If the development of grasslands is to be brought into the orbit of national territorial administration plans, then land suitable for grasses should be grasslands, land suitable for forests should be forest land and comprehensive development should take place linking grasslands, irrigated land and forests. The vast numbers of cadres and the masses should emulate and abide by each of the stipulations of the "Regulations" and protect, develop and make rational use of grasslands. We must fight every kind of unlawful behavior which destroys grasslands. Laws must be complied with and strictly enforced and transgressions must be investigated, so that those who are progressive receive due encouragement and those who break the law receive due punishment.

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2 May 1985

## ENVIRONMENTAL QUALITY

## PROTECTING WATER SOURCES WHILE DIVERTING CHANG JIANG NORTH

Beijing ZHONGGUO HUANJING BAO in Chinese 6 Nov 84 p 3

[Article by Zhu Yueming [2612 1471 2494] and Lu Guobao [7120 6665 0202]: "We Should Stress Water Source Protection While Diverting Water from the Chang Jiang Northward"]

[Text] The government has approved the report on a feasibility study of a first-stage project for the eastern route of water diversion from south to north. Under the east-route plan, first the water is routed from the Chang Jiang to the southern banks of the Huang He since water from the Chang Jiang can flow through the Beijing-to-Hangzhou Canal into Dongping Lake in Shandong Province, thus providing water for agriculture and industry in the downstream river plains of Huai, Yi, Mu and Si Hei.

For water quality to be maintained up to the standards for the water from the Chang Jiang, the Huai River Commission organized an investigation into pollution sources and began compiling materials in planning water source protection for water being diverted northward. In the first-stage project of the eastern route, the overall distance for the northward water diversion is 880 kilometers. Along the water diversion route, the aquatic surface area of four lakes totalling some 4000 square kilometers is connected, merging the major drainage systems of 16 rivers. Along the diversion route, sewage from more than 30 cities and counties empties directly or indirectly into the water diversion route with a daily discharge of one million cubic meters (sewage discharge from cities and towns along the main channel of the Huai River is not included). The most severe sewage pollution comes from chemical and paper making plants. Sewage from the periphery of four southern lakes is quite a problem. There are 26 municipalities and counties fronting on the lakes and a daily sewage discharge of 520,000 cubic meters of waste water, containing more than 20 toxic substances. Along both sides of the water diversion route, approximately 65 million mu of farm land has an effect on the water quality. Based on 1976 to 1980 statistical data, an average 52,000 tons of insecticides are used each year, averaging 0.8 kilogram of insecticide applied per mu.

There are 64 water quality monitoring station profiles along the water diversion route. According to 1980 to 1982 monitoring data, only at 10 station profiles is the environmental quality of surface water up to the third-level standard all year long; this represents only 15.6 percent of all

monitored station profiles. Along the Liangji Canal in the throat diversion sector, and the key diversion channel, Bulao He, the surface water basically fails to meet the tertiary standard of environmental quality all year round.

Northward from Pixian in the northern sector of the water diversion route, water quality is threatened owing to sewage discharges from Xuzhou, Jining and other cities. The daily sewage discharge is 100,000 cubic meters from Xuzhou City into the Bulao He. The daily sewage discharge is 280,000 cubic meters from Jining area into the Grand Canal; the daily discharge of toxic substance is 755 kilograms. According to the normal water diversion flow for the immediate future of 100 cubic meters per second, the amount of sewage in the Jining sector of the Grand Canal has exceeded the self-cleaning capacity of this body of water. Based on the relevant sections in the Environmental Protection Law, the principle and standard for control of diversion water quality are the following: water quality at the sewage outfall of factories (either direct or indirect discharge) should meet the industrial "three-waste" discharge standard. If the above-mentioned requirements are not met, water treatment should be carried out before a deadline together with enterprise re-organization and technical innovations. Effective immediately, all direct discharges of waste water into the water diversion route by new and old factories are prohibited. The "three-simultaneous" principle should be strictly adhered to for projects of new construction, remodeling and expansion; new pollution sources should be strictly controlled.

Ten proposals are made on protecting water sources and treating pollution sources in the various sectors: (1) Sewage from the Baoying Paper Mill should be treated before the water diversion route is opened; the sewage should meet the discharge standard and be discharged into the Baoshe He. (2) If water is to be supplied to the Li Canal in Huaiyin City, treatment of sewage water from factories and residents along the banks should be completed before a deadline. Boats at wharves should be well managed as to their sewage discharge so that the surface water of the Li Canal can meet the tertiary standard of environmental quality. (3) Waste water from the Hongze County Paper Mill should be treated before a deadline; it is prohibited to discharge untreated waste water from the mill into the main sewer. (4) As for city and town planning, their management should be enforced and treatment emphasized to ensure that the surface water (of the Suqian sector of the Grand Canal) measures up to the tertiary standard for environmental quality. (5) Treatment should be completed before a deadline for primary sewage-discharge factories in Pixian County. Loading and unloading methods at coal wharves in Pixian should be improved for better management and reduced pollution. (6) Treatment of waste water from major plants in Xuzhou should be stressed. It is required that water quality in the Bulao He should meet the tertiary standard of environmental quality of surface water when southern water begins its diversion. In Xuzhou City, discharge of sewage water into the Kui River should be strictly controlled. (7) Major and minor paper mills in Tengxian County should be merged in production and waste water treatment placed under centralized control. A closed water cycle should be adopted in the Lunan Chemical Fertilizer Plant; water use should be conserved. Surface water emptying into lakes from the Shizi He should meet the tertiary standard

for environmental quality. (8) The Jining Paper Mill should treat its sewage promptly. It is prohibited to discharge untreated sewage into the Liangji He. (9) Treatment should be stressed for pollution sources in cities and counties with inland water pollution. (10) In Huainan, Bengbu, Huaibei and Suzhou cities in Anhui Province, treatment of pollution sources should be stressed to improve water quality in the main channel of the Huai He and other rivers receiving sewage discharge.

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## ENVIRONMENTAL QUALITY

### PROTECTING WATER SOURCES OF TAIHU

Beijing ZHONGGUO HUANJING BAO in Chinese 30 Oct 84 p 3

[Article by Sheng Junbao [4141 0193 1405]: "Initial Success Seen in Protection Work of Water Sources of Taihu Lake"]

[Text] In the Chang Jiang delta (China's "golden triangle"), rivers and lakes interlace in a dense network; this delta is called the "land of plenty." Also famous in China and abroad are Suzhou's gardens and Tai Hu's scenery.

Large amounts of pollutants are discharged into rivers with industrial development, causing the bodies of water in the area to be seriously polluted. For more than 150 days a year, the Huangpu Jiang in Shanghai Municipality flows with black, smelly water. Inland water pollution in the Grand Canal south of the river (Chang Jiang) has merged into one long channel. This discharge of industrial effluent in the Taihu Basin has reached a daily level of 6.7 million cubic meters.

