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SYMPOSIUM TOLD OF PLAN TO BUILD SPACE STATION

OW080333 Tokyo KYODO in English 0304 GMT 8 Jun 87

[Text] Beijing, 8 Jun (KYODO)--China unveiled an ambitious space development program Monday that includes construction of an independent space station at the beginning of the 21st century.

Yang Jiachi, a professor at China's Academy of Space Technology, told participants at the opening of the First Pacific Basin International Symposium in Beijing that planning is currently under way to initiate research and development projects aimed at the construction of a space station.

He added that research has also begun on an economical cargo transportation system as a link between earth and space stations.

Yang said his government plans a research program to develop artificial intelligence (AI) space technology and automatic docking equipment for use in future manned space projects.

Space scientists from China, Japan, and the United States are among those taking part in the 3-day symposium, which will cover trilateral cooperation in space development.

Bao Kemin, vice head of the Chinese Society of Astronautics (CSA), welcomed participants to the conference at the friendship guesthouse and jointly sponsored by astronautical societies of the three nations.

Some 200 participants from a total of 15 nations including Britain, France, Australia, and India are attending the symposium, which will also deal with space technology and its applications.

Jiro Kondo, president of the Science Council of Japan, and Philip Culbertson, an official of the U.S. National Aeronautics and Space Administration (NASA), are among those taking part.

Following the symposium, participants are scheduled to tour China's rocket launching facilities and satellite tracking stations which have until now been off limits to foreigners.

China is conducting an ambitious satellite program and has launched a total of 19 satellites since 1970.

/9604
CSO: 4010/52

APPLE/IBM PC COMMUNICATIONS NETWORK ANNOUNCED

Tianjin TIANJIN KEJI XIAOXI [TIANJIN SCIENCE & TECHNOLOGY NEWS] in Chinese
No 10, 15 Oct 86 pp 23-24

[Manuscript provided by Sun Pengjiang [1327 7720 3068], Department of Electrical
Engineering, Tianjin University: "An Apple-IBM PC/XT Microcomputer Telecommuni-
cations System"]

[Text] An inexpensive and practical telecommunications data transfer system
was successfully developed recently by the Tianjin University Department of
Electrical Engineering, passing its municipal technical evaluation in June 1986.

The Apple and IBM PC/XT microcomputers are the most common types of computers
used in China at present. Development of this system has been to further the
development and use of these two computers, and achieves communications between
several Apple computers and IBM PC/XT's under the different operating systems
of these two computers without regard to location and the number of workstations,
thereby achieving the goal of resource sharing.

I. Primary Functions of the System

1. Under the two different operating systems of the Apple and IBM PC/XT com-
puters, this system achieves resource sharing of programs, data file resources,
and the storage equipment of both. To give an example, program files or data
files stored on disks on an Apple may be transmitted to and stored on the IBM
PC/XT's under control of the IBM PC/XT, and they may then be run on the IBM
PC/XT. And the same is true for the reverse situation.

2. The functions just described may all operate in "modem mode" or in "null
modem mode" to achieve telecommunications or machine-to-machine communications.

Transmission rate: 300 baud;

Data format: 1 start bit, 7 data bits, 1 bit for parity checking, 1 and 1/2
stop bits;

Communication distance: for telecommunications, wherever public phone lines go;
for machine-to-machine transfers, as far as 100 meters.

3. The IBM PC/XT can be the central computer, with several Apples (no limit) as workstations. This forms a centralized network situation, allowing the workstations to share resources with the central computer and the other workstations.

II. System Structure

A. Communications Mode

1. This system uses asynchronous communications, and the system structure is as shown in Figure 1:

```
┌──────┐   ┌─────────┐        ┌──────┐ ←-...   ┌──────┐        ┌─────────┐        ┌──────┐
│      │   │asynch.  │        │      │  --→    │      │        │asynch.  │        │      │
│Apple │   │commun.  │←──→    │local │         │remote│(←- - -→)│commun.  │←--→    │IBM   │
│      │   │adapter  │ \  /   │modem │ public  │modem │        │adapter  │        │PC/XT │
└──────┘   └─────────┘  \/    └──────┘ phone   └──────┘        └─────────┘        └──────┘
   │              RS-232-C           lines            RS-232-C                        │
 floppy                                                                          hard disk
```
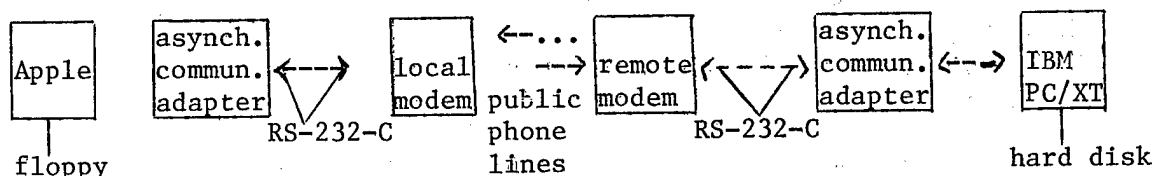
Figure 1.

2. The asynchronous communications adpater: this has 10 functions, and its most essential task is to change the parallel data from the computer into serial (sender), and just the opposite for the receiver (the serial data is changed into parallel). The data transmission rate is set at 300 baud, which is to connect the modems to public telephone networks.

3. The RS-232-C standard: this standard determines the electrical characteristics for the interface between the data terminal equipment and the data communications equipment. In order to ensure correct transmission of binary data and to correctly execute equipment controls, these signals must be the same as the signal to be sued. The RS-232-C standard provides a voltage range for data and control signals to satisfy these demands.

4. Modems: this provides the final link between the computer and the public telephone system. The speed is 300 baud, suitable for large amounts of dialogue communications (or the transmission for small files). When the rate is 300 baud, the longest continuous transmission is 30 bytes per second.

B. Network Structure

1. The structure of the telecommunications centralized network having modems is shown in Figure 2.

```
┌──────┐
│hard  │
│disk  │                                    ┌-----→ │modem│ ←-→ ┌─┐
└──────┘        ┌─────┐    ┌────────┐  ┌─────┘              │1│   Apple
   │            │     │    │public  │──┘                    └─┘
┌──────┐←- -→│modem│←--→│phone   │
│IBM   │        │     │    │network │──┐                    ┌─┐
│PC/XT │        └─────┘    └────────┘  └─────┐              │2│   Apple
└──────┘                                     └-----→ │modem│ ←-→ └─┘
```

Figure 2.

3
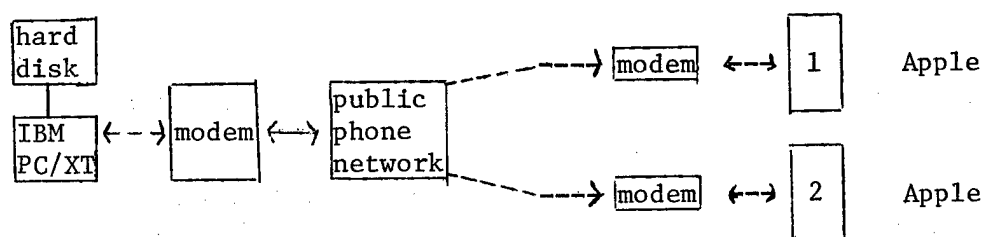
2. In the null modem mode, the machine-to-machine centralized network structure is shown in Figure 3.
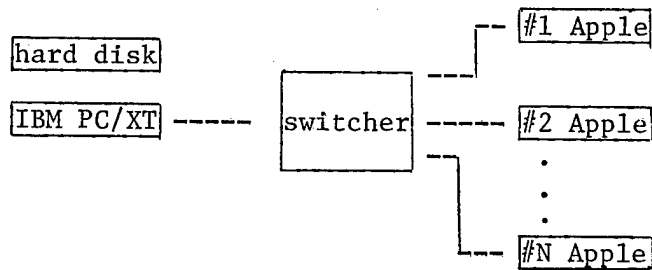
Figure 3.

Under the two modes just described, the following functions are available:

a) Any Apple II from #1 through #N can implement the sharing of IBM PC/XT resources;

b) Any Apple II from #1 through #N can implement resource sharing through the IBM PC/XT with any other Apple II;

c) The data processing tasks of all workstations can be adjusted and balanced, and pre-input processing can be done.

C. Communications program: four communications programs of two kinds have been designed for this system in accordance with differences in transmission directions.

First, transmission from the Apple to the IBM PC/XT:

a) A-I-1 (Apple send program)

b) A-I-2 (IBM receive program)

Second, transmission from the IBM PC/XT to the Apple:

c) I-A-1 (IBM send program)

d) I-A-2 (Apple receive program)

The evaluation held that: the design of this system is novel, and resolves the difficulty that is an inability to exchange information between Apples and IBM PC/XT's in this country because of their different operating systems, and that this system promises clear economic results.

12586/12232
CSO: 4008/1077

4

EFFECTS OF DETECTOR RESPONSE, PROJECTION SAMPLING ON THE CONTRAST OF CT
RECONSTRUCTED IMAGES

[Article by Qu Jianxiong [4234 1696 7160] of the Radio Electronics Department,
China University of Science and Technology]

[Text] Up to the present, in all algorithms concerning CT reconstructed
images, it has been assumed that the detectors are ideal. The actual
physically attainable detector response cannot be unlimited and the projec-
tion numbers obtained are also restricted. These are two important factors
influencing reconstructed image quality. This paper stresses the discussion
of their effect on reconstructed image contrast. We give a theoretical
analysis and, for conditions of two bodies centered on the image space
origin with Gaussian distribution, we provide a single formula relating
the center point's contrast to the detector response parameters and the
sampling parameters. We also give computed results. The curves obtained
were drawn on a plotter of a VAX-11/750 at the Electrical Engineering
Department of (Kantebuli) University.

I.

Suppose two bodies centered on the origin display Gaussian distribution. In
density, their distributions are respectively

$$\lambda_1(x,y) = \exp\left(-\frac{x^2+y^2}{2\sigma_1^2}\right) \tag{1}$$

$$\lambda_0(x,y) = \alpha\exp\left(-\frac{x^2+y^2}{2\sigma_0^2}\right), \tag{2}$$

taking $\sigma_0 \gg \sigma_1$ as in Figure 1.

The detector response can also be considered to be a Gaussian distribution [2,3]
which is the formula after simplification. Here suppose the corresponding
function is

$$h(s) = \exp\left(-\frac{S^2}{2\sigma_d^2}\right). \tag{3}$$
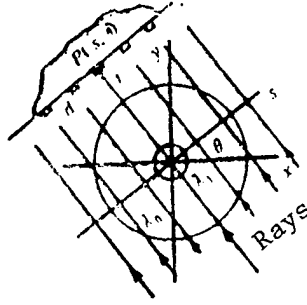
Figure 1

We assume each projection is composed of a finite number of sample points but the total number of sample points are infinite (i.e., continuously variable from 0° to 360°, see Figure 1). After considering the effect of detector response and projection sampling, the single projection we get is

$$\tilde{P}(s,\theta) = [P(s,\theta) * h(s)] \cdot \sum_{m=-\infty}^{\infty} \delta(s - md), \tag{4}$$

in which $P(s,\theta) = \int_{-\infty}^{\infty} \lambda(x,y)dt$ is the projection under ideal conditions, $*$ represents convolution, and d is the sample separation (see Figure 1).

Consider the variation of contrast at the origin of the two bodies after reconstruction. Define

$$\text{Contrast} = \frac{\tilde{\lambda}_1(0)}{\tilde{\lambda}_0(0)} \bigg/ \frac{\lambda_1(0)}{\lambda_0(0)}, \tag{5}$$

in which $\lambda_1(0)$, $\lambda_0(0)$ represent respectively the values of the original bodies at the origin and $\tilde{\lambda}_1(0)$, $\tilde{\lambda}_0(0)$ represent the values of the bodies at the origin after reconstruction.

Based on the well known Fourier projection theorem, the one dimensional Fourier transform of the projection P(s,θ) is just the two dimensional Fourier transform of the bodies λ(x,y) [4]. Therefore, by carrying out the two dimensional Fourier inverse transform with respect to the one dimensional transform of $\tilde{P}(s,\theta)$ we will get a reconstructed image $\tilde{\lambda}(x,y)$ after detector response and sampling effects are taken into consideration.

Consider formula (4). Now

$$P_1(s,\theta) = \int_{-\infty}^{\infty} \lambda_1(x,y)dt = \int_{-\infty}^{\infty} \lambda_1(s,t)dt = \sqrt{2\pi}\sigma_1 \exp\left(-\frac{s^2}{2\sigma_1^2}\right), \tag{6}$$

$$P_0(s,\theta) = \sqrt{2\pi}\alpha\sigma_0 \exp\left(-\frac{s^2}{2\sigma_0^2}\right). \tag{7}$$

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The one dimensional Fourier transforms of $P_0(s,\theta)$, $P_1(s,\theta)$, $h(s)$, $\sum\limits_{m=-\infty}^{\infty} \delta(s-md)$ are

$$P_0(s,\theta) \rightarrow P_0(R,\theta) = 2\pi\alpha\sigma_0^2\exp(-2\pi^2\sigma_0^2 R^2) \tag{8}$$

$$P_1(s,\theta) \rightarrow P_1(R,\theta) = 2\pi\sigma_1^2\exp(-2\pi^2\sigma_1^2 R^2), \tag{9}$$

$$h(s) \rightarrow H(R) = \sqrt{2\pi}\sigma_d\exp(-2\pi^2\sigma_d^2 R^2). \tag{10}$$

$$\sum_{m=-\infty}^{\infty} \delta(S-md) \rightarrow (1/d)\sum_{m=-\infty}^{\infty}\delta(R-m/d). \tag{11}$$

therefore

$$\tilde{P}_0(s,\theta) \rightarrow \tilde{\Lambda}_0(R,\theta) = [P_0(R,\theta)H(R)] * \left(\frac{1}{d}\sum_{m=-\infty}^{\infty}\delta(R-m/d)\right)$$

$$= \frac{\alpha}{d}(2\pi)^{3/2}\sigma_0^2\sigma_d \sum_{m=-\infty}^{\infty}\exp[-2\pi^2(\sigma_0^2+\sigma_d^2)(R-m/d)^2], \tag{12}$$

$$\tilde{P}_1(s,\theta) \rightarrow \tilde{\Lambda}_1(R,\theta) = \frac{1}{d}(2\pi)^{3/2}\sigma_1^2\sigma_d \sum_{m=-\infty}^{\infty}\exp[-2\pi^2(\sigma_1^2+\sigma_d^2)(R-m/d)^2]. \tag{13}$$

In order to avoid mixed iteration effects in the Fourier region caused by the sampling, we selected an appropriate filter. The filter was selected as a Gaussian model

$$F(R) = \exp(-2\pi^2\sigma_f^2 R^2). \tag{14}$$

The image after reconstruction is

$$\tilde{\lambda}_i(x,y) = \mathscr{F}_2^{-1}[F(R)\tilde{\Lambda}_i(R,\theta)], \quad i=0,1. \tag{15}$$

$\mathscr{F}_2^{-1}$ represents the two dimensional inverse Fourier transform.