While part of a region with severely polluted bodies of water, the Tai Hu as the core of the Tai Hu water system still maintains good water quality. The reason lies in a series of measures to protect the lake's water sources in effect since 1979; preliminary results have been gained in pollution control.

#### I. Comprehensive Investigation and Research on Taihu's Environmental Quality Has Been Carried Out

In 1979, the government ordered the research project: "Investigation and Research on Taihu's Environmental Quality"; the environmental protection departments organized a scientific research coordination team involving the Nanjing Geography Institute of the Chinese Academy of Sciences, Nanjing University, and Shanghai Normal College, and other units. The scientific research team made a comprehensive investigation and study of lake environmental quality with respect to water, aquatic life, and lakebed substances. For more than 2 years, tens of thousands of monitored data items for chemical analysis and large numbers of other investigation data were obtained to clarify the main sources of pollutants in the environment of Tai Hu waters, the time and space distribution of main pollutant contents in the lake environment, and dynamic variation in Taihu's environmental quality, as well as current environmental problems.

## II. Legislative Management

In June 1982, the Jiangsu Provincial People's Government promulgated the "Protection Regulations on Water Sources of Tai Hu," which has been approved by the Standing Committee of the Provincial People's Congress. In addition, as commissioned by the Environmental Protection Leading Group of the State Council, a Jiangsu Province Tai Hu Water Source Protection Commission was founded to organize and coordinate water source protection of various localities around the lake. With assistance from Zhejiang Province and the Shanghai Municipality, a water source protection zone was established in an area within five kilometers of Tai Hu. Thus, the total amount of pollutants from main rivers emptying into the lake was controlled, and the discharge into the lake from key pollution sources was reduced. As a result, the water quality of Tai Hu's famous scenery resorts and the breeding waters of the freshwater fisheries have generally met the functional requirements.

When the water source management was organized, the document "Tai Hu Water Quality Standard" was promulgated. The Tai Hu Water Quality Monitoring Center, a station, periodically monitors water quality in the lake, recording large numbers of data in changes in water quality.

## III. Formulate a Plan To Protect Tai Hu's Water Sources and Stressing the Comprehensive Prevention and Treatment of Water Pollution in the Lake Basin

The flow direction of the Tai Hu water system changes frequently. In order to ensure good lake water quality, industrial pollution should be controlled in cities and towns, such as Suzhou, Wuxi, Changzhou, and Huzhou, among others. In order to coordinate growth in construction in the Shanghai Economic Zone, the Ministry of Urban and Rural Construction and Environmental Protection has mandated the document "Comprehensive Planning for Prevention and Treatment of Water Pollution in the Tai Hu Basin."

The work done to protect Tai Hu's water sources is a good model in protecting water systems and lakes from pollution by stressing prevention. A set of procedures, systems and policies has been compiled; it has been proved that this is an effective approach, meeting the principles of scientific management.

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## ENVIRONMENTAL QUALITY

### PROTECTING ECOLOGY IN ARID REGIONS

Beijing ZHONGGUO HUANJING BAO in Chinese 4 Dec 84 p 3

[Article by Qian Taitao [6929 1132 3447]: "Urgent Task in Ecological and Environmental Protection of China's Arid and Semi-Arid Regions"]

[Text] With the growth of construction in Northwest China in past years, the population in the area has climbed rapidly; thus, a series of severe problems have appeared regarding the protection of ecology and the environment. Since Northwest China is in an arid and semi-arid climatic environment, the ecosystem is quite fragile. It is even more urgent that the ecological environment be protected. Among the problems, paramount is desertification; next comes water and soil erosion. Also urgent are the deterioration of grasslands, destruction of plant cover in mountain forests and sandy plains, secondary salinization of soil, and protection of rare animals and plants. The irrational utilization of water resources is an important cause leading to the deterioration of the ecological environment in the area.

The total area of desert, rocky desert and desertified land in China is 1.49 million square kilometers, accounting for 15.5 percent of the total national territory. Among these categories, the area of desertified land is 328,000 square kilometers, accounting for 3.4 percent of the total national territory, mainly distributed in China's northern arid and semi-arid regions, including 207 counties (cities and banners) in 12 provinces and regions, such as Qinghai, Gansu, Xinjiang, Ningxia, Shaanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanxi, Henan and Hebei. About 35 million inhabitants are affected by desertification. Over the past decades, the area of desertified land has spread year by year, approximately at the rate of 1000 square kilometers a year. Hence, desertification appears as a problem of the protection of ecology and the environment in territorial regulation. This is also a difficult problem of macro-environmental protection in opening up the vastness of Northwest China.

The reason for the spread of desertified land, although they are related to the arid climate, especially year after year of dry weather recently, yet more important are man's irrational economic activities; some people call this type of desert a "man-made desert." The main reason for the desertification of sandy soil in China's semi-arid area is the large-scale irrational land reclamation (in 40 percent of this area), overgrazing of grasslands,

(about 30 percent of the land), and excessive firewood collection, cutting of plant stalks, overharvesting of mountain forests, and plant cover on sandy plains (about 20 percent of the area). Besides the abovementioned reasons, more important is the irrational utilization of water resources and building of large numbers of reservoirs in the upper reaches of rivers, leading to streams drying up in the lower reaches, changes of channels for natural waterways, and abrupt changes in the ecological environment; thus, plant cover died out over large areas of the sandy plains, drying up of rivers and lakes, salinization, and dropping of groundwater levels, among other factors. For example, desert poplar trees died out in large areas in the lower reaches of the Tarim River in Xinjiang; this was caused by the absence of periodic flooding in the lower reaches due to dams built and flow interrupted by land reclamation. Comparing 1978 with 1958, the area of wild growing desert poplar trees in the lower reaches of the Tarim River was reduced by 3.13 million mu, which corresponds to 1.3 times the afforestation area in the same period throughout Xinjiang.

Hence, the prevention of the continuous spread of desertification is an urgent task in protecting the ecology and environment of China's arid and semi-arid areas. In preventing the continual expansion of desertification, the basic approach is "prevention is more important than treatment." A series of enforced administrative measures should be adopted to resolutely stop random cultivation, grazing and wood harvesting in sandy land and grasslands of the semi-arid region. Ratios among agriculture, forestry and grazing in these areas should be changed to closely protect the precious natural plant cover of the sandy area. Water resources should be rationally utilized in the arid area. Moreover, China has a complete set of successful experiences in the treatment of desert and desertified land. For example, beginning from the late 1950s, large scale sand treatment was carried out in six provinces and regions in Northwest China and Inner Mongolia. After efforts of more than two decades, a number of advanced models of desert treatment appeared in the fringe of China's arid and semi-arid regions, such as the pine (zhangzisong) trees planted on sandy land for artificial consolidation of sand at Zhanggutai in Liaoning Province, airborne scattering of seeds for experimental forests in the desert of the Yulin area in northern Shaanxi, grass square sand barriers and plant belts for sand consolidation (along both sides of sand slope) along the railroad at Zhongwei in Ningxia, the man-planted suosuo trees and botanical garden on the sand dunes of Minqin in Gansu, large areas of shrubs planted for consolidating sand at Turfan in Xinjiang, and man-planted meadows at Wushenshao in Inner Mongolia, among other projects. These are good models for the large-scale treatment of desertified land. We should clearly sum up and promote these experiences to enter a new phase in the prevention and treatment of desertification in China.

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## ENVIRONMENTAL QUALITY

### SICHUAN PROVINCE WORKS TO CONTROL NEW POLLUTION SOURCES

Chengdu SICHUAN RIBAO in Chinese 27 Oct 84 p 2

[Article by Ren Wenxiao [0117 2429 1321] and Chen Rongxiu [7155 2837 4423]:  
"Prevention of New Pollution by Design in Sichuan Province--Balanced  
Development of Production and Environmental Protection"]

[Text] To develop construction and production and environmental protection together in Sichuan Province beginning with design, considerable achievements were gained in preventing new pollution. Last year, 87 percent of large- and middle-sized capital construction projects in the province had facilities for pollution prevention and treatment. In many small construction projects, more than 50 have adopted measures for pollution prevention and treatment.

Since the Third Plenary Session of the Eleventh Central Party Committee, design of better environmental protection facilities has been considered a vital integral part in project designs by the professional design departments of the province. In the expansion projects of the Sichuan Chemical Plant, the Honghao General Chemical Plant, the 612 projects of the Sichuan Sulfuric Acid Plant, and the pyrite ore-dressing project at Yanmen, among others, the design units vigorously coordinated with other design, construction and project units to thoroughly carry out environmental protection measures to effectively prevent new pollution.

At present, sections and offices have been set up for designing environmental protection projects in the Southwest Power Design Institute of the Ministry of Hydroelectric Power, the Eighth Design Institute of the Chemical Industry Ministry, the Chongquin Iron and Steel Design Institute of the Ministry of Metallurgical Industry, the Sichuan Provincial Chemical Industry Design Institute, the Sichuan Petroleum Exploration Design Institute, and the Chongqing Coal Design Institute, among others. Design norms for environmental have been compile to make a management system of environmental protection design at the first stage. In the gas and oil field exploitation, the Sichuan Petroleum Exploration Design Institue extensively applied a new technique of low alkalinity and highly efficient mud drilling of oil wells, as well as the close cycle circulating apparatus for waste water from oil wells and fields, thus considerably reducing pollution from waste water.

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## ENVIRONMENTAL QUALITY

### ENVIRONMENTAL PROTECTION IN HENAN

Beijing ZHONGGUO HUANJING BAO in Chinese 30 Oct 84 p 3

[Article by Xia Zaizhou [1115 0961 5287] and Zhao Xinyuan [6392 2450 7108]:  
Rapid Growth of Environmental Protection Work in the Central Plain"]

[Text] In the past few years, more than 200 million yuan was spent by Henan Province to combat environmental pollution; more than 3,000 treatment projects were reported. Throughout the province, the annual treatment amounted to 200 million tons of industrial waste water, 62.2 billion cubic meters of waste gas, and more than 9 million tons of refuse. Achievements have been gained in boiler remodeling, smoke and dust removal, treatment of tail gas of sulfuric acid and hydrochloric acid production, promotion of new cyanide-free techniques in zinc coating, control of mercury pollution, solving problems in power plants as concerns flue-ash discharge into rivers, centralized supply of heat and gasification of fuel, full recycling of the "three-wastes" in industries, as well as treatment of alkali soil, reforestation, windbreaks and sand consolidation, soil and water conservation, prevention and treatment of endemic diseases, rational exploitation and utilization of natural resources, and maintaining ecological balance, among other activities. Environmental conditions of some localities have been improved.

In Jiaozuo, Haobi and Pingdingshan cities, carbonaceous shale is used as a low-caloric-value fuel; satisfying achievements were scored in the production of shale bricks and shale cement. The annual production capacities of the province amounted to more than 170 million shale bricks, more than 65,000 cubic meters of shale building blocks, and more than 200,000 tons of shale cement. Each year, more than 800,000 tons of shale is used. In the past, most power plant ash from burned pulverized coal was discharged into rivers. In recent years, full recycling was used for ash from pulverized coal in making cement, wall materials, for mud pouring into mine shaft in putting out fires, dam building, and road construction, among others, with an annual use of 180,000 tons of this ash. In Jiaozuo, Luoyang and Xinyang cities, more than 5000 mu of soil has been improved, using this coal ash.

Centralized heat supply and fuel gasification have been gradually promoted in cities. At present in Zhengzhou and Luoyang, the capacity of centralized heat supply has reached a level of 700 tons of steam an hour. Marsh gas is

being used by 40,000 peasant households in villages. Since 1979, a new cyanide-free technique of zinc coating has been promoted and generally practiced throughout the province.

Among more than 8,000 boilers in the province, smoke and ash removal equipment was installed in more than 6,000 boilers; comprehensive remodeling has been carried out on more than 2,000 boilers, in realizing coal and power economies, production and temperature level maintenance, safe operation, and smoke and ash removal.

In the province, more than 23 million mu has been reforested; 1.5 billion trees have been planted; and greenery was planted in the plains of nearly 30 counties and cities. The treated alkali and saline soils and sandy plains amounted to 1.36 million mu; the treated water and soil erosion area came to 37,000 square kilometers, and the biological prevention and treatment of crop areas damaged by pests totalled more than 6 million mu. Eighteen nature preserves of various types have been built; comprehensive studies were conducted in some of the nature preserves,

In the province, adequate monitoring capacity on air and water quality has been gradually realized, centered around cities. Each year, more than 35,000 conventional monitored data of various types can be obtained for a preliminary understanding of the environmental quality status of the province.

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AUTHOR: ZHAO Xanyuan [6392 3352 0337]

ORG: None

TITLE: "Design of Maneuverable Trajectories of Re-entry Vehicle"

SOURCE: Beijing YUHAN XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS]  
in Chinese No 1, 31 Jan 85 pp 1-10

TEXT OF ENGLISH ABSTRACT: This paper mainly discusses the design of maneuverable trajectories of a re-entry vehicle. Two methods are discussed. The first one is to design optimal maneuverable trajectories by means of the optimal control theory. The method for calculating optimal re-entry maneuverable trajectories in this paper is simple and easy and requires less time. The second one is to attain the engineering design method of selecting re-entry maneuverable trajectories from the requirement for pledging terminal velocity to be maximal under the condition of considering the effect of attack angle on drag coefficient.