Formula (15) written out clearly is just

$$\tilde{\lambda}_0(x,y) = \tilde{\lambda}_0(r,\varphi) = \frac{\alpha}{d}(2\pi)^{3/2}\sigma_0^2\sigma_d \int_0^{2\pi}\int_0^{\infty}\exp(-2\pi^2\sigma_f^2 R^2) \sum_{m=-\infty}^{\infty}\exp[-2\pi^2(\sigma_0^2+$$

$$+\sigma_d^2)(R-m/d)^2] \cdot \exp[i2\pi rR\cos(\theta-\varphi)]RdRd\theta, \tag{16}$$

$$\tilde{\lambda}_0(0) = \frac{\alpha}{d}(2\pi)^{5/2}\sigma_0^2\sigma_d \int_0^{\infty}\exp(-2\pi^2\sigma_f^2 R^2)$$

$$\cdot \sum_{m=-\infty}^{\infty}\exp[-2\pi^2(\sigma_0^2+\sigma_d^2)(R-m/d)^2]RdR. \tag{17}$$

Similarly

$$\tilde{\lambda}_1(0) = \frac{1}{d}(2\pi)^{5/2}\sigma_1^2\sigma_d \int_0^\infty \exp(-2\pi^2\sigma_f^2 R^2)$$

$$\cdot \sum_{m=-\infty}^\infty \exp[-2\pi^2(\sigma_1^2+\sigma_d^2)(R-m/d)^2]RdR. \tag{18}$$

The two integrals above are both convergent. The transform integrals and the order of the summations as well as the definition of contrast employed (see formula (5)) give

$$\text{Contrast} = \frac{\sigma_1^2}{\sigma_0^2} \cdot \frac{\sum\limits_{m=-\infty}^\infty \int_0^\infty \exp[-2\pi^2((\sigma_1^2+\sigma_d^2)(R-m/d)^2+\sigma_f^2 R^2)]RdR}{\sum\limits_{m=-\infty}^\infty \int_0^\infty \exp[-2\pi^2((\sigma_0^2+\sigma_d^2)(R-m/d)^2+\sigma_f^2 R^2)]RdR} \tag{19}$$

Directly computing the integral in the formula above gives

$$\text{Contrast} = \frac{\sigma_1^2(\sigma_0^2+\sigma_d^2+\sigma_f^2)}{\sigma_0^2(\sigma_1^2+\sigma_d^2+\sigma_f^2)} \cdot \left(\frac{\begin{array}{l}1+2\sum\limits_{m=1}^\infty\left\{\exp\left(-\dfrac{2\pi^2 m^2(\sigma_1^2+\sigma_d^2)}{d^2}\right)+\right.\end{array}}{\begin{array}{l}1+2\sum\limits_{m=1}^\infty\left\{\exp\left(-\dfrac{2\pi^2 m^2(\sigma_0^2+\sigma_d^2)}{d^2}\right)+\right.\end{array}} \right.$$

$$\left. \frac{+\dfrac{(2\pi)^{3/2}(\sigma_1^2+\sigma_d^2)}{d(\sigma_1^2+\sigma_d^2+\sigma_f^2)^{1/2}}\cdot m\cdot\exp\left(-\dfrac{2\pi^2 m^2\sigma_f^2(\sigma_1^2+\sigma_d^2)}{d^2(\sigma_1^2+\sigma_d^2+\sigma_f^2)}\right)\cdot\text{erf}\left(\dfrac{m\sqrt{2}\,\pi(\sigma_1^2+\sigma_d^2)}{d(\sigma_1^2+\sigma_d^2+\sigma_f^2)^{1/2}}\right)\right\}}{+\dfrac{(2\pi)^{3/2}(\sigma_0^2+\sigma_d^2)}{d(\sigma_0^2+\sigma_d^2+\sigma_f^2)^{1/2}}\cdot m\cdot\exp\left(-\dfrac{2\pi^2 m^2\sigma_f^2(\sigma_0^2+\sigma_d^2)}{d^2(\sigma_0^2+\sigma_d^2+\sigma_f^2)}\right)\cdot\text{erf}\left(\dfrac{m\sqrt{2}\,\pi(\sigma_0^2+\sigma_d^2)}{d(\sigma_0^2+\sigma_d^2+\sigma_f^2)^{1/2}}\right)\right\}} \right) \tag{20}$$

Since σ_0 is taken as very large, the value of the sum in the denominator of the formula above is nearly zero (when $\sigma_0 = 1$, for different d, σ_d, σ_f conforming to a physical significance, this value is no larger than a magnitude of 10^{-9}), therefore we simplify the formula to

$$\text{Contrast} = a\left\{1+2\sum_{m=1}^\infty [\exp(m^2 t_1)+bm\exp(m^2 t_2)\cdot\text{erf}(mc)]\right\}. \tag{21}$$

in which $a = \dfrac{\sigma_1^2(\sigma_0^2+\sigma_d^2+\sigma_f^2)}{\sigma_0^2(\sigma_1^2+\sigma_d^2+\sigma_f^2)}$

$$= \frac{\left(\dfrac{\sigma_1}{\sigma_d}\right)^2\left[\left(\dfrac{\sigma_0}{d}\right)^2\Big/\left(\dfrac{\sigma_d}{d}\right)^2+1+1\Big/\left(\dfrac{d}{\sigma_f}\right)^2\left(\dfrac{\sigma_d}{d}\right)^2\right]}{\left(\dfrac{\sigma_0}{d}\right)^2\Big/\left(\dfrac{\sigma_d}{d}\right)^2\left[\left(\dfrac{\sigma_1}{\sigma_d}\right)^2+1+1\Big/\left(\dfrac{d}{\sigma_f}\right)^2\left(\dfrac{\sigma_d}{d}\right)^2\right]}, \tag{22}$$

$$b = \frac{(2\pi)^{3/2}\left[\left(\frac{\sigma_1}{\sigma_d}\right)^2 + 1\right]\left(\frac{\sigma_d}{d}\right)}{\left[\left(\frac{\sigma_1}{\sigma_d}\right)^2 + 1 + 1\Big/\left(\frac{d}{\sigma_f}\right)^2\left(\frac{\sigma_d}{d}\right)^2\right]^{1/2}}, \tag{23}$$

$$c = \frac{\sqrt{2\pi}\left[\left(\frac{\sigma_1}{\sigma_d}\right)^2 + 1\right]\left(\frac{\sigma_d}{d}\right)}{\left[\left(\frac{\sigma_1}{\sigma_d}\right)^2 + 1 + 1\Big/\left(\frac{d}{\sigma_f}\right)^2\left(\frac{\sigma_d}{d}\right)^2\right]^{1/2}}, \tag{24}$$

$$t_1 = -2\pi^2\left[\left(\frac{\sigma_1}{\sigma_d}\right)^2 + 1\right]\left(\frac{\sigma_d}{d}\right)^2, \tag{25}$$

$$t_2 = \frac{-2\pi^2\left[\left(\frac{\sigma_1}{\sigma_d}\right)^2 + 1\right]}{\left(\frac{d}{\sigma_f}\right)^2\left[\left(\frac{\sigma_1}{\sigma_d}\right)^2 + 1 + 1\Big/\left(\frac{d}{\sigma_f}\right)^2\left(\frac{\sigma_d}{d}\right)^2\right]}, \tag{26}$$

$\mathrm{erf}(x) = \frac{2}{\sqrt{\pi}}\int_0^x e^{-t^2}dt$ is the error function.

From formulae (21) to (26) we know that the contrast is a function of σ_1/σ_d, σ_0/d, d/σ_f, and σ_d/d.

We give three classes of curves of contrast variation. Figure 2 is the curves relating contrast and σ_1/σ_d selecting $\sigma_0/d = 10$. Figure 2(a) and 2(b) correspond to $d/\sigma_f = 0.4$ and 0.8. The five curves in each figure from bottom to top correspond to $\sigma_d/d = 0.2$, 0.6, 1.0, 1.4, and 1.8.

From these curves we know that for very small bodies, the detector response severely influences the contrast. At the same time, they also show that when the sampling spacing increases (the value σ_d/d becomes small), the contrast value falls.

The influence of different filters on contrast is also evident (compare Figures 2(a) and 2(b)) because use of too narrow a filter will lose a part of the information.

Figure 3 gives the relation between contrast and d/σ_f with $\sigma_0/d = 10$. Figures 3(a) and 3(b) respectively correspond to $\sigma_d/d = 0.8$ and 1.6. The five curves in each figure from the bottom up are for $\sigma_1/\sigma_d = 0.4$, 0.8, 1.2, 1.6, and 2.0.

Figure 4 shows the relationship of contrast to variation of σ_d/d, also for $\sigma_0/d = 10$. Figures 4(a) and 4(b) correspond to $d/\sigma_f = 0.4$ and 0.8. The parameters of the five curves are as for Figure 3.

Closely inspecting Figure 3 and Figure 4, it is not difficult to see that their results are the same as for Figure 2.
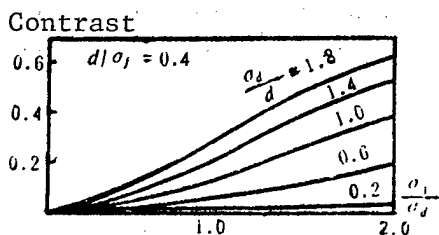
Contrast

Figure 2(a).   Contrast and σ_1/σ_d
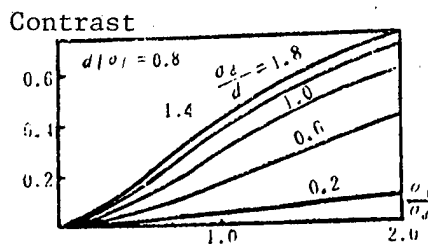
Contrast

Figure 2(b).   Contrast and σ_1/σ_d
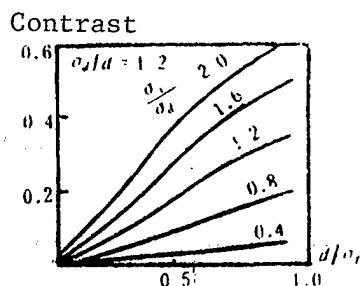
Contrast

Figure 3(a).   Contrast and d/σ_f
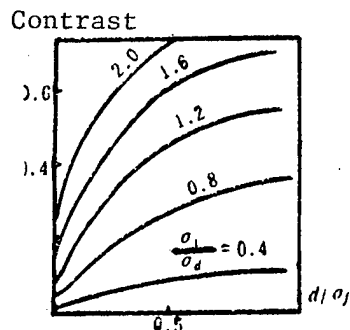
Contrast

Figure 3(b).   Contrast and d/σ_f
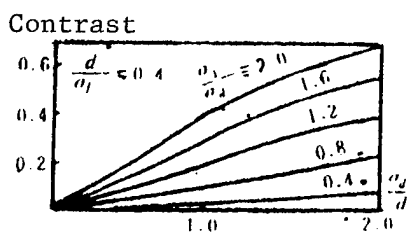
Contrast

Figure 4(a).   Contrast and σ_d/d

Contrast $\frac{d}{\sigma_l} = 0.8$
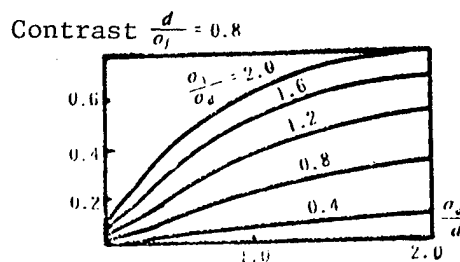
Figure 4(b).   Contrast and σ_d/d

II.

In the actual application of CT, how to distinguish micro differences in biological structures, increase resolution, as well as how to improve the algorithms for reconstructing images to reduce accompanying pseudo images are all questions people have been concerned with resolving all along. The results we have obtained show that the influence of projection sampling and finite response of detectors on the contrast of reconstructed images is obvious, especially for very small bodies. The response of flat detectors is a major factor in contrast loss. Consequently, theoretical research and technical experiments carried out on detector response to obtain a deeper understanding of the process are undoubtedly of very great practical significance.

REFERENCES

1. Qu Jianxiong [4234 1696 7160], ZHONGGUO KEXUE JISHU DAXUE XUEBAO [JOURNAL OF CHINA UNIVERSITY OF SCIENCE AND TECHNOLOGY], 16.1(1986).

2. Hsieh, R.C. and W.G. Wee, IEEE SMC, 6.12(1976), 854-862.

3. Judy, P.F., Med. Phys., 3.4(1976), 233-236.

4. Lewitt, R.M., IEEE. Proc., 71.3(1983), 393.

5. Bracewell, R.N., "The Fourier Transform and Its Applications," McGraw-Hill, 1978.

6. Miles, J.W., "Integral Transforms in Applied Mathematics," Cambridge Press, 1971.

12966/6091
CSO: 4008/1070

ECONOMIC RESULTS OF AUTOMATION IN ORE DRESSING

[Article by Su Zhen [5685 7201] of Zhongnan Industrial University: "Economic Results of Automation in Ore Dressing and Direction of China's Development"]

[Summary] From a survey on 5 crushing workshops, 14 grinding workshops, and 19 floatation workshops in several foreign countries, we have discovered that computers are mostly used for stabilization in automatic ore dressing with remarkable results.

1. Crushing. In automatic crushing, it is easier to maintain a balance between the rates of feed and discharge resulting in the reduction of per-unit energy consumption.

2. Grinding. According to experiences at home and abroad, the processing capacity with automatic control is generally increased 3 to 5 percent, and sometimes as high as 10 percent. Because of the random factor, the capacity of manual processing fluctuates by a margin of more than 10 percent, and is usually set at the lower limit for safe operation.

3. Floatation. According to statistics in the 19 floatation workshops surveyed, most of them showed a marked reduction in the use of frothing agents as a result of automation. In manual floatation, the timing for the use of frothing agents and the amount used are mostly inaccurate. For convenience, the standards for the use of collectors and frothers are usually set too high. In the stabilized control system, however, the amounts to be used are strictly regulated according to the amounts of metals or ores, and waste can be avoided. In China, the ore dressing plant of Fenghuangshan Copper Mine has reduced the consumption of pine oil by about 20 percent and that of (huengyao) by more than 10 percent.

Generally, automatic control can markedly raise the recovery rate and the grade of concentrates, when the ores are complex and the required technical conditions have to be strictly followed. In such cases, the stabilized control system can constantly readjust the quantity so that it will always remain within the set limits. As to the ores of a simple nature which can be easily floated and requires no intricate processing, however, manual operation should be good enough.

In industrially developed countries where investment in automation is not so heavy, the adoption of automatic control system in ore dressing would help

save raw materials, raise equipment efficiency and the production index, improve working conditions, and yield quick investment returns.

China's automation in ore dressing began in the 1950's with automatic prospecting for metal bullion and automatic measurement of ores. It was not until the 1970's that its research in single-parameter control in ore dressing began. Automation is now in the stage of the application of simulation meter control and the research in microcomputer control. To accelerate China's automation in ore dressing, Fenghuangshan Copper Mine imported a computer-controlled system from Finland in 1980, and then began its research in direct digital and optimal control with computers.

This mine threats two types of ores, namely, pyrite and magnetic iron ore, both containing copper. With the mixing-separating floatation process, it selects copper and sulfide concentrates from the ores, and iron concentrates from magnetic tailings. Formerly, with manual control, its main problem was that when the pyrite content of ores fluctuates seriously, the amount of sulfide in the concentrate cannot measure up to the required standards.

The use of computerized control on grinding and floatation has increased the processing capacity and raised the grade of copper 0.88 percent and that of sulfide 4.11 percent in their concentrates. It also raises the recovery rate of sulfide concentrates 4.75 percent and reduces the consumption of flavine and pine oil by more than 10 percent and about 20 percent respectively. Its investment in the computerized control system (including the computers, meters, other devices, and training expenses) amounted to $2.22 million, and its economic benefits in terms of annual output amounted to 577,000 yuan.

In evaluating the automation in Fenghuangshan Copper Mine, the following three points should be noted: First, if the process of ore dressing is simple, the recovery rate of copper is already as high as 91 to 93 percent, and not much potential can be tapped in stabilized control. Second, its investment is two to three times that of foreign countries, because most of the required meters, devices, and computers had to be imported, and some of these meters had changed hands several times before coming to China, thus adding to the costs. Third, it takes some time for the imported technology to be assimilated, applied, and mastered before it can yield any economic benefit.

Based on the experience at home and abroad, automation in ore dressing can definitely increase the processing capacity, raise the output index, reduce the consumption of reagents, and improve the working conditions. Therefore, automation in ore dressing is one of the key factors in China's modernization of this industry. In light of the realities in China, the following policies should be adopted:

1. Domestic production of meters and other devices. Computers, meters, and the required devices are the prerequisites of automation, and we must be able to produce them, or most of them, in China before the economical results can be significantly improved.

2. Computer control for large ore dressing plants with good potential. for some large ore dressing plants requiring complex techniques and strict compliance with technical standards, and having definite latent resources, we should import some key items (such as the computer mainframe and some essential meters). Then we can set up our own system of automatic control and proceed to train our own personnel.

3. Automatic regulation of key parameters in ore dressing for ordinary plants. For most ore dressing plants, which are not yet ready for complete automation, priority should be given to automatic regulation of certain key parameters. The reason is that China is already mature in the theory and technology of such automatic regulation and can conduct it with either microcomputers or simulation meters. It requires less investment and takes less time to train the technical force.

4. Automatic parameter monitoring and automatic production control. Automatic monitoring with the major parameters in ore dressing (such as the amount, thickness, fineness, flow, pH value, and grade of ores) is simpler than automatic regulation. The use of microcomputers for the collection, accumulation, analysis, and control of linear data can more speedily supply information to the production sites for guidance in the production process and for scientific management.

5. Research in automatic control of advanced world standards. For ore dressing, the industrially advanced countries have already used artificial intelligence which can automatically regulate the structure and parameters of a system according to the ore characteristics, equipment conditions, production environment, price changes, and other factors, or automatically work out the optimal production program, create the best working conditions, turn out products of the best quality, and lower the production cost to the minimum. For such research, we have to go deeper into theories, design more complex software, and use some special equipment. Difficulties will also be encountered. However, since it is necessary as a technical reserve, we should support the units concerned in continuing this work as a contribution to automation in ore dressing.

9411/12828
CSO: 4008/2068

14

RECOMMENDATIONS ON DEVELOPING POLYCRYSTALLINE ALUMINA FIBER

Luoyang NAIHUO CAILIAO [REFRACTORIES] in Chinese No 1, 20 Jan 87 pp 47-51

[Article by Lin Yulian [2651 5148 3550] and Xing Shouwei [0438 1343 3262] of the Luoyang Refractories Institute, Ministry of Metallurgical Industry]

[Excerpts] Refractory fiber materials have important energy-conservation applications. Production in China has increased from 2,000 tons in 1981 to 5,000 tons in 1985. Thousands of industrial furnaces in China are equipped with refractory fiber liners and extensive research and development efforts are spent on new material development and testing.

I. Brief Review of Refractory Fiber Development in China During the Sixth 5-Year Plan

I.1. Full-Scale Utilization in Metallurgical Furnaces

The rate of increase of refractory fiber utilization in industrial furnaces in China was 8 percent from 1982 through 1985; 54.5 percent of the furnaces now use fiber liners, at an energy saving of 120,000 tons of standard coal and 30.96 million yuan of economic results.

I.2. Resistance Furnace Continuous Melt/Spray Technique

Working from 1979 to 1983, Luoyang Refractories Institute [LRI] achieved experimental success in resistance furnace continuous melt/spray techniques. A production line was set up in the Sanmenxia Refractories Plant in 1985 to produce 500 tons of aluminum silicate fiber wool per year. The production line can operate continuously for as long as 15 days and the products met national standards. Guangdong, Zhejiang, and Shandong have recently set up similar plants.

I.3. Breakthrough in Polycrystalline Alumina Fiber Production

In 1984, LRI completed the development of a 5 ton/year facility for producing polycrystalline fibers with 80 percent AL_2O_3 using a colloidal method. Tests made at 1400°C showed a temperature increase 4 to 5 times faster and an energy saving of 30 to 50 percent. Application tests are being conducted in industrial furnaces.

I.4. Imported Production Facilities

During the Sixth 5-Year Plan Beijing Refractories Plant imported an advanced
continuous melt/spin blanket-weaving production line from American
Combustion Engineering. This facility went into operation in June 1984. In
March 1985 a Babcock-Wilcox continuous melt/spray production line began
production in Shan Xian. Another American Combustion Engineering line is
being built in Guiyang. The first Chinese-built refractory fiber production
facility based on the imported technology is expected to be built in Nanjing
in 1986.

I.5. Six national standards on aluminum silicate fiber blanket quality and
test procedures were issued during the Sixth 5-Year Plan. Tentative regulations
on refractory fiber applications were also issued.

II. Directions of Foreign Developments

The colloidal method for producing high temperature (1500-1600°C) polycrystal-
line refractory fiber containing 95 percent Al_2O_3 was first developed by the
British company Imperial Chemical Industries. This material opened up high-
temperature industrial applications. Polycrystalline alumina fibers have
been successfully used in American and West Germany industries with substantial
energy savings.

Since polycrystalline alumina fibers have a high cost, a hybrid of alumina
(95 percent Al_2O_3) and aluminum silicate fibers was developed. The alumina
provides the structural skeleton at high temperatures. Moderate amounts of
alumina in the hybrid greatly reduced the shrinkage of the fiber blanket.
However, the shrinkage rate does not decrease very much when the alumina
content is above 60 percent. Hybrids have been developed in the United
States and Japan for applications in the 1400-1500°C range.

Driven by cost considerations, the recent trend is toward lowering the alumina
content; 72 percent Al_2O_3 and aluminum silicate hybrid fibers are being
developed in the United States and Japan. Hybrid fiber blanket containing
50 percent of (95% Al_2O_3) and 50 percent aluminum silicate fiber has a linear
shrinkage of 1.57 and 1.76 [as published] at 1 day and 7 days respectively.
Similar blankets using 72 percent Al_2O_3 fibers showed shrinkages of 1.32 and 1.71
at the same time intervals. Industrial applications in Japan and the United
States showed that hybrid fibers containing high (95 percent) Al_2O_3 and lower
(72 percent) Al_2O_3 performed similarly.

III. Recommendations for Development in China

China is at a trasitional period from producing low- and intermediate-temperature
refractory fiber to developing high-temperature refractory fibers. The State
Economic Council and the Ministry of Metallurgical Industry have made the
development of high-temperature refractory fibers a high-priority project in
the Seventh 5-Year Plan. The time is right for the development of high-temperature

fibers because of the following reasons. The higher the operating temperature, the more energy the refractory fibers will save. In China, there are more than 500 heating furnaces operating above 1350°C in the steel-rolling industry alone. The application potential and energy savings are very great. In addition, China has already built up a technology base for producing high-temperature fibers using the colloidal method.

Our recommendations for increased efforts are:

1. Before 1980, China developed intermediate-temperature fibers for 1100 to 1200°C applications, but the production is limited. These fibers can be produced at reasonable costs and should be mass produced and promoted.

2. The development of high-temperature fibers should be accelerated. The first priority is to expand the colloidal production of polycrystalline alumina fibers so that enough material can be produced for tests and for developing hybrid products. The State Economic Council has begun to plan a 100-ton colloidal alumina fiber production facility.

3. Once there is enough material for application tests, representative industrial applications will be selected for demonstration tests. Product standards and design criteria will be considered.

4. Attention should be given to problems in high-temperature applications such as adhesive materials, fixtures, and erosion by high-temperature gas flows. The effects of hot gas flows are particularly important because many industrial furnaces use oil or natural gas as fuels.

5. Strength the research effort: The technology of producing polycrystalline alumina fibers is very complex and there are many remaining problems to be addressed by basic research. Attention should be given to heat-treatment procedures, stabilizer selection, property changes and damage mechanisms, and ways to reduce production costs.

5. Certain key technologies should be imported to speed up the production and application of high-temperature refractory fibers in China. This may be combined with the effort to build the 100-ton production line.

9698/12851
CSO: 4008/2106

COMPUTER-AIDED TRANSFORMATION OF DESCRIPTIVE MODE OF MATHEMATICAL MODELS OF A CONTROL SYSTEM

[Article by Gu Wenjin [7357 2429 6930] and Sun Fuchun [1327 1381 2504] of the Second Naval Artillery Institute: "Computer-aided Transformation of Mathematical Models of a Control System"]

[Text] Abstract: The mode and program flow chart of computer-aided mathematical models of a control system are introduced. The transformation algorithm is simple and directly perceived, occupies less memory and features a wide application range. It has been used on the CAD library of PC-1500 computers. It is widely employed in research institutes and factories and enjoys favorable comments.

I. Presentation of the Problem

In recent years, as the use of computer technology becomes more popular, computer-aided design (CAD) of control systems has become a promising design method. However, this design technique is based on certain mathematical models. Therefore, it is necessary to carry out the necessary and rational transformation of mathematical models in various forms.
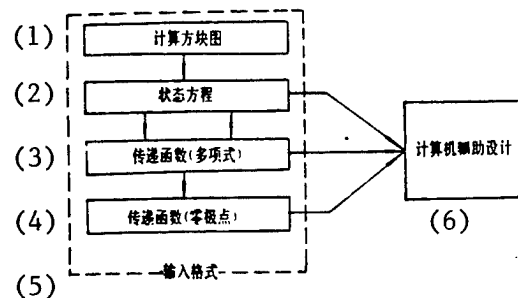
Figure 1.

Key:
1. block diagram
2. equation of state
3. transfer function (polynomial)
4. transfer function (zero pole)
5. input format
6. computer-aided design

The expressions of mathematical models generally include (1) differential equation, (2) equation of state, (3) transfer function (polynomial), (4) transfer function (zero pole mode), and (5) block diagram for computation. Among these five modes, the latter four are widely used. The majority of CAD employs an equation of state or a transfer function (polynomial or zero pole mode), as shown in Figure 1.

This paper will introduce the transformation models employed by the CAD library at our institute. Each program allows the user to choose one of the four input modes to carry out the calculation. This kind of transformation is simple and direct and occupies less memory. It has a wide range of applications.

II. Mathematical Description of the Transformation Models

1. Determining the Equation of State from the Block Diagram

In most block diagrams, each segment can always be transformed into a first order standardized segment

$$\frac{X_i}{u_i} = \frac{C_i + d_i S}{a_i + b_i S} \quad (i = 1, 2, \cdots, N)$$

(1)

where   is the output of the ith segment,   is the input of the ith segment, and N is the total number of segments.

Equation (1) can also be written as

$$(a_i b_i S) X_i = (C_i + d_i S) u_i$$

(2)

Or, it may be written in matrix form.

$$(A + BS)X = (C + DS)u_i$$

(3)

where

$$
\left.
\begin{array}{l}
A = \mathrm{diag}(a_1, a_2, \cdots, a_n) \\
B = \mathrm{diag}(b_1, b_2, \cdots, b_n) \\
C = \mathrm{diag}(c_1, c_2, \cdots, c_n) \\
D = \mathrm{diag}(d_1, d_2, \cdots, d_n)
\end{array}
\right\}
$$

(4)

It is called the segment parameter matrix.

It is possible to list a series of equations based on the relation between the segments in the block diagram. For instance, Figure 2 shows a five segment system.
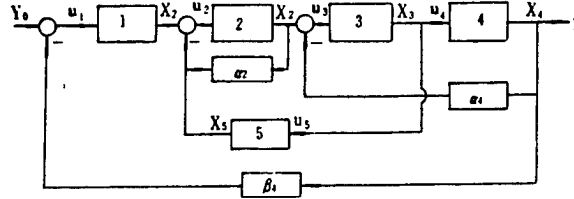
Figure 2.

In the figure, a_2, a_4, β_4 are pure amplifying coefficients to be treated as linking coefficients. The following equations can be arrived based on the figure

$$\begin{cases} u_1 = Y_0 - \beta_4 X_4 \\ u_2 = X_1 - a_2 X_2 - X_5 \\ u_3 = X_2 - a_4 X_4 \\ u_4 = X_3 \\ u_5 = X_3 \end{cases} \quad (5a)$$

$$Y = X_4 \quad (5b)$$

In matrix form, it is written as

$$\begin{cases} u = WX + W_0 Y_0 & (6a) \\ Y = EX & (6b) \end{cases}$$

where

$$W = \begin{bmatrix} 0 & 0 & 0 & -\beta_4 & 0 \\ 1 & -a_2 & 0 & 0 & -1 \\ 0 & 1 & 0 & -a_4 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

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$$W_0 = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$E = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

W is called the segment connective matrix. Each element of it columns represents the connective coefficient between the ith and jth segment. If there is no connection, the element is zero. E is called the output matrix. If the ith segment is an output segment, then the ith element of E is 1, while the rest of them are zero.

After substituting Equation (6a) into (3), we get

$$(B-DW)SX = (CW-A)X + CW_0Y_0$$
$$+ DW_0SY_0 \qquad (7)$$

Or, it may be written as

$$SX = (B-DW)^{-1}(CW-A)X$$
$$+ B-DW)^{-1}CW_0Y_0 \qquad .$$
$$+ (B-DW)^{-1}DW_0Y_0 \qquad (8)$$

If the Y_0 step input segment $d_i = 0$, then

$$(B-DW)^{-1}DW_0SY_0 = 0$$

Therefore, Equation (8) is

$$X = FX + PY_0 \qquad (9a)$$

The output function is

$$Y = EX \qquad (9b)$$

where

$$\left. \begin{array}{l} F = (B-DW)^{-1}(CW-A) \\ P = (B-DW)^{-1}CW_0 \end{array} \right\} \qquad (10)$$

Equation (9) is the equation of state calculated based on an arbitrary block diagram. Thus, (F, P, E) can be determined to carry out the required computer-aided design. Of course, the method requires that the parameter of

the input segment $d_i=0$. However, it is capable of maintaining the status of the original block diagram. If we want to remove the constraint that $d_i=0$, it is necessary to transform the state variables.