The calculated results show that the deviation of trajectories designed by these two methods is not much, thus the method of engineering design is feasible.

AUTHOR: CHANG Xianqi [1603 7359 1142]

ORG: None

TITLE: "One-dimensional Two-phase Flow in Combustion Chamber of Solid Propellant Rocket Motors"

SOURCE: Beijing YUHAN XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 1, 31 Jan 85 pp 11-23

TEXT OF ENGLISH ABSTRACT: In this paper, a numerical solution for a basic equation for one-dimensional two-phase nonequilibrium flow in the combustion chamber of solid propellant rocket motors is discussed in detail, the effect of particle size on the flow field in the chamber and pressure-time curves is analyzed, and some useful conclusions are drawn through comparison with results of one-dimensional two-phase constant lag flow in the chamber. This is useful for predicting pressure-time curves accurately and providing accurate boundary conditions for the calculation of two-phase flow through the nozzle.

AUTHOR: WANG Jiasheng [3769 1367 0524]

ORG: None

TITLE: "Electric or Magnetic Dipole in Stratified Uniaxially Inhomogeneous Anisotropic Media"

SOURCE: Beijing YUHANG XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS]  
in Chinese No 1, 31 Jan 85 pp 24-34

TEXT OF ENGLISH ABSTRACT: A formulation for calculating the electromagnetic field in an arbitrary layer in terms of the primary source excitation in a stratified homogeneous media is outlined. The source can be an electric or magnetic dipole which is oriented in arbitrary directions. This formulation is generalized then for stratified uniaxially inhomogeneous and anisotropic media. This problem is facilitated by decomposing a general wave field into TE and TM modes. The procedure for calculation is discussed and some examples are presented.

AUTHOR: WANG Boyi [3769 2672 2034]  
XU Yanhou [1776 3601 0186]  
JI Zhenyu [1518 7201 1342]

ORG: None

TITLE: "Propagation of Electromagnetic Waves in Inhomogeneous and Lossy  
Reentry Plasma Sheath Layer"

SOURCE: Beijing YUHAN XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS]  
in Chinese No 1, 31 Jan 85 pp 35-46

TEXT OF ENGLISH ABSTRACT: This paper presents a theoretical method to analyze the propagation characteristics of the electromagnetic waves through a reentry plasma sheath layer which is based on the stratified layer model and invariant imbedding principle. The power transmission and reflection coefficients of electromagnetic waves are calculated. The theoretical results are in good agreement with the actual measurements in flight. The advantages of this method are: the physical concepts are clear and direct-viewing, formulae are simple and applicability is powerful, and the computer program in this paper is applicable to any sheath layer thickness, distribution of electronic density and electronic collision frequency, and stratified layer media.

AUTHOR: XU Wengan [1776 3306 1626]

ORG: None

TITLE: "Pressure-coupled Response Function of Solid Propellants Including Those with Negative Pressure-exponents"

SOURCE: Beijing YUHAN XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 1, 31 Jan 85 pp 47-58

TEXT OF ENGLISH ABSTRACT: A new pressure-coupled response function of solid propellants has been theoretically derived by means of a combustion response model based upon the steady-state burning model of composite solid propellants including those with negative pressure-exponents. In this combustion response model, the burning surface of a given propellant is divided into two parts, namely, one consisting of a region of the AP surface covered by molten binder with the corresponding binder surface and the other consisting of a region of the AP surface uncovered by molten binder with the remaining binder surface. In analyzing the part of AP surface covered by molten binder, the condensed-phase reaction and the opposite gasification of covered AP are considered. For plateau and mesa propellants, the real part of the pressure-coupled response function may be positive. The results calculated by the derived pressure-coupled response function for the S04-5A propellant are in reasonable agreement with the instability behavior observed experimentally. When the greater part of the burning surface is covered with the molten binder, the nonsteady state combustion can also occur. The combustion response model can be used not only to explain the instability behaviors of the plateau and mesa propellants, in contrast to the pressure-coupled response functions presented by previous investigators, but also to show that the steady-state burning model developed for composite solid propellants, including those with negative pressure-exponents, is reasonable and acceptable.

AUTHOR: YANG Shixue [2799 0013 1331]

ORG: None

TITLE: "The Analysis and Calculation for the Dynamic Characteristics of the Omni-axial Movable Flexible Joint Nozzle"

SOURCE: Beijing YUHAN XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 1, 31 Jan 85 pp 59-77

TEXT OF ENGLISH ABSTRACT: In this paper, an analysis and calculation for the dynamic characteristics of the omni-axial movable flexible joint nozzle are presented under the simulated motor chamber pressure. It mainly consists of the analysis and calculation of the measured data, the transient pivot point and the vector moments. Moreover, the following parameters are calculated: the vector angle, the sweeping speed, the vector azimuth, the length of actuator, the thrust misalignment and the axial/radial displacements of the nozzle under different pressures.

The calculating method is suitable for the firing test after transducers are mounted correctly, and it is suitable for measuring and calculating the characteristics of the flexible joint in a neutral position.

AUTHOR: LOU Hongtian [2869 3163 3944]

ORG: None

TITLE: "Transition Effects of Boundary Layer on Static and Dynamic Stability of Slender Cone"

SOURCE: Beijing YUHAN XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 1, 31 Jan 85 pp 88-98

TEXT OF ENGLISH ABSTRACT: This paper presents the experimental technique of transition effects of the boundary layer on static and dynamic stability of the slender cone and analyzes its results. The experimental Mach number is  $M_\infty = 5.047$ . The model is a 10 degree half angle sharp cone, and the free flow Reynolds number based on the model length  $L$  is  $Re_L = 2.2 \times 10^6 \sim 13.3 \times 10^6$ .

The experimental results show that the effects of the  $Re$  number on static and dynamic stability of the slender cone are very important. The main cause is the variation of the  $Re$  number which induces change in the position of the nature transition of the boundary layer in the cone face, thus changing the induced moment and induced damping moment of the transition. When the transition exists on the surface of the after body of the cone, there is a great increase of dynamic stability and a great decrease of static stability; on the other hand, when the transition occurs forward of the center of gravity, there is some decrease in dynamic stability and some increase of static stability. The variation, as the function of the  $Re$  number, corresponds to the static stability and dynamic stability.

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CSO: 4013/144

AUTHOR: ZHU Ziqiang [2612 5261 1730]  
CHEN Zhenpei [7115 4394 1014]  
LI Jitao [2621 4949 7118]  
TANG Guangjie [0781 0342 3381]

ORG: ZHU, CHEN and LI all of the Department of Physics, Sichuan University;  
TANG of the Department of Hydrogeology, Chengdu College of Geology

TITLE: "Research on Optic Spatial Frequency Analysis of Linear Structures  
in Remote Sensing Images"

SOURCE: Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 12 No.1, 20 Jan 85 pp 1-5

TEXT OF ENGLISH ABSTRACT: This paper describes the fundamental principle and  
experimental method for spatial frequency analysis of the linear structures  
in remote sensing images. The faint geologic structures in the ERTS image of  
Yanting County, Sichuan Province, have been analyzed by the method, and  
useful results have been obtained.