The above principle can easily be programmed. The flow chart of the program is shown in Figure 3.
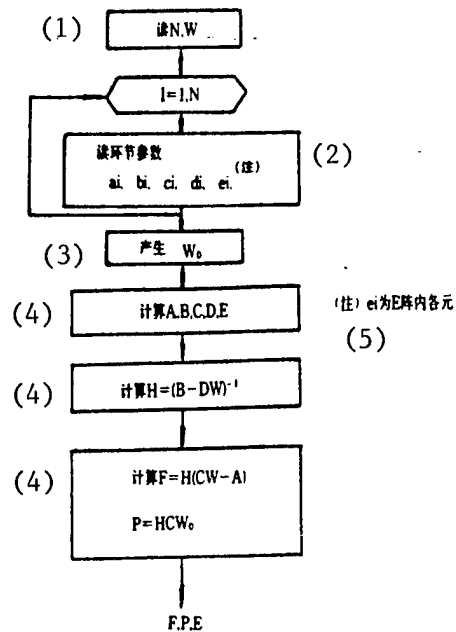
Figure 3

1. read N, W
2. read segment parameters
3. generate
4. calculate
5. (Note) ei is an element of the matrix E.

2. Determining Transfer Function from the Equation of State

The transfer function of a system with an equation of state (9) can be written as:

$$G(S) = \frac{Y(S)}{Y_0(S)} = E(SI-F)^{-1}P$$

$$= E\frac{adj(SI-F)}{det(SI-F)}\ P$$

$$= \frac{C_1S^{n-1}+C_2S^{n-2}+\cdots+C_n}{S^n+B_1S^{n-1}+\cdots+B_n} \quad (11)$$

Its numerator and denominator coefficients $C_i, B_i (i=1,2,\cdots,n)$ can be calculated by using a Sourian-Fram (or Leveirier-Faaddeva) equation.

$$\begin{cases} H_1 = I_n \\[2mm] B_k = -\dfrac{1}{K} \, tr(FH_k) \\[4mm] \qquad\qquad (K=1,2,\cdots,n) \quad (12) \\[2mm] H_{k+1} = FH_k + B_k I_n \\[2mm] C_k = EH_k P \end{cases}$$

A detailed proof of this formula can be found in references [2,3]. The corresponding computer program flow chart is shown in Figure 4.
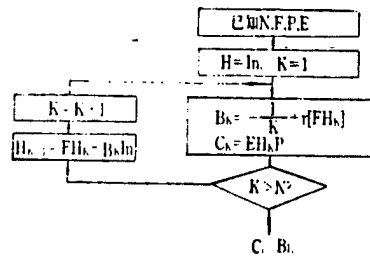
Figure 4

3. Determining the Equation of State from the Transfer Function

If the system is controllable and measurable, then its transfer function has no common factor. It can be expressed as

$$G(S) = \frac{C_1 S^{n-1} + C_2 S^{n-2} + \cdots + C_n}{S^n + B_1 S^{n-1} + \cdots + B_n} \quad (13)$$

There must be a standard controllable format

$$\begin{cases} \dot{X} = FX + Pu \\ Y = EX \end{cases}$$

where

$$F = \begin{bmatrix} 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ & & & \ddots & 1 \\ -a_n & -a_{n-1} & \cdots & & -a_1 \end{bmatrix} \quad (14)$$

$$P = \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 1 \end{bmatrix} \quad (15)$$

$$E = [C_n, C_{n-1}, \cdots, C_1] \quad (16)$$

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The transfer function can be transformed into the equation of state as long as the program goes over the above equations. Of course, equation (13) can also be transformed into a standard observable form. Because the equation is relatively simple, the program flow chart is omitted.

4. Transforming a Polynomial Transfer Function into a Zero Pole Format

In general, the zero pole point of the system is determined by using a root extracting method for a higher order equation. The most representative one is the Lin Shie [2621 1102 6166] and Zhao Fangxiong [6392 6078 3574] method, or the factor splitting method.

Let us consider the following polynomial

$$f(S) = S^n + a_1 S^{n-1}$$
$$+ \cdots + a_{n+1} S + a_n \qquad (17)$$

Let us divide it by the quadratic equation $\varphi(S) = S^2 + PS + q$

The quotient is

$$Q(S) = S^{n-2} + b_1 S^{n-3} + \cdots + b_{n-3} S + b_{n-2}$$

and the complementary formula is $R(S) = mS + W$

i.e. $$f(S) = Q(S)\varphi(S) + R(S) \qquad (18)$$

Comparing the coefficients of (17) and those (18) of the same power, we get

$$\begin{cases} b_1 = a_1 - P \\ b_2 = a_2 - Pb_1 - q \\ b_i = a_i - Pb_{i-1} - qb_{i-2}, \ (i=3,4,\cdots,n) \end{cases} \qquad (19)$$

If $\varphi(S)$ is not a quadratic factor of $f(S)$, there exists small terms ΔP and Δq which make $\varphi(S)$ a quadratic factor of $f(S)$. $\Delta P, \Delta q$ are derived from the following equations.

First, let us determine the coefficients $C_i (i=1,2,\cdots,n)$:

$$\begin{cases} C_1 = 1 \\ C_2 = b_2 - Pc_1 \\ C_i = b_{i-1} - Pc_{i-1} - qc_{i-2}, \end{cases} \qquad (20)$$
$$(i=3,4,\cdots,n)$$

Then, we will find D, X, Y:

$$\begin{cases} D = C_{n-1}^2 - (C_n - b_{n-1})C_{n-2} \\ X = b_{n-1}C_{n-1} - b_n C_{n-2} \\ Y = -b_{n-1}(C_n - b_{n-1}) + b_n C_{n-1} \end{cases} \quad (21)$$

Finally, we determine
$$\begin{cases} \Delta P = X/D \\ \Delta q = Y/D \end{cases} \quad (22)$$

From ΔP and Δq, we get the second order approximation values of P and q.

$$\begin{cases} P^* = P + \Delta P \\ q^* = q + \Delta q \end{cases}$$

In analogy, it is possible to determine the third, fourth,.... order approximation of P and q until ΔP and Δq are less than the accuracy requirement (usually until $\varepsilon = 10^{-5}$). After a factor $\varphi(S)$ is found, let $\varphi(S) = 0$ to determine two roots of the higher order equation $f(S)$. In the meantime, the power of the original equation drops by two. All the roots can be found by repeating the process.

When the power of the higher order equation N is an odd number, a first order factor should be split first. $f(S)$ is divided by $\eta(S) = S + B$ to obtain the quotient
$$Q(S) = S^{n-1} + b_1 S^{n-2} + \cdots + b_{n-2}S + b_{n-1}$$

and the complementary term $R(S) = W$

i.e. $$f(S) = Q(S)\eta(S) + W \quad (23)$$

Comparing the coefficients of (17) with those of (23) of the same power, we get
$$\begin{cases} b_1 = a_1 - B \\ b_i = a_i - Bb_{i-1} \ (i = 2, 3, \cdots, n) \end{cases} \quad (24)$$

If $\eta(S)$ is not a first order factor of $f(S)$, there exists ΔB which makes $\bar{\eta}(S) = S + (B + B)$ a first order factor of $f(S)$. B can be calculated based on the following
$$\begin{cases} C_1 = 1 \\ C_i = b_{i-1} - BC_{i-1}, \ (i = 2, 3, \cdots, n) \end{cases} \quad (25)$$
$$\Delta B = b_n / C_n \quad (26)$$

to determine the second order approximation of $B^*=B+\Delta B$. Similarly, the third, fourth,... order approximation of B can be found until the given accuracy requirement is met. After the power of the original equation is lowered by one, it becomes an even power equation which can be treated with the method described earlier.

Please note that in the first approximation, when N is even, P and q can be determined by the last three coefficients of f(S)

$$P = a_n/a_{n-2}$$

$$q = a_{n-1}/a_{n-2}$$

When N is odd, $B = a_n + a_{n-1}$.

The transformation is to find the zero pole of the polynomial transfer function by treating the numerator and denominator of the polynomial by the method described above.

The flow chart of the program to find the roots of f(S) is shown in Figure 5.
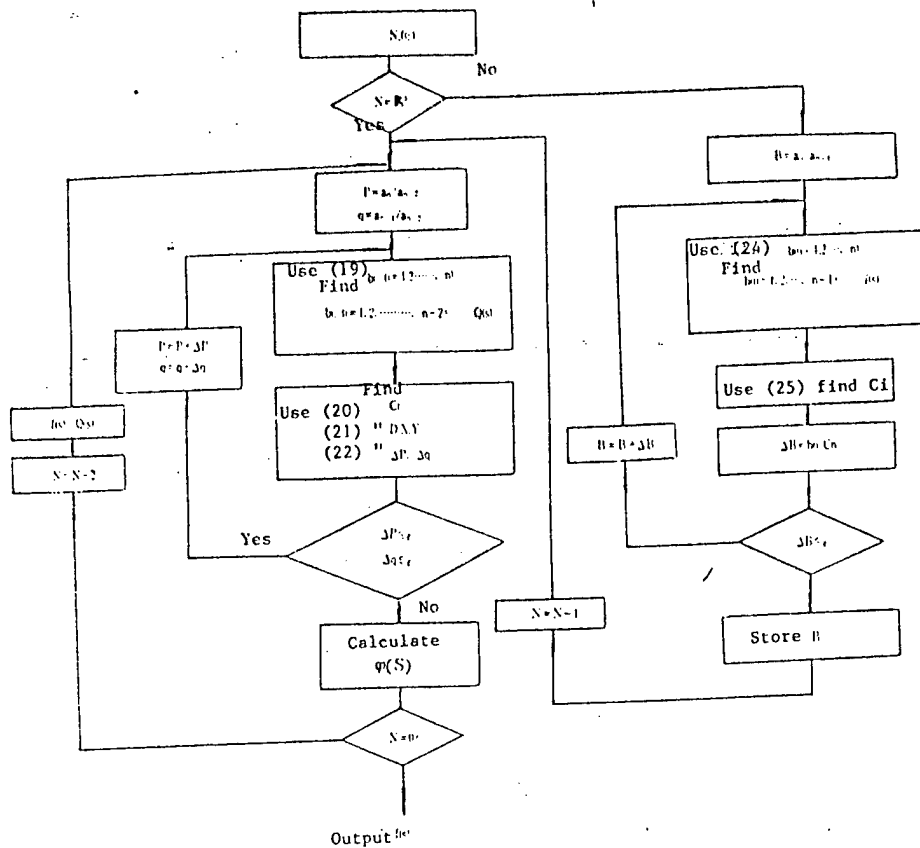
Figure 5.

III. Example

Find the equation of state and transfer function of y to u (in polynomial and zero pole format) in the system shown in Figure 6.
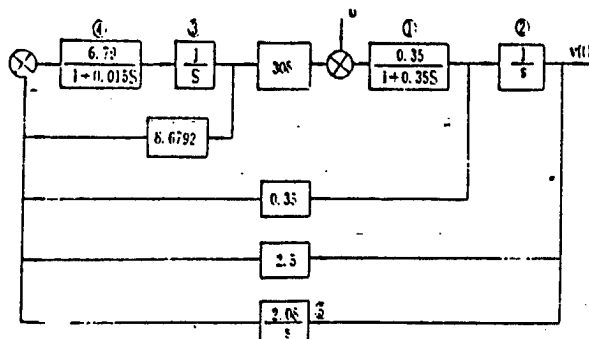
Figure 6.

The result is as follows:

$$F = \begin{bmatrix} -2.86 & 0 & 308 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ -158.44 & -1131.67 & -3928.79 & -66.7 & -452.67 \\ 0 & 208 & 0 & 0 & 0 \end{bmatrix} ; \quad P = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} ;$$

$$E = [01000]$$

$$G(S) = \frac{S^3 + 66.667S^2 + 3928.3319S}{S^5 + 69.5238S^4 + 4118.8081S^3 + 60021.272S^2 + 348553.335S + 289996.3848}$$

$$G(S) = \frac{S(S + 33.3333 + 53.0775j)}{(S + 0.9893)(S + 26.022 + 49.2038j)(S + 26.022 - 49.2038j)}$$

$$\times \frac{S + 33.3333 - 53.0775j}{(S + 8.2451 + 5.161j)(S + 8.2451 - 5.161j)}$$

REFERENCES

[1] Xiong Guangleng [3574 0342 2807] editor, Digital Simulation of Control System, Qinghua University Press, 1982.

[2] James A. Cadzow, Discrete-Time System, 1973

[3] Nobuhide Suda, translated by Cao Changxiu [2580 1022 0208], Matrix Theory in Automatic Control, Science Publishing Co., 1979.

[4] Hu Shousong [5170 1108 2646] editor, Principle of Automatic Control, Defense Publishing Co., 1984.

PATENTED COMPUTER TECHNOLOGY EXPORTED TO U.S.

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 13 May 87 p 3

[Article by He Huangbiao [0149 7806 1753] and Shi Ying [2457 3853]: "Chinese-Character-Input Computer Technology Exported to U.S."]

[Text] The "five-stroke Chinese-character-input computer technology," the invention of young expert Wang Yongmin [3769 3057 3046], has been awarded a patent in the United States and is the subject of a technology transfer agreement with Digital Electronics Corp [DEC], reportedly the second largest computer firm in the world. It was disclosed at a press conference on patent exports convened in Beijing by the China National Technical Import Co. This is the first time China exported patented computer technology to that country.

Since 1978, Wang Yongmin, a middle-aged inventor from Hunan Province, has conducted a comprehensive historical study on the etymological origins and structural principles governing over 10,000 Chinese characters. As a result of this project and other voluminous statistical studies, he gradually put together a Chinese-character-input method that is theoretically sound, well-conceived, and structurally rigorous. It is simple and highly effective; any person with an education above the elementary school level can input almost 7,000 single characters and varying numbers of phrases in just a dozen minutes. Now a recognized piece of outstanding Chinese-character-input technology with the most users in the nation, the system is being popularized in dozens of central ministries and commissions and throughout the country's 29 provinces, regions, and municipalities. In 1984, Wang Yongmin created a stir in the United States where he was invited to attend a national software exhibition and demonstrate at the United Nations. After studying scores of Chinese-character-input systems, DEC finally chose the "five-stroke technology."

12581
CSO: 4008/56

SHANGHAI INCREASES OVERSEAS SCIENTIFIC EXCHANGES

OW071657 Beijing XINHUA in English 1520 GMT 7 Jun 87

[Text] Shanghai, 7 Jun (XINHUA)--More than 70 percent of Shanghai's research institutions have forged ties with corresponding overseas units, and such exchanges cover 30 spheres, including urban development, medical and health work, bridge construction, treatment of industrial wastes and the upgrading of traditional industries.

Shanghai Municipality has entered into scientific exchanges with about 60 countries and regions. It sponsored 23 academic symposiums last year, including an international conference on hepatitis and liver cancer and a food storage meeting for the Asia-Pacific region, which were participated in by several hundred overseas specialists.

Meanwhile, the municipality sent 600 scientists or technicians abroad on study tours last year, involving 29 percent more people than in 1985.

In addition, its research institutions joined efforts with overseas units in arranging various types of product exhibitions, and exchanges of students and technical information.

Since the beginning of last year, Shanghai has forged cooperative relations with the governments of a dozen countries, including Japan, France, Poland, Federal Germany, Italy and the Soviet Union in environmental protection, energy technology, urban infrastructure construction, and medical and health work.

Furthermore, the municipality has run, through its cooperative efforts with the World Health Organization (WHO), 16 research and training programs to carry out joint researches on birth control, nerve science and endemic diseases.