AUTHOR: TANG Guichen [0781 6311 3819]  
QIU Peixia [5941 0160 7209]

ORG: Both of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences

TITLE: "Frequency-Selection and Mode-locking and Nd-YAG Laser"

SOURCE: Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 12 No 1, 20 Jan 85 pp 11-14

TEXT OF ENGLISH ABSTRACT: Mode-locking of Nd:YAG laser has been achieved at four spectral lines (1.052  $\mu\text{m}$ , 1.061  $\mu\text{m}$ , 1.064  $\mu\text{m}$  and 1.073  $\mu\text{m}$ ) by inserting prisms as dispersion elements in the cavity. The calculations on prisms are consistent with the experimental results. The stable output wavelength of the laser has been obtained.

AUTHOR: LOU Qihong [2869 4388 3163]  
WANG Runwen [3769 3387 2429]  
CHENG Xusan [2052 1645 0005]  
et al.

ORG: All of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences

TITLE: "A Large Area X-ray Source and Its Preionization Characteristics for XeCl Excimer Laser"

SOURCE: Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12 No 1, 20 Jan 85 pp 20-21, 19

TEXT OF ENGLISH ABSTRACT: A large area cold cathode diode X-ray source and its performances and dosage distribution along with the laser tube and the effects of X-ray intensity on the laser output energy have been investigated experimentally.

AUTHOR: HUANG Yongkai [7806 3057 2818]  
RONG Jianmin [2051 1696 3046]

ORG: Both of the Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences

TITLE: "Ring Cavity CO<sub>2</sub> Laser for Branch-Selection and Narrow Resonance Produced by SF<sub>6</sub> in Cavity"

SOURCE: Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12 No 1, 20 Jan 85 pp 25-28

TEXT OF ENGLISH ABSTRACT: A new type of branch-selected ring CO<sub>2</sub> laser is described. Laser output at the vibration-rotation lines has been obtained at 9.5 μm and 10.6 μm. The narrow resonance behavior of SF<sub>6</sub> in the cavity has been observed.

AUTHOR: ZHENG Jianhe [6774 1696 0735]  
LI Yushan [2621 3768 0810]  
WANG Shurong [3769 3219 2837]  
et al.

ORG: All of Changchun Institute of Physics, Chinese Academy of Sciences

TITLE: "Proton-exchanged Optical Waveguides in  $\text{Ti:LiNbO}_3$ "

SOURCE: Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 12 No 1, 20 Jan 85 pp 32-36

TEXT OF ENGLISH ABSTRACT: We report the method, condition for the single-mode waveguide, index profile, exchange coefficient, surface state and thermal stability of optical waveguides formed in  $\text{Ti:LiNbO}_3$  substrate by proton exchange in benzoic acid.

AUTHOR: ZHU Xiaochun [2612 4607 2504]  
CAO Gendi [2580 2704 1229]  
ZHANG Weizai [1728 0143 0961]  
et al.

ORG: All of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences

TITLE: " $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$  and  $\text{Pb}_{1-y}\text{Sn}_y\text{Se}$  Laser Crystals"

SOURCE: Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 12 No 1, 20 Jan 85 pp 48-50

TEXT OF ENGLISH ABSTRACT: This paper reports the  $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$  and  $\text{Pb}_{1-y}\text{Sn}_y\text{Se}$  crystals which have the suitable carrier concentration, low dislocation densities and a proper depth of P-N junction. The crystals have been directly obtained by a horizontal unseeded vapor growth technique at an appropriate controlling condition for crystal growth. They have been used in fabricating the CW tunable diode lasers.

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CSO: 4009/157

2 May 1985

AUTHOR: WANG Ganchang [3769 3227 2490]

ORG: Institute of Atomic Energy

TITLE: "Progress of Inertial Confinement Fusion (ICF) Research"

SOURCE: Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 4 No 4, Dec 84 pp 289-302

TEXT OF ENGLISH ABSTRACT: In this article, we briefly describe the recent progress of ICF research. Four topics in this field have been selected which are considered to be the most important at present. These are: the "Cannonball" target; high power krypton fluoride (KrF) laser; ion beam diodes; and imploding foil/plasma.

The "Cannonball" target's principle and advantages over the ordinary ablation drive are given. It is particularly pointed out that, by using this kind of target, the Japanese researchers have obtained, so far, the highest yield of neutrons in the world, i.e.,  $4 \times 10^{10}$  neutrons per pulse. The important problem of hole sealing of such a target is also discussed.

The second topic described is the powerful KrF excimer laser pumped by electron beams. This laser is now generally regarded as one of the more promising lasers as a driver for ICF. Here we briefly describe the complex kinetics of pumping, quenching, radiation and absorption of this very interesting laser. A compression of KrF laser pulse length from about 100 nanoseconds (ns) to a few ns is necessary for ICF work. We describe three of the compression methods, namely, pulse splitting and then stacking; Raman back scattering; and the mixing of these two.

The present status of ion beam production is discussed, especially diodes which produce the ion beams. Three kinds of diodes are mentioned. These are the pinched reflex diode (PRD), diode with externally applied magnetic field and hybrid amphion diode. New works of Reiden-IV, Institute of Laser Engineering, Osaka, and Etigol, Nagaoka Technical University, Nagaoka, are also reported.

Also discussed is the imploding foil/plasma. This method can produce plasma of very high temperature and very intensive soft X-ray which may either be used to produce an X-ray laser or as a new driver for ICF.

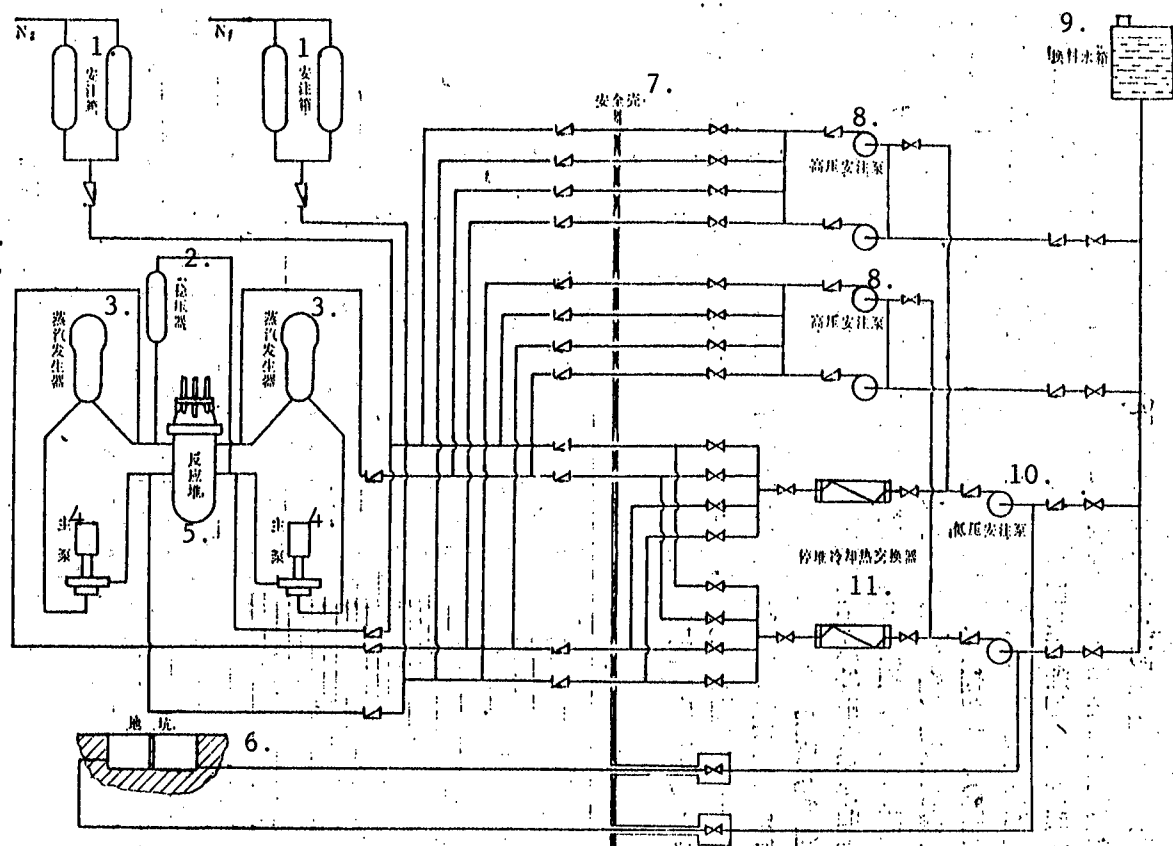
AUTHOR: OUYANG Yu [2962 7122 0056]  
ZHANG Lian [1728 1670]  
DU Shenghua [2629 5110 5478]  
et al.

ORG: All of Research and Design Institute No 728

TITLE: "Safety Design of Qinshan Nuclear Power Plant"

SOURCE: Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 4 No 4, Dec 84 pp 303-311

TEXT OF ENGLISH ABSTRACT: Safety issues have been greatly emphasized through the design of the Qinshan Nuclear Power Plant. Reasonable safety margins were taken into account in the plant design parameters, and the design incorporated various safeguard systems, such as engineered safety feature systems, safety protection systems and features to resist natural catastrophes, e.g., earthquakes, hurricanes, tides, etc. Preliminary safety analysis and environmental effect assessment have been done and anti-accident provisions and emergency policy have been carefully considered. Qinshan Nuclear Power Plant's safety related systems have been designed in accordance with the common international standards established in the late 1970s, as well as with the existing engineering standards of China.



Key:

1. Safety injection tank
2. Hydraulic pressure regulator
3. Steam generator
4. Main pump
5. Reactor
6. Pit

7. Safety casing
8. High pressure pump
9. Exchange tank
10. Low pressure pump
11. Shutdown cooling heat exchanger

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CSO: 4009/145

AUTHOR: FANG Honglie [2455 3163 3525]  
FU Shufen [0265 3219 5358]  
G.T. Moore

ORG: All of the Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences

TITLE: "Stationary Pulse Solutions for a Free Electron Laser"

SOURCE: Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 33 No 7,  
Jul 84 pp 935-942

TEXT OF ENGLISH ABSTRACT: The stationary pulse solutions for a free electron laser are obtained by using the classical theory. Computation shows that the stationary solutions can only be found under certain conditions. The shapes of the solutions do not depend on the shapes of initial optical pulses as long as these conditions are satisfied.

AUTHOR: ZHANG Yuheng [1728 5940 1854]  
WANG Jun [3769 6511]

ORG: Both of the Department of Physics, University of Science and  
Technology of China, Hefei

TITLE: "The Relations Between Voltage and Magnetic Field of Superconducting  
Weaklink (I)"

SOURCE: Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 33 No 7,  
Jul 84 pp 952-958

TEXT OF ENGLISH ABSTRACT: The quantum diffraction of the superconducting  
weaklink and the quantum interference of the de-SQUID have been calculated  
theoretically based on the constant current source RSJ model. An analytical  
expression describing the constant amplitude oscillation of the dc voltage  
component with magnetic field for double junction de-SQUID has been obtained.

AUTHOR: ZHANG Yuheng [1728 5940 1854]  
WANG Jun [3769 6511]

ORG: Both of the Department of Physics, University of Science and  
Technology of China, Hefei

TITLE: "The Relations Between Voltage and Magnetic Field of Superconducting  
Weaklink (II)"

SOURCE: Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 33 No 7,  
Jul 84 pp 959-966

TEXT OF ENGLISH ABSTRACT: In this paper, the superconducting weaklink and the influence of the feedback radiation on its I-V curve is studied based on the constant source RSJ model. The analytical solution has been obtained and the relationship between the change of the I-V curve and the feedback radiation field intensity from the cavity has been given for the case in which the field is very weak. The theoretical results show that the feedback radiation can change the amplitude and shape of  $V(H)$ , but its period is unchanged.

AUTHOR: GONG Changde [7895 2490 1795]  
XING Dingyu [6717 1353 6877]  
LIU Mei [0491 2812]

ORG: GONG and XING both of the Department of Physics, Institute of Solid State Physics, Nanjing University; LIU of Nanjing Institute of Technology

TITLE: "Discussion of the Superconducting Critical Temperature in a N-S Multi-film Structure"

SOURCE: Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 33 No 7, Jul 84 pp 967-974

TEXT OF ENGLISH ABSTRACT: The McMillan tunneling model has been generalized and applied to a N-S multi-film structure with the thickness of each film being smaller than the superconducting coherent length. The order parameters and superconducting critical temperature of the structure are calculated, and the possibilities of enhancing  $T_c$  by modifying the electron-phonon coupling and contaminating with different atoms in the interface regions are also discussed.

AUTHOR: WU Hangsheng [0702 2635 3932]  
WENG Zhengyu [5040 1767 1342]

ORG: Both of the University of Science and Technology of China, Hefei

TITLE: "Theory of the Critical Temperature for Superconductors with Small  $\lambda$  (I)"

SOURCE: Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 33 No 7,  
Jul 84 pp 975-988

TEXT OF ENGLISH ABSTRACT: A formula for the critical temperature of superconductors with small  $\lambda$  is derived from the Eliashberg equation. The effective phonon spectrum is taken in the present paper as the Einstein spectrum. The values of  $T_c$  calculated from our formula are compared with the numerical solutions of the Eliashberg equation in the case of  $\mu^* = 0$  and the agreement between them is fairly well within the region of  $\lambda < \Lambda$ .