A technical physics institute and a silicate research institute have set up joint ventures with Japan and Singapore. The Shanghai Computing Technology Institute and an American institution jointly set up a software company, which has developed software products for six overseas firms and is expected to earn U.S.$100,000 by the end of this year.

/9604
CSO: 4010/52

IMPORTED TECHNOLOGY REVIVES TRADITIONAL SHANGHAI INDUSTRIES

Shanghai WEN HUI BAO in Chinese 22 Apr 87 p 1

[Article by Wu Xiao [0702 2556] and Sun Zhonglian [1327 0022 6647]: "Imported Technology Brings New Prosperity to Old Industries"]

[Text] The party's policies of reform and opening to the outside world have breathed life into Shanghai's traditional industries and made them flourish. Thus far 74 percent of the large and medium-sized old-line enterprises in the municipality's industrial system have been transformed to various extents. Through technology importation and transformation, production has taken on a remarkably different look or is beginning to do so, particularly in 15 industries, notably food, knitwear, printing, low-voltage apparatus, bearings, electronic vacuum devices, plastics, rubber products, three "major domestic electronic appliances," three "major light industrial appliances," and others.

Premier Zhao Ziyang toured Shanghai in July 1981. Noticing that Shanghai industry had aged and lacked staying power, he instructed that technological transformation be made a priority. In light of the premier's instruction, the relevant municipal agencies draw up a municipal plan on key transformation projects and began overhauling old enterprises systematically and in a planned way in the latter half of 1981. In 1983, the State Council approved that pilot projects in importation and power decentralization be carried out in Shanghai, thereby giving the transformation of old enterprises, especially those in leading industries, a shot in the arm. From 1982 to the end of last year, technical transformation projects worth 2.51 billion yuan in total investment, of which almost $400 million are foreign capital, have been completed or put into production. Transformation on this scale is unprecedented in the history of the people's republic.

Because of rising production capacity resulting from technical transformation, most of the 15 industries, such as food and knitwear, have succeeded in improving their technical standards, enhancing the competitiveness of their products, expanding exports, and earning more foreign exchange. Through importation and transformation, most enterprises have begun to break their old habit of relying exclusively on overcapacity--"operating at full capacity and using equipment, sites, and plants to the full"--as a way to exploit potential and increase output. Take knitwear, for instance. That industry used to be dominated by small factories in side streets. In conjunction with urban

renewal over the past several years, it renovated or expanded 70 percent of the enterprises, occupying 200,000 sq m, replaced almost 1,000 knitting machines, over 2,500 hosiery machines, and more than 6,000 sewing machines, and imported over 1,000 machines of all types. Consequently about 30 percent of the equipment is on a par with that of their international counterparts of the late seventies and early eighties. Because of technology importation and renovation, No 1 Knitwear Factory has increased its output of exported garments, earning $10,000 in foreign exchange per capita per year. Or take the printing industry. After importation and transformation during the last few years, it has created the rudiments of a book and magazine printing system which is advanced by international standards. High-speed automatic printing has replaced manual printing. There are now combined machines instead of single machines, computer typesetting instead of manual typesetting, and offset printing instead of letterpress printing. At present, as much as 60 percent of all books and periodicals printed in the entire city are typeset and offset by computer. From plate-making to printing, color offsetting has been computerized and standardized.

The food industry, traditionally characterized by manual operations, has spent more than 200 million yuan to import technology since 1981, resulting in the gradual transformation of over 80 percent of its enterprises. Both equipment and product mix have changed significantly. Many new products have appeared, including hard candies with multiflavored fillings and ice cream, greatly increasing the industry's market competitiveness.

Because of Shanghai's solid industrial and technical base and its comprehensive lineup of industries, technical transformation in these key industries has produced fairly good economic results. Take the durable consumer goods industry, for instance, which depends primarily on technical transformation to increase output. Over the past few years, the output of bicycles increased 49.5 percent; sewing machines, 29.8 percent; cameras, 115.2 percent; TV sets, 196.5 percent; and washing machines, 751.9 percent. Every yuan of investment yields 1.94 yuan in output value and 0.47 yuan in taxes and profits.

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CSO: 4008/48

SHANGHAI BRANCH OF CAS LAUNCHES OFFENSIVE

Shanghai WEN HUI BAO in Chinese 4 Apr 87 p 1

[Article by Huang Xin [7806 6580] and Zhou Yuan [0719 0955]: "Research Institutes in Shanghai Working Hard To Solve Scientific Problems in Industry and Agriculture"]

[Text] A strong contingent comprising over 1,000 scientific research workers at institutes under the Chinese Academy of Sciences [CAS] in Shanghai has positioned itself at the front of the "main battleground" of serving the national economy. According to preliminary statistics, 12 research units have undertaken more than 140 projects designated by the state as key research projects in the Seventh 5-Year Plan. Research in all areas is now in full swing.

Exploiting their strength in multidisciplinary and comprehensive research, CAS institutes in the Shanghai area usually go after projects with substantial economic and social results. The Biochemistry Institute, for instance, is working to develop a genetically engineered vaccine for Hepatitis B; the Cell Biology Institute is conducting tests to make a genetically engineered growth hormone; the Silicate Institute is researching high-temperature structured ceramics that may be used to make auto engines, and the Technical Physics Institute is trying to produce remote-sensing testing instruments for China's first meterological satellite, et cetera.

Many problems in agricultural and industrial production that urgently await solution are the scientific researchers' priority projects. For instance, the intermediate testing and development of an all-fluorine ion-exchange membrane is one such urgent problem in the manufacturing of alkaline in China's chemical industry at the moment. The alkaline manufacturing industry is low in output and high in electricity consumption and causes serious pollution. Each year large sums of foreign exchange are spent to import a highly pure form of alkaline. Scientific research personnel at the Organic Chemistry Institute have achieved a few breakthroughs in high-efficiency and energy-saving ion-exchange membrane research. As a result of this project, China's chlorine alkaline industry is about to undergo a technical revolution. The Plant Physiology Institute in Shanghai has solid experience in plant photosynthesis, nitrogen fixation, and microbiology research. During the Seventh 5-Year Plan, its numerous research workers will launch an all-out

attack to tackle a range of key research projects in the field of biotechnology that deal with stored protein, photo-effect genes, nitrogen fixation gene, phytotoxin-resistant protein, gene manipulation and control, protoplasm culture, and accelerated plant reproduction. A host of pest- and disease-resistant, superior, and high-yield crop varieties is being developed.

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CSO: 4008/48

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SHANGHAI'S ADVANCED TECHNOLOGY SPREADING NATIONWIDE

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 3 May 87 p 1

[Article by Zhang Shihong [4545 0013 7703]: "Shanghai Cooperating Extensively With Other Provinces and Municipalities"]

[Text] Advanced technology is emanating from Shanghai to the rest of the nation. Shanghai S&T personnel turn up in all 29 provinces, regions, and municipalities. Cooperative projects at all levels and in all forms now total more than 3,000 and numerous scientific achievements are bearing fruit all over the nation. More than 200 cities and counties have established friendly relations with various counties and districts in Shanghai. Provinces in the interior are also supplying Shanghai with more and more raw materials and industrial bases. This busy interflow of technology and materials has created a new interdependency between Shanghai and other provinces and municipalities, with one nurturing the other, and given a powerful boost to the drive by every jurisdiction to increase output and make savings.

Current cooperation between Shanghai and other provinces and municipalities has the following new features:

From cooperation aimed at simply expanding production capacity, interregional enterprise groups have graduated to a higher level of partnership--software development that revolves around management and advanced skills. In the light of production requirements, these enterprise groups have adjusted their organizational setup, developed raw materials jointly, undertaken specialized cooperation, and worked to upgrade their products. The primary goal they are striving to achieve is to export and earn foreign exchange. Through enterprise groups, the fine products of over 380 Shanghai enterprises are being distributed all over the nation, with a sharp increase in output.

The scope of lateral associations has been broadened from industrial production to short-term loan circulation, transportation, agriculture, foreign trade, tourism, and other areas. The industrial and commercial banks of eight provinces and municipalities, including Beijing, Shanghai, Tianjin, Jiangsu, and Zhejiang, have set up interprovincial networks to provide funds for short-term loans. Assorted trade centers and warehouses in Shanghai have opened extensive new commodity circulation channels with other provinces and municipalities. A joint passenger and freight transport system, involving

rivers, land, and sea, has been established between Shanghai and various cities along the Chang Jiang and the coast. The directors of the agricultural bureaus and departments of the five provinces and municipalities in the Shanghai economic region have instituted a joint conference system to expedite the exchange of S&T achievements in agriculture. Led by its mayor, a Changzhou delegation recently toured Shanghai and decided to make the vitalization of enterprises and the exploitation of their potential for intensive development the centerpiece of cooperation with Shanghai. They compared each other's economic targets, industry by industry, sector by sector, looking for differences and similarities and helping and learning from each other, to the benefit of both sides' economic results.

The furthering of lateral associations has had a profound impact on Shanghai industry and the adjustment of its product mix. The Shanghai Textile Bureau has channeled a portion of its investments to Shandong, Jiangsu, Zhejiang, and other provinces. When the projects go into production, they can supply the Shanghai textile industry with 100,000 pieces of cotton yarn and 100 million meters of grey cloth each year. Not only will this ease the pressures on transportation, energy supply, and factories, but it will also enable the textile industry to concentrate its energies on intensifying its international competitiveness.

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CSO: 4008/56

PROBLEMS IN REFORM ON RESEARCH INSTITUTES DISCUSSED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF SCIENCE AND TECHNOLOGY] in Chinese No 2, Feb 87 pp 10-11

[Article by Ge Yuehua [5514 1878 5478]: "Several Problems Encountered in the Reform of Research Institutes"]

[Text] Since the second half of 1984, 27 research institutes in Tianjin have conducted experiments in reforming the science and technology system. Great changes have occurred among these research institutes in the past 2 years. They have changed from a closed to an open type of organization, and their science and technology personnel have come out of their inner sanctums to look for work in the real world of production. Scientific research achievements have also greatly increased, the period required for the transformation of these achievements into productive forces have been much shortened, and the economic results have been much improved. However, some difficulties have also been encountered in this reform. We recently conducted a survey of 15 experimental research institutes and discovered the following problems:

I. Problem of Self-sufficiency in Funds

An important feature in the reform of the science and technology system is the adoption of a compensation contract system in the use of operating funds. We should say that this issue has touched the research institutes' most sensitive and vulnerable spot and has driven them into the economic field where they have to face the real problems of looking for scientific research tasks in the first line of production. Economic considerations have become the key factor in their self-reform. However, the problem is that their income cannot be increased fast enough to keep pace with the reduction in their operating funds. Hence their serious predicament. A certain research institute in Tianjin, for example, began its experimental reform in 1984. At that time, it requested that its operating funds be reduced by 30 percent for the current year and by 60 percent in the second year, and that in the third year, when it would be economically independent, the allocation of these funds would cease. Then, in early 1986, its personnel at all levels were mobilized in the struggle for economic independence. The institute assigned income quotas in writing to all its research offices and requested that the fulfillment of these quotas be ensured. However, its income in the first half-year was less than 12 percent of the annual allocation received before the experiment. It was far from economically self-sufficient. Furthermore, the departments in

charge were very enthusiastic in collecting the amount reduced, and some of them even demanded that the amount be verified and turned in every month in the same way enterprises turn in their profits. Under these conditions, the finance departments still demanded that 50 percent of the net profits be turned in. Groaning under this heavy pressure, the research institute was unable to plan for its own long-range development.

It is correct for the local authorities to expect the open-type research institutes to be self-sufficient and economically independent. However, the steps they take cannot be too quick. Investment in local research institutes has never been heavy over the long run. Their infrastructure is poor, the competence of their science and technology personnel is mediocre, and therefore their "regenerative" power is fairly weak. We may say that they are still in the stage of installation and construction. Their income from technology transfers, training, and serving is small and unsteady. Economic pressure may force research institutes to conduct reforms; but if the pressure on their load-bearing capacity is excessive, they may either be demoralized and remain at a standstill or be forced to do anything for money, regardless of their orientation and commitments. As a result, the reform will be adversely affected.

II. Problem of Rewards

In 1984, Tianjin Municipality issued a formal document stipulating that experimental research institutes may pay bonuses on the basis of their personnel's contributions and the way they completed their tasks, and that the amount of bonuses should not be more than the equivalent of 2 and 1/2 months of pay. This reward policy did promote the reform of the research institutes at that time. Later, however, the situation changed. Because of the controlled increase in consumption funds, the bonus funds equivalent to 2 and 1/2 months of pay could not be appropriated. When the science and technology personnel fulfilled their tasks, their expected bonuses could not be obtained, and the terms in the signed agreements were "gone with the wind." The science and technology personnel had many complaints and have lost faith in the promises of the leadership. This experience affects their planning for this year. The research institutes dare not set any quota or sign any agreement with the science and technology personnel about their tasks. They can only wait and see. The units previously desiring to join in the experiment have changed their minds, while those who have already done so now want to back out.

The system of responsibility should be linked with rewards; without rewards, there can be no responsibility system. At present, the bonuses for the experimental units are the same as those of others. Under this circumstance, the significance of the experiments has been reduced. Unless the problem of rewards for the research institutes is solved, the responsibility system can hardly be enforced, and the contract system of compensations from external sources cannot be effectively practiced. There will be a retreat after the advance already made in the reform.

III. Problem of Unappointed Personnel

In a certain institute which practiced the system of assigning tasks under
contract, 11 persons were left without a task. They were organized to study
while remaining on the "waiting list." Their wages were paid as usual while
they studied. According to the institute's regulations, however, their wages
would be reduced 10 percent if they had to wait more than 6 months. Some of
these persons said: I will eat in the home of whoever cuts my pay. In the
fifth month, the institute had to give them temporary jobs. However,
temporary jobs cannot last long, and finally the institute reluctantly
admitted them to the task group. Another institute practicing the system of
appointment also did not know what to do with those left unappointed. It
reported the problem to the higher authorities and was told by the authorities
to assimilate them internally. Finally, it had to let them join the task
group. Many experimental institutes have had the same experience. At the
beginning of the reform, they had a strong determination to make a success of
the system of contracting tasks to appointed persons. Later, however, they
did not see much hope for the reform and could only retreat.

It is true that personnel appointments and free grouping have changed the
longstanding practice of arbitrary assignment by administrative means,
improved personal relations in the task group, reduced unnecessary friction
and internal feuds, and increased work efficiency. Furthermore, the
intellectual structure of the institute's personnel will tend to be more
rational. However, the disposition of unappointed persons has become a
problem to the system of contracting tasks to appointed persons. The
institutes should try hard to assimilate them internally. However, since
research institutes generally operate on a small scale with specific demands
for specific specialties, they have real difficulties in developing economic
diversification or starting a tertiary industry. If the departments in charge
above do not think of some way, the problem of unappointed persons will remain
unsolved, and the institutes cannot make any headway in the system of
personnel appointments.