AUTHOR: SONG Zengfu [1345 1073 4395]  
LIAN Shoren [6647 4801 0088]  
GUI Youxi [2710 1429 0823]  
et al.

ORG: All of the Department of Physics, Beijing University

TITLE: "The Electronic Raman Scattering and Two-Photon Fluorescence in  $\text{LiYF}_4:\text{Nd}^{3+}$ "

SOURCE: Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 33 No 7,  
Jul 84 pp 1017-1023

TEXT OF ENGLISH ABSTRACT: The following spectra of  $\text{LiYF}_4:\text{Nd}$  have been observed for the first time: (i) the electronic and electron-phonon Raman spectra of the stark sub-levels  $Y_1$ - $Y_6$  of energy levels  $^4I_{11/2}$  excited by 4880 Å  $\text{Ar}^+$  laser beam; (ii) two-photon fluorescence and electron-phonon spectra excited by 6943 Å ruby laser beam.

9717

CSO: 4009/156

2 May 1985

AUTHOR: LI Zhijian [2621 1807 1017]  
TIAN Lilin [3944 4539 2651]  
MA Xinrong [7456 9515 2837]

ORG: All of the Institute of Microelectronics, Qinghua University

TITLE: "Effect of High Electric Field on Minority Carrier Generation in Silicon Depletion Layer"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 6 No 1, Jan 85 pp 1-10

TEXT OF ENGLISH ABSTRACT: The effect of high electric field on minority carrier generation is investigated systematically by using MOS C(t) characteristics. A model based on Ieda's theoretical relationship between electron emissivity and field intensity is proposed for simulating the experimental results. This model is successful not only for the experiments of the present work, but also for the reasonable explanation of all experimental nonlinear Zervbst curves ever published in the literature. It is concluded that, being a general effect in silicon, the enhancement of minority carrier generation by electric field should exist in samples of perfect crystal structure as well as in samples containing high concentration of structural defects. Accompanying the kink of C(V) characteristics of deep depleted MOS structure, a jump (sudden rise) in effective surface generation velocity is observed. This phenomenon is related to the electron injection from the valence band of the high impurity concentration region under the gate into the depletion region by tunneling.

AUTHOR: BAO Ximao [7637 1585 5399]  
ZHANG Xinyu [1728 2450 1342]  
LIU Cheng'en [2692 2110 1869]

ORG: All of Nanjing University

TITLE: "Deep-level Defects in Ion-implanted and CO<sub>2</sub> Laser-annealed Silicon"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in  
Chinese Vol 6 No 1, Jan 85 pp 11-18

TEXT OF ENGLISH ABSTRACT: Seven deep-level traps have been found in As-implanted silicon. The CW CO<sub>2</sub> laser annealing is an effective method for removing deep-level defects induced by ion-implantation. The available laser power density range is 350 W/cm<sup>2</sup>-600 W/cm<sup>2</sup>, which is in keeping with that of activation of implanted impurity.

A clear slip dislocation was induced by CO<sub>2</sub> laser scanning with a power density higher than 600 W/cm<sup>2</sup>. The deep level H(0.33 eV) of slip dislocation has been measured by DLTS technique.

AUTHOR: CHEN Xin [7115 2500]  
HE Qing [0149 7230]  
WANG Zhenshu [3769 2823 2873]  
ZHOU Xining [0719 3556 1337]

ORG: All of the Institute of Metal Research, Chinese Academy of Sciences

TITLE: "Scattering Mechanism of Electric Transport Process in Titanium Disulfide"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 6 No 1, Jan 85 pp 25-31

TEXT OF ENGLISH ABSTRACT: A correlation curve for thermoelectric power  $S$  vs temperature  $T$  within the range of 90-400°K has been measured in accordance with the problem concerning the scattering mechanism of electric transport process in  $TiS_2$ . A comparison of the measured data with the theoretical curves is given based on the homopolar optical phonon scattering and the carrier-carrier scattering hypotheses. It is believed that the homopolar optical phonon scattering mechanism would be more acceptable.

AUTHOR: LIU Zhenping [0491 2182 7720]  
LI Tianke [2621 1131 0344]

ORG: Both of the Department of Physics, Liaoning University

TITLE: "Binding Energy of Donors in GaAs-Ga<sub>1-x</sub>Al<sub>x</sub>As Quantum Well Structures"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in  
Chinese Vol 6 No 1, Jan 85 pp 32-40

TEXT OF ENGLISH ABSTRACT: Binding energies of the ground state are calculated using a variational approach for shallow donors in quantum well structures consisting of a single slab of GaAs sandwiched between two semi-infinite slabs of Ga<sub>1-x</sub>Al<sub>x</sub>As. The binding energy of donors is calculated as a function of GaAs layer thickness and of the impurity position. Two alloy compositions,  $x = 0.1$  and  $0.4$ , are studied. The calculations are carried out when finite potential barriers determined by realistic conduction band are offset.

The results of the present calculations are compared with those of some previous calculations. It is found that the impurity atom is located at the center of the quantum well (on-center impurity) with composition  $x = 0.4$ . When the well thickness  $L \leq 50$  Å, the modification is considerable, for example, when the peak value correction exceeds 15 percent. Furthermore, the influence of the different effective masses of GaAs and Ga<sub>1-x</sub>Al<sub>x</sub>As on the ground state binding energy is investigated.

AUTHOR: ZHU Wenzhen [2612 2429 3791]  
CHANG Xiuqin [1603 4423 0530]  
LI Yuexia [2621 2588 7209]  
et al.

ORG: All of the Institute of Semiconductors, Chinese Academy of Sciences

TITLE: "Electron Trapping Induced by Electron Beam Irradiation in SiO<sub>2</sub>"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in  
Chinese Vol 6 No 1, Jan 85 pp 41-48

TEXT OF ENGLISH ABSTRACT: The electron trapping induced by electron beam irradiation in SiO<sub>2</sub> is investigated and the photodepopulation spectrum, the photoinjection characteristics as well as the shift of flat-band voltage in response to photoinjection are measured by use of the internal photoemission technique. The depth of the trapping energy in the forbidden energy gap is given, together with capture cross section, effective trap density and the dependence of the capture cross section or the effective trap density on the electric field.

AUTHOR: PAN Xiaoming [3382 2556 2494]

ORG: Nanjing Solid State Devices Research Institute

TITLE: "A Novel FET with a Recessed Source Structure"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in  
Chinese Vol 6 No 1, Jan 85 pp 49-54

TEXT OF ENGLISH ABSTRACT: A novel recessed source structure field effect transistor (RSFET) is presented. The operation principles of the RSFET have been analyzed using a numerical two-dimensional device simulation program. A comparison between the RSFET and other existing structures is also given.

AUTHOR: YU Mingren [0205 7686 0086]  
ZHU Furong [2612 4395 2837]  
WANG Xun [3769 6598]  
WANG Binqi [3769 3453 1505]  
SHAO Kai [6730 0418]  
et al.

ORG: YU, ZHU and WANG Xun all of the Modern Physics Institute, Fudan University; WANG Binqi and SHAO, et al., all of the Nanjing Solid State Devices Research Institute

TITLE: "An Interfacial Analysis of MoNb-GaAs Schottky Barrier Diodes"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 6 No 1, Jan 85 pp 55-60

TEXT OF ENGLISH ABSTRACT: The GaAs-Nb-Mo-Au Schottky barrier diodes have been fabricated on epitaxial GaAs layers by electron beam evaporation of Nb and then D.C. plasma sputtering of Mo and Au. The compositional depth profiles and the interfacial characteristics of these diodes are measured by XPS associated with Ar ion etching. The results obtained are as follows: The interdiffusion between Au and GaAs can be prevented if the thickness of the sputtered Mo layer is larger than 1000 Å. The pure Nb layer no longer exists as a result of the Mo interdiffusion. This leads to a structural change of the original GaAs-Nb-Mo-Au into a GaAs-(Nb, Mo, Ga, As)-Mo-(Mo, Au)-Au multilayer. In the transition region of the interface, Mo exists in the metal form, and the Nb atoms form a low valence oxide after chemical reaction with the native oxide on the GaAs surface. The fact that the thermal stability of MoNb-GaAs Schottky barrier is better than that of the Mo-GaAs structure is presumed to be related to the larger heat of formation of the Nb oxides.

AUTHOR: WANG Zhengxiao [3076 2973 1321]

ORG: Institute of Semiconductors, Chinese Academy of Sciences

TITLE: "Calculation and Analysis of Small-signal Microwave Network Parameters of GaAs FETs"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 6 No 1, Jan 85 pp 67-75

TEXT OF ENGLISH ABSTRACT: This paper develops the method presented by M. Reiser [IEEE TRANS., ED-20, 1973, p 35] in which small-signal microwave network parameters of FET are calculated through Fourier transform of the response waveforms of the gate and drain current under the influence of step gate and drain voltage. First, Reiser's expression for calculating Y parameters is modified to some extent. Next, the effects of the series resistances of source, gate and drain are taken into account. In addition, the requirement for a sufficiently small signal is satisfied. The calculation is made for the typical 1  $\mu\text{m}$  gate length GaAs MESFET by using this method, and the results agree well with the experimental data.

AUTHOR: XU Li [1776 4539]  
QIAN Peixin [6929 0160 0207]  
HOU Dongyan [0186 2639 1750]  
WANG Yusheng [3769 6276 3932]  
YAN Jianhua [7051 1696 5478]  
ZHENG Shengnan [6774 0524 3948]  
et al.

ORG: XU, QIAN and HOU, et al., all of the Institute of Microelectronics, Qinghua University; WANG, YAN and ZHENG all of the Institute of Atomic Energy

TITLE: "Thermal Post-Treatment Characteristics of Metastable Carrier Concentration in As-Implanted Silicon After Transient Annealing"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 6 No 1, Jan 85 pp 76-81

TEXT OF ENGLISH ABSTRACT: By means of transient annealing with infrared irradiation, metastable carrier concentration ( $6 \times 10^{20} \text{ cm}^{-3}$ ) which appreciably exceeds the value of equilibrium solid solubility of arsenic in silicon was obtained in high-dose arsenic-implanted silicon samples. These samples were subjected to thermal post-treatments at different temperatures ranging from 20 to 800°C, and it was observed that above 390°C the activated impurity concentrations decrease with the increase of post-treatment time. The samples were investigated experimentally by using Hall effect measurement, layer-removal technique by anodic oxidation and etching, TEM, RBS and channeling effect technique. In this paper the detailed experimental results are shown and the possible mechanism of deactivation of activated arsenic atom is discussed.

AUTHOR: ZHOU Binglin [0719 3521 2651]  
CHEN Zhengxiu [7115 2973 4423]

ORG: Both of the Shanghai Institute of Metallurgy, Chinese Academy of Sciences

TITLE: "Deep Levels in Semi-insulating GaAs"

SOURCE: Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 6 No 1, Jan 85 pp 100-103

TEXT OF ENGLISH ABSTRACT: Hall measurements were performed at a temperature range from 180 to 500°K on undoped SI-GaAs crystals. Two kinds of samples were obtained--the high-resistivity samples with activation energy of 0.71-0.64 eV determined by EL2 level and the middle-resistivity samples with two activation energies of 0.43 eV and 0.37 eV determined by EL5 and EL6 levels. The identification of deep levels in middle-resistivity samples is different from that reported by Martin, et al., and our analysis has been proved by the heat-treatment experiments.

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4009/139

HONG KONG MEDIA ON CHINA

HONG KONG DELEGATE TO CPPCC RAISES PATENT REFUSAL ISSUE

HK010525 Hong Kong SOUTH CHINA MORNING POST in English 1 Apr 85 p 13

[Text] Peking, Mar 31 -- Peking's refusal to grant patent rights to the Hong Kong-produced Vitasoy drink was raised yesterday by a Hong Kong delegate to the Chinese People's Political Consultative Conference.

Mr Li Kwee-seong, chairman of Hong Kong Soya Bean Products Company Ltd, said there were drinks on sale in China using the brand name of his company product, Vitasoy.

(The SCM [South China Morning] Post reported earlier this month a food product factory in Foshan, Guangdong, is producing and marketing openly in the mainland a drink under the Vitasoy brand name and in packages similar to the Hong Kong product).

Mr Lo raised the question in a group discussion of Hong Kong and Macau delegates to the CPPCC.

The imitation will hurt China's image, he said.

His company had filed an application for a patent registration of Vitasoy in 1983.

The application was turned down 18 months later based on a rule that a product cannot be registered when it is the name of a common substance.

Mr Lo said his product is neither a vitamin nor just soyabean.

"Vitasoy is by no means a name of a commonly-used thing."

He said he had raised the matter with Mr Je Pengfei, director of the Hong Kong and Macau Affairs Office, when they met in December.

He was then referred to a relevant official.

However, he was informed that he could not appeal against the decision, according to regulations, but he could apply again.

There are other cases of Hong Kong products being imitated in China, Mr Lo said.

"After the signing of the agreement, Hong Kong companies should not be rejudiced," he said.

China should notify Hong Kong companies that they can register their products in China as patents.

CSO: 4010/123

END