IV. Problem of Intermediate Test Base Construction

An intermediate test base is a prerequisite for the practical application and
commercialization of technology, and it paves the way for large-scale
industrial production by research institutes. A new phenomenon in research
institutes since the beginning of the reform is their stronger emphasis on
intermediate test base construction. Along with the development of
intermediate test workshops (factories), however, the combination of factory
and institute into a scientific research unit has brought with it a new
problem. If, for example, the intermediate test workshop requires a three-
shift operation for continuous production, the workers cannot, according to
regulations, have night differentials for working at night or overtime pay for
working overtime because the research institutes are establishments. On the
other hand, intermediate test workshops belong to a production branch and
should be regarded as enterprises. Thus the cadres cannot have time off, and
the workers' wages are deducted if they take sick leave or personal leave. In
the distribution of uniforms, the department concerned does not allow it
because they are establishments. However, in charging their water and

electricity fees, the department concerned considers them as enterprises which should pay more. As a result, they are squeezed from both ends.

Furthermore, a certain amount of circulating funds are required for turning out products or small batches of new products from intermediate tests; but the research institutes usually feel the lack of circulating funds. Some research results having a promising market as well as the required technical conditions have to postpone their intermediate tests time and again for lack of funds.

The construction of intermediate test bases for research institutes will be even more important and the two problems just mentioned will become even more acute with the progress of reform in the science and technology structure. They must be carefully studied and solved in time.

V. Problem of "Long, Short" Tasks

In the initial stage of the reform, we placed greater emphasis on the economic benefits of research results and the need for research institutes to have their own sources of income. Thus "short, level, and speedy" projects were increased with a corresponding decrease in long-range reserve projects. This emphasis has had its positive effects on the shift in the research organs' orientation. However, a research institute must have the capacity for future tasks. To maintain a fairly high technological level, it must pay attention to long-range research projects serving as a technological reserve, and to the arrangement of various tasks in proper proportions. What we lack now is precisely the policies and measures to guarantee this arrangement. Generally, science and technology personnel are willing to undertake "short, level, and speedy" projects, but not long-range projects that are intended as a reserve. It is quite difficult to arrange for research in, for example, "high-molecule materials for the medical field" and "technology for the fusion of cells," which are time-consuming and do not yield immediate economic benefits.

This problem should be solved as a matter of policy, and attention must be paid to the use of economic levers to readjust the proportions of different types of research. Some measures must be adopted to ensure that the income of those engaging in long-range and infrastructural research will not be lower than the income of those engaging in "short, level, and speedy" projects, and that the labor and intellectual power they have spent will be adequately compensated; otherwise, the disproportion between long- and short-term tasks will become more and more serious and its consequences will be more and more obvious along with the progress of our social industrialization. It will be ultimately detrimental to the interests of the state and the science and technology personnel.

VI. Problem of the System of Institute Director Assuming Full Responsibility

The system of the director responsibility for the institute is an important aspect of the reform in the leadership system among the research institutes. According to our survey, the progress of its development is not quite ideal. Contradictions between the party and the government have emerged in varying degrees among the research institutes where this system has been adopted. The relationship between some secretaries and institute directors was formerly

quite cordial, but friction developed within 2 months of its adoption. Some secretaries and institute directors came to the same institute from other units at the same time. Soon their relationship became tense. In one case, the secretary was an old-timer, and the director got his job because of the secretary's strong recommendation. After the adoption of this system, the secretary was dissatisfied with the director and felt sorry for having recommended the wrong person. When conflicts between the party and the government came to the surface, the higher authorities had to send work teams to help resolve the contradictions and harmonize the relationship. Because of the stress on party leadership, organizational concepts, individuals' submission to the organization, and so forth after the party rectification, some units that adopted this system lost their enthusiasm. The system of director responsibility therefore exists in name only.

Such conditions cannot be attributed simply to inadequate preparation of our minds for this system, or to problems with the political consciousness of the institute director and the secretary as individuals. There are some real problems yet to be solved. Take, for example, the question of cadres. In the past, the party controlled cadres; now the director has the power to appoint and dismiss them. Then in what way can the principle of party control over cadres be embodied? What procedures should be followed if the director wants to appoint or dismiss cadres? What should be done if the director's decision to appoint or dismiss some cadres is controversial? In the absence of any rules and regulations to go by in these areas, we can only rely on the judgment of an "enlightened secretary." This mostly calls for random decisions and is apt to create conflicts between the party and the government. It will be really difficult to practice the system of director responsibility.

REGULATIONS ON USE OF RETIRED PROFESSIONALS EXPLAINED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF SCIENCE AND TECHNOLOGY] in Chinese No 2, Feb 87 pp 16-17

[Text] Question: Recently, the staff offices of the Central Committee and the State Council issued the "Provisional Regulations on Making Use of Retired Professional Technicians" (hereinafter referred to as "Regulations"). Please comment on their significance.

Answer: To make full use of retired professional technicians, the "Regulations," approved and issued by the Central Committee and the State Council, constitute another important statute supporting the "Decision of the CPC Central Committee on reforming the Science and Technology System."

Millions upon millions of professional technicians are required for the socialist modernization of China. We not only need a large number of outstanding young and middle-age professional backbone elements for the key posts, but also want to provide the facilities for professionals of the older generation to continue to demonstrate their ability and wisdom. According to incomplete statistics, China now has only some 14 million professional technicians. This number is extremely inadequate for the modernization program. In the past several years, because of the enforcement of the retirement system for cadres, workers, and senior science and technology personnel, a number of professional technicians are leaving their posts every year. These comrades have for a long time made important contributions to the cause of socialist construction and have acquired abundant knowledge and technical experience. They are still in good health, capable of continuing to do what they did, and eager to devote their energy to the cause of the four modernizations and the unification of the motherland in their later years. In the past, they were the mainstay in socialist construction; now, they are still great assets to the party and the state. Mobilizing this professional technical force to play a positive role is consistent with the policy that has always been upheld by the party and the state of respecting knowledge and talent. It is useful in making up the shortage of professional and technical resources in China, in making use of the ability and wisdom of this entire force, and in training a new generation of scientific and technical talent. It is also consistent with the wish of the professional technicians who have retired, and is beneficial to their physical and mental health. These "Regulations" are an important measure for reforming the system of

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professional technician management in China, which all departments, regions, and units should conscientiously implement.

Question: Who are those referred to in the "Regulations" as professional technicians? Are the "Regulations" applicable to the science and technology personnel who have retired from administrative posts?

Answer: The so-called professional technicians generally refer to the technical cadres who have attended a specialized school, specialized university, or regular university, or have an equivalent educational background, and who possess a certain amount of professional knowledge and practical working ability. All cadres occupying positions at the primary, medium, and high professional levels in various national economic sectors, including science, technology, culture, education, and public health, and holding titles of the same professional levels, belong to this category. The "Regulations" apply to those engaging in professional technical activities after retirement.

The purpose of the "Regulations" is to mobilize these retirees to serve economic construction and social development. Therefore, science and technology personnel in administrative positions can take part in professional and technical activities after retirement as stipulated in the "Regulations" provided they have certain professional know-how and are capable of performing professional and technical duties.

Question: What kind of work can retired professional technicians do for the units employing them? Can they run civilian research institutes?

Answer: According to the "Regulations," "all units may employ retired professional technicians as lecturers, translators, or research tutors, and for personnel training, technology development, technical consultation, and other professional and technical service." In addition, these retired professional technicians may take part in academic group activities and other scientific and technological endeavors. During the reform, the retirees in some localities have raised their own funds to set up civilian organs for scientific and technological endeavors. During the reform, the retirees in some localities have raised their own funds to set up civilian organs for scientific research and technology development or to offer technical services, with responsibility for profits and losses. Practice has proved this to be a good way for them to play a useful role. The units concerned should support, help, and guide them. Of course, the establishment of civilian research organs should be approved by the departments concerned, and these research organs should be registered with the industry and commerce administration departments according to the regulations of the local people's government.

It should be pointed out that, as required by the "Regulations," the retired professional technicians can do only professional and technical work. Generally, they should not be employed to do administrative work or to provide leadership over technical work. In dealing with such undertakings as medicine and civil engineering designs which involve personal safety, and with other work in which the economic responsibility should not be borne by individuals, we should follow the regulations of the departments concerned.

Question: Why should the principle of doing only what they are capable of and on a voluntary basis be upheld when we make use of retired professional technicians?

Answer: The retirement of cadres, workers and staff members, and senior science and technology personnel at old age is in line with China's socialist labor system. According to the law, the state should safeguard their rights of rest and recuperation and their rights to other forms of social welfare. Therefore, if we want to employ them, they must first be willing to work for us. We should not force them to do anything against their will. More important still, we must not act indiscriminately in a general rush. The "Regulations" emphasize that if we want to make use of retired professional technicians, we must uphold the principle that they should do what they are capable of, mainly in consideration of the fact that the cadres who have retired because of old age are no match for the young comrades either physically or mentally. Even though they may be physically fit for some type of work, the units employing them should take very good care of their health and livelihoods. Their working hours need not be uniform, the tasks assigned should be suitable for them in terms of quantity and intensity, and the way they do their work can be diversified. In short, everything must be based on considerations of their physical and mental health. On the other hand, the retirees should also be objectively aware of the difference between their own energy and physical strength and those of the younger comrades, and in undertaking any professional and technical work, they should consider what they are really capable of and should alternate work with rest. Only thus can they make a greater contribution to the motherland.

Question: Are there any limits or restrictions set by the state for the remuneration of these retirees?

Answer: No. According to the "Regulations," the retirees employed to do professional and technical work can get paid according to the principle "from each according to his ability and to each according to his work." Remuneration can be discussed and determined between them and the employing unit and stipulated in the technical contract or employment agreement on the basis of the nature of the task, the economic and social benefits it can create, and other factors. The state can regulate their income through taxation. In other words, if the individual income reaches the taxable amount, he should pay the individual income regulation tax according to the law.

Question: If the retired professional technicians are paid for their work, why can they continue to draw their pensions and enjoy the other benefits?

Answer: According to China's constitution, citizens have the right to material assistance from the state and society when they are old, ill, or disabled. The pensions and other benefits are earned by retired professional technicians because of this right through social insurance, social relief, and medical and public health facilities, according to the law. This legitimate right cannot be forfeited because of the remuneration they have from their employment. On the contrary, to facilitate the professional and technical work which they have undertaken, they should be entitled to other privileges,

such as participation in academic or scientific and technological activities, with travel and other expenses paid by the unit sending them or by the unit inviting them. If they are employed to work away from home, their original residential registration can be preserved. If they are employed by a unit of other localities, and sustain injuries inn the line of duty, the employing unit should treat them in the same way as it would its own regular employees. The "Regulations" contain specific stipulations in this respect.

Question: How should the departments and units support and help retired professional technicians in continuing to play their role?

Answer: Making use of retired professional technicians is in line with the party's policy toward intellectuals, and is one of the important policy decisions for China's reform of its science and technology system. All departments and units have the duty of strictly complying with the request of the "Regulations" for supporting and helping them in their work after retirement, paying attention to their real problems, and helping them find the solutions.

The science and technology commissions, labor and personnel departments, and science and technology associations at all levels should actively cooperate in studying the related policies and problems and working out the required measures. All academic groups and all social organizations concerned should use every facility at their disposal to organize retired professional technicians in various ways to serve the four modernizations and the unification of the motherland. In the units where retired technicians of the high and medium professional levels are fairly concentrated, a special person should be appointed for this work. All units should create the necessary conditions and provide the necessary facilities for them to continue their work, and allow them to borrow books and materials from the libraries of their former units and to participate in professional and academic activities. Should they need the use of their former units' equipment, materials, and unpublicized technical data, they should obtain the permission of their former units and pay for the use of the equipment.

According to the "Regulations," retired professional technicians should be commended or rewarded for their outstanding contributions. If their scientific and technological achievements are eligible for a state invention reward, natural science reward, science and technology advancement reward, reward for rational proposals, or reward for technical innovation, the employing unit should, according to the regulations, apply to relevant department in charge for the rewards to be approved and given.

Question: What are your demands on these retired professional technicians?

Answer: The "Regulations" safeguard the rights of China's retired professional technicians to continue their work under the labor system. They will have the opportunity to demonstrate their skill in China's socialist modernization program. We sincerely wish them continued success. They have been nurtured and educated by the party and the people for many years, and now serve as paragons for the younger professional technicians. We also hope that they will set good examples in abiding by the state's law, implementing

various party and state policies, carrying forward the fine traditions, stressing professional ethics, carefully preserving the technical and economic interests of their former units and their employing units, and building a socialist spiritual civilization.

Question: Can professional technicians retired from the armed forces be employed to continue their professional work?

Answer: Professional technicians who have retired from the armed forces and are employed to do their professional work in or outside the armed forces shall be governed by the "Regulations."

Question: In recent years, there has been some discrepancy between the "Regulations" and the regulations of the central and the local authorities concerning the retirement of cadres, workers, and staff members. What will be done about it?

Answer: In case of any discrepancy between the "Regulation" and the former regulations, the "Regulations" will prevail.

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CSO: 4008/2103

DIFFICULTIES IN PRODUCING TALENTS, SUGGESTED POLICIES

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF SCIENCE AND TECHNOLOGY] in Chinese No 2, Feb 87 pp 18-19

[Article by Yang Jike [2799 4764 3784], vice governor of Anhui Province: "'Ten Difficulties' in Producing Talents and '10 Remedies'"]

[Text] In my opinion, there are over 10 difficulties in producing talent. I have chosen the 10 important ones and will try to show what they actually are and what should be the remedies. I do this only for the purpose of provoking an enlightened discussion by people of high ideals throughout the country.

It is difficult to produce talent from a situation in which "what I say goes." Remedy: Encourage the free airing of views. China's feudal rule over the past several thousand years has left its stamp on the people and fettered their minds. This stamp came into sharper relief during the "cultural revolution." There were very few wise emperors, and the best they could do was "to be enlightened by listening to a wide range of views, instead of remaining in the dark by listening to what they like to hear," and to grant limited democracy by "accepting counsel." However, the decision had to be made by "His Royal Self." The saying "speakers will not be guilty" actually meant that "voicing disagreement is a crime, but I pardon you." As Sima Guang commented, "this means rejecting counsels instead of soliciting them" It would be far worse if the purpose were to "lure the snakes out of their holes for wholesale slaughter." Thus people throughout the country dared not step forward or open their mouths.

Recently, the leading comrades of the Central Committee raised this slogan: "What the speaker does is a service to the listener." "What I say goes" is thus replaced by "letting everyone have his say." Among the many speakers, there must be someone who is genuinely learned and farsighted. We must pool their wisdom and choose what is best. We should ascertain the truth by listening to all views, and then use practice as the criterion for testing truth. Thus talent will appear among the men of action who know scientific truths and have perceptive power.

It is difficult to produce talent out of iron rice bowls. Remedy: No more exclusive rights of job placement by the state. The evils of the "iron rice bowls" no longer need to be dwelt upon. However, it must be pointed out that its biggest evil is probably the lack of competition. Without competition,

people will lose their will to advance and to pioneer. A promising youth with an iron rice bowl in hand can hardly turn out to be a talented person. The only driving force for him to become one may be his personal hobby. However, can a personal hobby fit in to the program of economic and social development?

The graduates of Shenzhen University are not assigned jobs exclusively by the state, and the special committee, set up in the university to attend to the details of employment recommendation, has produced very good results. After the structural reform, it may not be hard to predict that many talented persons will appear.

It is difficult to produce talent out of piles of documents. Remedy: Let people take root in the society.

In ruling a state, there is the tradition of "from documents to documents" in China. This is called "critical interpretation of ancient texts," "linguistics," or the "Han school of philology." During the reign of Qianlong in the Qing dynasty, Wang Niansun and his son spread the idea that people would be buried in piles of academic papers to learn as much about the ancient texts as possible. This idea was closely related to the prevalence of literary inquisitions during the reigns of Kangxi, Yongzheng, and Qianlong. Now let me ask: How many talented persons were actually made out of this huge number of scholars? Perhaps even the name of Wang Niansun himself is now unknown.

The situation has changed a great deal in recent years. The party's general and specific policies have enabled many talented persons to emerge from their obscurity, and more and more people with high ideals have entered society to make their contributions to the state's economic construction. They have left their piles of documents and have taken root in the society.

It is difficult to produce talent in ivory towers. Remedy: Overlapping and fusion.

A special characteristic of scientific development in the 20th century is the vigorous growth of overlapping disciplines. If people are confined within the ivory tower of only one discipline instead of relying on the overlapping and fusion of disciplines, they will not be able to benefit society or become talented persons.

The first key project in China's scientific and technological research is the program of agricultural zoning. Its main task is comprehensive research in the natural resources and economic conditions of the three major sciences and in the production of the five trades in geographic areas under both similar and different conditions.

It is difficult to produce talent from the old examination system. Remedy: Use all types of talents.

In the 19th year of Emperor Daoguang's reign, Gong Zizhen wrote his famous "Jihai Year Poem," which reads:

"Only in wind and thunder can the country show its vitality.
Alas! The 10,000 horses are all muted.
O Heaven! Bestir yourself, I beseech you,
And send down men of all talents."

Here he portrayed the deplorable situation of "10,000 horses being muted" as a result of the narrow confines of the old examination system.

The old examination system has been abolished, but a society imbued with such a system still exists. The honor of being the number One Scholar in the highest imperial examination, as shown in the operas, is still yearned for by many people, and a university diploma is still worth a lifetime of effort. A senior high school graduate in Anhui failed eight times in his entry examination for higher learning, but he still refused to give up. He hopes "to succeed one fine morning."

In my opinion, the economic structural reform with the objective of "invigorating the domestic economy and opening the country to the outside world" in the past several years has gradually led to a new situation of "Heaven bestirring itself." In this new situation, are people in various quarters accepting men of all talents? The concept of the old examination system should be dumped into the trash heap of history during the advance of society.

It is difficult to produce talent if people are evaluated purely on the basis of scholastic attainments or work experiences. Remedy: Give people the opportunity to show their ability.

The practice of evaluation purely on the basis of scholastic attainments or past experiences has obvious restricting effects on talent among intellectuals. The causes are very complex. First, China has the feudal tradition of respecting aged people. Second, the state has control over intellectuals. Third, intellectuals generally lack an environment in which to assert themselves. In this connection, Sima Qian recorded part of the dialogue between Mao Sui and Lord Pingyuan as follows: "Lor Pingyuan said: 'A capable man in the world is like a awl in a pocket. Its pointed end will sooner or later come out into the open.' Mao Sui said: 'Today, I beg you to put me in the pocket. If I can get into the pocket, what will come out into the open will be more than the pointed end." Here "pocket"means the environment in which people can demonstrate their talent through competition. If an awl is put into water instead of a pocket, it will rust and can never come out into the open. Fourth, a long time has to lapse before knowledge may become a commodity waiting to be sold to the highest bidder. Therefore, intellectuals cannot be "hoarded like a rare treasure." An "awl" in water is no "rare treasure," nor can it make its own presence felt. In the absence of any fair way, people can only evaluate intellectuals by looking at their diplomas or past records.

Remedy: Take the "awl" out of water and put it in a "pocket."

It is difficult to produce talents by cramming. Remedy: Guide and inspire them. Let me cite an example which may be irrelevant. The roasted lean-meat

duck in Chaohu is superior to a fatty one in Beijing both in nutrition and in taste. The reason is that Chaohu ducks are free to go around looking for food, while Beijing ducks are reared and fed in cages. Going around helps the growth of muscle, while being fed in cages results in the growth of fat. Muscle contains protein, while fat contains cholesterol. Protein has metabolic effects, while cholesterol causes diseases in the blood vessels.

It is difficult to produce talents by sticking to old ruts. Remedy: Reform and innovation. Those who stick to old ruts are desperately clinging to the rules and regulations which cannot bring people happiness under present conditions. In fact, they do not recognize the evolution of the universe of the existence of the basic laws of evolution. They are also unwilling to carry out any reform, innovation, invention, or discovery for the advancement of human society. They believe that as long as they comply with the old rules and regulations, everything in the world will be fine and rosy. However, scientific laws are independent of people's subjective will, and what they eventually get will be contrary to their wish.

For a remedy, we should support and cherish those reformers, pioneers, and creative inventors. At the same time, those who stick to the ruts should be educated through practice. Time is marching on; how can they be permitted to remain complacent and conservative?

It is difficult to produce talent behind closed doors. Remedy: Open to the outside world and establish contacts. The historical experience of more than a century has proved that parochial arrogance and keeping ourselves behind closed doors can bring about hundreds of evils but not a single benefit. After the 3d Plenary Session of the 11th CPC Central Committee, the cardinal policy of invigorating the domestic economy and opening the country to the world was adopted, while that of keeping ourselves behind closed doors was discarded. For 8 years, new developments have continued to bring benefits to the state and the people, and new people have continued to come forward with their contributions.

Science and technology are themselves the embodiments of scientific laws which do not bear any class stamp, but their use has the characteristics of class, depending on whom they serve. Dynamite can be used to open mines and build roads in socialist construction; however, it can also be used by terrorists for plundering and hijacking. The reason is quite obvious. Wall Street is the headquarters of capitalist finance, but why cannot its methods of circulating funds be used to serve socialism with Chinese characteristics?

For the remedy, we should encourage those who are capable of obtaining whatever is best in various cultures, sciences, and technologies, that is, extracting the essence and discarding the dross, to serve our socialist construction. Talented people will appear as soon as this policy is decided on.

It is difficult to produce talents with the tactics of trying to win over, or to obstruct, people. Remedy: Market circulation. Winning over and obstructing people are soft and hard tactics. It is not only difficult but definitely impossible to produce talents with these tactics.

For the remedy, we should open technology markets and talent markets. The
simultaneous opening of technology markets, talent markets, commodity markets,
monetary markets, and labor markets will certainly result in mutual benefits.
The success of any enterprise will be largely decided by the supply and
marketing services as well as regulation by these five markets. The opening
of technology markets has just begun, following the Central Committee's
decision on reforming the science and technology system. The opening of
talent markets, however, still has to wait, although the Central Committee's
action on the system of personnel appointment in the scientific, educational,
and public health fields not long ago represented a gratifying forward step.
The free movement of experts and professors above the age of 60 will soon
materialize. In the practice of markets, where people can "fully demonstrate
their ability," we can certainly anticipate the appearance of many talented
people in society.

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CSO: 4008/2103

VIEWS OF SCIENCE, TECHNOLOGY CADRES BUREAU OFFICIALS ON PERSONNEL POLICY

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF SCIENCE AND TECHNOLOGY] in Chinese No 2, Feb 87 p 25

[Article: "What the State Science and Technology Commission's [SSTC] Science and Technology Cadres Bureau Intends To Do: First, Greater Flexibility in Handling Resignations; Second, Permitting Science and Technology Personnel To Undertake Contracted Projects; and Third, Stimulating the Management of Planning"]

[Text] Comrade Zhao Bao [9392 5508] of the Science and Technology Cadres Bureau of the SSTC said: One of the three tasks to be done for the system of science and technology cadre management in line with the policy of further invigorating the domestic economy and opening the country to the outside world is to be more flexible in dealing with the question of resignation. In the past, resignations could only be conditional. In other words, who could resign and who could not resign were predetermined. Generally, arbitration is needed if resignation created any problem. Our tentative idea for the future is that in the units where trained personnel are too many, some of those who cannot be used to good advantage should be permitted to leave, as long as they join the light and textile industries, the rural enterprises, or those enterprises particularly selected by the state for development, and provided they give 3-6 months' notice to their unit. Upon their departure, they may carry with them their personal files, may retain their administrative affiliation, and need not wait for any examination and approval or arbitration. If the necessary arrangements have not been completed, the unit may consult with them about the postponement of their departure. The whole idea is that we will be more flexible in dealing with resignations.

The minister of astronautics said: The Ministry of Astronautics is prepared to send out 10,000 persons to undertake contracted projects and to back them up with funds and equipment. These funds and equipment will become the ministry's shares of stock and they entitle it to the sharing of dividends. The contractors' wages may be doubled. Song Jian [1345 0256] said: Their wages may be not only doubled but also tripled or quadrupled. This arrangement will enable the surplus personnel to be used to better advantage. However, we have also considered the interests of the units, the individuals, and the recipients of aid. Contracting involves risks. If the units will give them the necessary support, and the contractors will use part of their profits as bonuses for those who have made outstanding contributions in

completing the state's important projects, it will arouse enthusiasm in several quarters. This is our second idea.

The third idea is to revitalize the management of planning. In addition to supporting the science and technology personnel in their contracted projects, we may organize the surplus personnel to help the rural enterprises. A comrade of the Shanghai Metallurgy Research Institute proposed that those who have not yet received their titles be sent down to the basic levels for 2 years. Then, on their return, their title will be given according to the quality of their work. In this connection, Jilin Province has some good ideas. It plans to send 1,000 persons to help the rural enterprises for 1 year, and to do this as a regular system. We believe that these methods may be used for the coastal areas to support the frontier and remote areas, and for the large scientific research units to support the rural enterprises with their manpower.

Comrade Zhao Bao added: To reform the system of personnel management, we must break through the closed system of personnel research. We must proceed from the structural reform of the entire country, consider the overall situation, and combine the use of market mechanisms in macroeconomics with greater flexibility in microeconomics. This will be the breakthrough point in the reform of or personnel system. In the future, we must break away from the traditional methods of cadre management. We must change the former "how to control" into "how to be flexible," replace administrative with economic methods, and open more channels for efficient personnel management.

ZENG XIANLIN ON SCIENTIFIC, TECHNICAL REFORM

Beijing KEJI RIBAO in Chinese 12 Apr 87 p 1

[Article by Li Renqin [2621 0088 6024]: "Scientific and Technical Reform to Focus on Pilot Projects in 1987"]

[Text] "Vigor, caution, and exploration" are the watchwords for the furthering of scientific and technical structural reform and implementation of the two State Council documents: "Some Regulations on Furthering Scientific and Technical Structural Reform" and "Regulations on Incorporating Scientific Research Institutes into Large and Medium-sized Enterprises." This was pointed out by Vice Minister Zeng Xianlin [2582 2009 2651] of the State Science and Technology Commission at the conference called to discuss the plans of certain cities carrying out pilot projects in scientific and technical reform. The thrust of scientific and technical reform this year is to select cities of different types to be test-sites at different levels. Cities thus selected must act vigorously in the spirit of the two documents. They must move quickly, at the same time paying meticulous attention to detail and resisting the herd instinct.

The conference on scientific and technical reform in experimental cities was convened by the State Science and Technology Commission, State Economic Commission, State Structural Reform Commission, National Defense Science, Technology, and Industry Commission, and the office of the Science and Technology Leading Group of the State Council. Zeng Xianlin said at the end of the conference, "The two documents point up a clear direction for and make demands on the furthering of scientific and technical structural reform. They are targeted at and will serve to correct some of the shortcomings in current reform and the byproducts of reform, such as the pursuit by certain research institutions of self-perfection and self-containment."

Referring to the purpose of scientific and technical structural reform, Zeng Xianlin said, "Reforming the organizational setup and operational mechanisms of scientific and technical organizations, overhauling the appropriations system, implementing the royalty contract system and scientific and technical personnel hiring system, creating a technical market, setting up a scientific and technical development fund--all these are means. The basic objective of reform is to develop a proper 'orientation' and 'dependency' and end the divorce between scientific research institutions and industry. Thus the goal

of reform in experimental cities is to promote urban economic results and social development. Only by pursuing this goal can scientific and technical structural reform arouse the interest and gain the support of all society, thereby creating a favorable climate. Scientific and technical reform cannot take place in isolation but must be combined with urban and economic structural reforms openly in accordance with a comprehensive urban development plan."

Concerning the entry of scientific research institutions into enterprises and groups of enterprises, Zeng Xianlin said that a variety of models and methods may be used provided they are acceptable to both parties. The purpose of "entry" is to achieve unification of leadership. Appropriate preferential measures should be taken to encourage "entry," but efforts should be made to prevent "forced" or "phoney" marriages.

Shenyang, Nanjing, Guangzhou, Harbin, Huangshi, and other cities have put forward implementation plans for pilot projects in scientific and technical reform. Other experimental cities will be selected by the proper authorities in the State Council. The Ministries of Electronics Industry, Machine-building Industry, and Posts and Telecommunications also presented reports at the conference describing the implementation of the two documents and outlining opinions and ideas about scientific and technical reform in the future.

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CSO: 4008/55

DECISION ON SUPERCONDUCTIVITY RESEARCH

Beijing KEJI RIBAO in Chinese 12 Apr 87 p 1

[Article by Xie Ning [6200 1337]: "Coordinated Efforts Called For To Win Superconductivity Race"]

[Text] The State Planning Commission and the State Science and Technology Commission jointly issued the "Decision on Organizing Kelvin Temperature Superconductivity Research" on 11 April. The "Decision" points out that to speed up the development of its superconductivity research, China must mobilize its limited human, material, and financial resources effectively, make full use of the nation's existing research strength and material advantages, exercise united leadership, and mount a coordinated offensive.

The gist of the "Decision" is that under the leadership of the CPC Central Committee and the State Council, the State Planning Commission and State Science and Technology Commission will directly lead and coordinate superconductivity research nationwide; that a commission of experts on superconductivity will be established to offer advice to national decision-makers and be responsible for planning; that a joint research and development center on superconductivity will be created in the Physics Institute of the Chinese Academy of Sciences to implement the plan and organize academic exchange, both domestic and international; and that Kelvin temperature superconductivity research will be made a special item to be incorporated into the nation's scientific and technical plan during the Seventh 5-Year Plan and be offered financial support.

Zeng Xianlin [2582 2009 2651], vice minister of the State Science and Technology Commission, pointed out at a news conference on 11 April that China has become a leader in the worldwide competition in superconductivity research. But this competition is a round robin, not an elimination series: you may lead now, but you may not lead in the future. Superconductivity research is a massive piece of systems engineering, consisting of basic research, applied research, and development, which are inseparable. Superconductivity research in China must follow this principle: organize, fight in coordination, and mount a joint offensive. Planning and leadership must be centralized. A fair degree of centralization must be combined with division of labor. There should be centralization without over-centralization, division without confusion. Superconductivity research must not only bring forth achievements but, ultimately, also result in products.

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COORDINATION IN SUPERCONDUCTIVITY RESEARCH STRESSED

Beijing KEJI RIBAO in Chinese 13 Apr 87 p 1

[Text] The State Planning Commission and the State Science and Technology Commission announced on 11 April that they would exercise direct leadership over and coordinate superconductivity research nationwide, establish a commission of experts on superconductivity research, create a joint research and development center on superconductivity, and incorporate superconductivity research into the Seventh 5-Year Plan. We applaud these four exciting moves, which will certainly play a critical role in China's participation in the worldwide superconductivity research race.

At present superconductivity research is surging forward around the world. Kelvin temperatures are being toppled all the time and the rapidity with which research results are being applied is extraordinary. The race on superconductivity is not only an academic and technical competition and a test of willpower and faith. It is also a fight in the organizational and economic senses, a "group competition" overall. Whoever brings together the various disciplines in natural science and coordinates the sectors in the national economy to the greatest extent possible and marshals human, material, and financial resources optimally, will gain the upper hand and occupy an invincible position in the front ranks of superconductivity research and application.

China has the tradition of and experience in mobilizing its advantages for a coordinated offensive. The testing of the two bombs, the invention of synthetic insulin and synthetic RNA--all these achievements, which are among the most advanced in the world, were exactly the results of mobilizing national resources for a common cause. China has a superior socialist system, reformed operational mechanisms that can both fire the spirit of competition and strengthen macroeconomic guidance, and rare-earth materials. Also, Chinese scientific and technical workers have shown a keen spirit of cooperation in the international race in superconductivity. Provided we use the best screw and the best part on the machine running at high speed, with one heart and one mind, we will win this competition, scale the heights of superconductivity research, and position ourselves at the frontier of research and application in the world. When China exerts itself, it will succeed.

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CSO: 4008/55

SCIENCE, TECHNOLOGY FINANCING STRATEGIES

Beijing KEJI RIBAO in Chinese 27 Apr 87 p 3

[Article by Jiang Chun [3068 2504]: "Establishing Multi-Level Mechanisms to Integrate Science and Technology with Finance"]

[Text] For years budgetary appropriations have been the main source of science and technology funding. This kind of "supply system" is ridden with problems and is the primary reason for the lack of vitality in scientific and technical organizations and the difficulty of translating science and technology into productive forces.

As scientific research and technical inventions these days become more and more diversified and multi-level, there arises a demand that funds be used more flexibly and in a wider range of forms. The continuous differentiation and merging of science and technology requires a free movement of funds, both horizontal and vertical. The extensive application of science and technology in all areas of our lives and in production demand that funds be supplied through a multitude of channels. Thus it is now an important part of the drive for scientific, technical, social, and economic development to make full, flexible, and imaginative use of all forms of fund-raising.

The marriage between science and finance in the future can take place at several levels.

The Top Level: Science and Technology Development Bank

The China Science and Technology Development Bank, which will specialize in the financial side of science and technology, may be subordinate to multiple leaders--the State Science and Technology Commission, the state bank, and financial agencies. Its decision-making organs must include far-sighted scientists, engineers, economists, financiers, and entrepreneurs who have a wealth of knowledge about the country. It must keep its administration lean and hire a small competent staff. At the beginning, it may set up its headquarters in Beijing and then establish branches in large urban centers with a sizable pool of scientific and technical resources and formidable economic prowess, such as Shanghai, Tianjin, Wuhan, Xian, etc. Gradually the provinces may do likewise. The science and technology development bank should use advanced equipment and apply modern management methods.

It is the main task of the China Science and Technology Development Bank to provide loans to finance scientific and technical projects that influence the macroeconomy and the long-term development of the entire national economy. It should also assume overall responsibility for formulating plans and policies integrating science and technology and finance. Specifically, it is to: 1) provide loans on favorable terms to priority projects in science and technology urgently needed by the development of high technology and national economic construction; 2) nurture the development of new or key industries with long-term and low-interest loans, thereby expediting the adjustment of China's industrial structure; 3) issue credit for the purpose of importing, assimilating, and applying advanced foreign technology, and 4) provide the nation's scientific, technical, and financial sectors with accurate and reliable information.

In view of the high-risk nature of the operations of the Science and Technology Development Bank, most of its funds should be state funds. Specifically, they may come in part from the general revenues at each level, in part from the central bank, and in part from the three scientific and technical funds. When a loan is repaid, the money should be retained by the bank as capital. When a project fails, the state should assume most of its liabilities.

The Intermediate Level--Specialized Banks

One after another, all specialized banks in the nation (particularly the Bank of Industry of Commerce) have been moving out of their traditional areas of lending to offer scientific and technical loans. This is a positive form of scientific and financial integration, which must continue even after the establishment of the Science and Technology Development Bank in the future because the latter differs from specialized banks in its scope of operation, business focus, organizational setup, and personnel. Moreover, the specialized banks make up an extensive network with numerous branches. They are closely related to all localities, sectors, and enterprises and have an intimate knowledge of the details of social economic development. Their role cannot be replaced by the Science and Technology Development Bank. Specialized banks may select a number of professionals well versed in both finance and science to set up and improve departments that handle the financing of science and technology.

Unlike the Science and Technology Development Bank, specialized banks stress the microeconomy and go by credit principles when they make science and technology loans. What is important to them is the repayment of loans and economic results. They insist that a project be technically advanced, feasible in terms of production, and economically sound. Their scope of lending primarily includes the following: 1) the development and test manufacturing of new products, particularly projects that require limited outlays and a short lead time, pay off quickly, turn out readily marketable and popular products, generate handsome profits, and can retire their debts; 2) intermediate testing prior to the conversion of science and technology into direct productive forces; 3) the application and dissemination of scientific and technical achievements, particularly that of new technology and processes;

and 4) providing buyers and sellers of scientific technical achievements with funds for short-term loans and supporting the circulation of new products.

The state bank may take the lead in putting together "syndicated loans" to finance scientific and technical projects that require massive funds and impact the national economy and people's livelihood.

Specialized banks may tap new funding sources to supplement their existing funding channels. These are some preliminary ideas: establish a science and technology development fund by drawing a portion of the funds from extra-budgetary deposits in the form of bank credit; pool some of the scientific and technical funds at the disposal of the science and technology commissions at various levels and of enterprises in the form of financial trust; absorb the savings of all kinds of scientific research institutions and joint research and production organizations; and issue science and technology bonds.

Another Intermediate Level: Venture Enterprise Investment

Venture enterprise investment is a new investment mechanism combining science and technology, on the one hand, with finance, on the other. It comprises three components: venture capital, venture investment company, and venture enterprises. A venture investment company is an enterprise specializing in making venture investments. It raises funds in accordance with the principle of "sharing risk" and lends to enterprises which hope to convert high technology into new products. Venture enterprises are R&D-oriented enterprises. China New Technology Enterprise Investment Company is the country's first venture enterprise investment company. Experience shows that this kind of venture investment meets the objective requirements of scientific, technological, social, and economic developments in China and has become an important way to combine science, technology, and finance.

The primary targets of venture investment are newly established small and medium-sized enterprises and scientific and technical personnel with new ideas and new inventions who come together voluntarily forming free associations. Venture investment gives preference to: 1) industries applying sophisticated technology, also known as high-tech industries; 2) new industries; and 3) the R&D of new products intended for the market. In addition, venture investment companies may provide all kinds of consulting services and technical suggestions, even to the extent of taking part in management and recommending qualified personnel.

In view of the characteristics of venture investment, both venture investment companies and venture enterprises may adopt the stockholding system and raise funds from among enterprises, the sectors, and individuals by issuing stocks at home and abroad. At present, banks should serve as fund-raising units, pooling funds among the major enterprises and departments concerned. Later funds may be raised on the market primarily from among individuals.

Grassroots Level: Establishing Science and Technology Development Insurance Companies

Since the possibility of failure in scientific research is very high, there is a need for specialized science and technology development insurance companies to offer insurance for R & D loans or investments, share the economic losses incurred by such loans or investments, and make compensation. In addition, science and technology development insurance companies must support scientific and technological development by raising funds through a multitude of channels.

Science and technology insurance is a very risky business where compensation involves huge amounts of money and the possibility of operating at a loss is high. To protect the economic interests of both the insurer and insured, we need to raise science and technology development insurance funds in appropriate ways, calculate and determine insurance premium rates scientifically, and use insurance funds properly. Through painstaking work, science and technology development insurance companies can play a vital role in promoting the integration of science and technology and finance.

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CSO: 4008/55

ELECTRONICS PRICING CONFERENCE SETS 10 TASKS

Beijing DIANZI SHICHANG in Chinese 2 Apr 87 p 1

[Article by Wei Shi [0787 1395]: "Using Economic Mechanisms To Improve Management in the Electronics Industry"]

[Text] What new plans have been made for pricing and taxation in the electronics industry this year? How is the industry going to make use of the law of value and the tax lever to adjust the price structure, open up the market, and develop the electronics industry? These questions were answered at the electronics industry pricing conference which closed in Chongqing in early March.

The conference focused on pricing and taxation plans for the industry in 1987. It was pointed out that pricing this year must revolve around cost-cutting and the increase of output, earnings, and economic results. The effort to rationalize prices and adjust the distribution of profits properly must continue. In conjunction with the application of the tax lever, the industry must vigorously develop popular, readily marketable products and open up markets. It must set a reasonable cost of earning foreign exchange by exporting electronic products, establish a system of domestic-international price ratios and price differentials, set target costs for major products to be included in the criteria by which enterprises are evaluated by the higher authorities, further industrial management, study the profit distribution standards and level of profitability of reasonable prices, work out detailed plans and suggestions for tax reductions or increases, and gradually put together a pricing system for the electronics industry that can control the macroeconomy and invigorate the microeconomy.

The conference set 10 specific tasks for pricing work this year: 1) work out a coefficient of the cost of earning foreign exchange for each category of electronic exports; 2) put forward a drawback plan and a domestic spare-part pricing plan for TV sets to be exported; 3) study and determine ways of improving the pricing management, examination-and-approval procedures, and pricing principles of military goods destined for the foreign market; 4) present an electron tube price adjustment plan; 5) issue the target costs of major products and compare and appraise the quality and costs of different products; 6) lift price control on electronic apparatus and permit enterprises to set their own prices at an appropriate time, remove the price floor of

electronic spare parts, further the work of the pricing group and the association, and strengthen guidance and organization; 7) step up taxation management, use the tax lever effectively, set the various tax rates at reasonable levels and make appropriate adjustments; 8) pay attention to and come to grips with professional training, information exchange, price management, and intraindustry competition, etc; 9) put forward a plan to forecast the profit levels of different electronic products and control the profit rate; and 10) organize and initiate research to develop a forecasting model for the costs and prices of computer software.

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CSO: 4008/48

NAVY BUILDS LARGE COMMUNICATION STATION

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 3 May 87 p 1

[Article by Cai Hong [1752 5725] and Jian Ping [1696 1627]: "Large Communication Station Aids Long-Distance Voyages"]

[Text] The communication signals of the Chinese Navy cover the entire globe, according to leading organs in the navy. A naval ship 18,000 km from home can communicate and exchange information with leading naval organs in Beijing.

In recent years, the communication department of the Navy has stepped up efforts to overhaul existing communication stations systematically to make them compatible with advanced data communication, language communication, and graphic transmission. At the same time, it has also built large-scale communication stations. Today the Chinese Navy boasts the world's most powerful ultralongwave communication system and a long-distance shortwave communication system that is internationally and domestically advanced. The naval forces are being equipped in batches with a new ultrashortwave radio suited for internal communication among naval ships at sea. One after another coastal units are building relay communication lines fitted with microwave relayers and ultrashortwave relayers, effectively improving communication between the islands and the mainland. Advanced communication equipment and technology, such as fiber optics, microcomputer communication, and satellite communication have also begun to enter the naval communication system.

It is the navy's communication system alone which ensured that Beijing was able to communicate with and command the units at sea during several long-distance voyages--China's first scientific expedition to the Antarctic, the three trips by S&T personnel to the South Pacific to conduct scientific experiments, and the visit by a Chinese fleet to three South Asian nations. During the Antarctic expedition, Beijing received and sent out over 260,000 sets of telegrams and talked on the radiophone more than 510 times, without missing a beat.

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CSO: 4008/56

EXPERIMENTAL SATURATION DIVING TO 300 METERS UNDER WAY

HK100656 Beijing CHINA DAILY in English 10 Jun 87 p 1

[Article by Chen Xin]

[Text] A series of sophisticated experiments of major importance to the development of China's diving and underwater technology and operations are under way.

The experiments on saturation diving at a depth of 300 meters are considered a significant research project in the country's current 5-year plan (1986-90).

The Shanghai Institute of Underwater Technology is seeking reliable reference data through simulated deep-sea divingusing mixed gases-- helium, nitrogen and oxygen--for compression.

Special technology has been developed for the first time in China for use by the institute, which comes under the control of the Ministry of Communications and the Ministry of Petroleum Industry.

The tests started on 23 May and finish on Friday. They cover diving phsiology, medical issues, underwater communications and other subjects.

"As this project is an unprecdented one in China considering its depth as well as its multi-subject research, it will surely contribute a great deal to the utilization of marine resources, ocean salvage and strengthening of our navy," Shi Zhongyuan, associate professor and president of the institute, said.

Investment in the project totals 4.23 million yuan ($1.13 million). Researchers from the Shanghai Salvage Bureau and China's coastal Jiangsu and Shandong Provinces are taking part.

Four divers are required to stay for 7 days under the pressure of 30 kilograms a square centimeter (29 times more than what a man living on land bears) before a 293-hour decompression process returns them to normal atmospheric pressure.

The tests, in a wet chamber, use newly developed under-water breathing apparatus.

Experiments are also being carried out involving monitoring body-organ functions, metabolic analysis and psychiatric observation while high-speed compression is in progress. Other tests will check the chamber automatic control equipment and some underwater operation devices.

"The key point of our project is the sealing character of the pressure vessel. Danger will emerge if the leaking rate rises," Chen Baosong, technical director of the project said.

Chen said two studies conducted before the tests started found the leaking rate was below 0.3 percent in 24 hours, far less than the generally recognized standard of 1 percent a day.

In saturation diving, a mixture of helium and oxygen used to be the working gas to create a high pressure nerve syndrome and distortion of sound. But scientists have found that adding an appropriate amount of nitrogen can help improve the result. Researchers in many countries now use a mixture of the three gases called Trimix.

So far, P.B. Benett, a professor at Duke University in the United States, has achieved the record depth of 686 meters through his experiments, Atlantic I-IV, using Trimix.

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CSO: 4010/52

BEIJING INSTITUTE DEVELOPS ROBOTS FOR INDUSTRIAL USE

OW091202 Beijing XINHUA in English 1154 GMT 9 Jun 87

[Text] Beijing, 9 Jun (XINHUA)--The Beijing Research Institute of
Automated Machine Building, which is under the State Machine-Building
Industry Commission, has just manufactured four "PJ-1" painting robots.

To date, China has developed over 100 models of robots, but so far, most
have been used in labs and few have been installed for production use.
The "PJ-1" robots are the country's first produced for industrial use.

Gao Shiyi, director of the institute's Robot and Automatic Technology
Research Center, said, "The 'PJ-1' is a multi-function, computer-
controlled robot, which can be used for all types of surface painting."

The "PJ-1" was first developed in 1985, and has been used successfully
for 9 months at the Beijing Jeep Co., Ltd., in the assembly of 12,000
jeeps.

According to Gao, "The 'PJ-1' is expected to do well on domestic and
international markets because of the product's high-quality and low
price."

The institute is getting ready to manufacture the second batch of 10
"PJ-1" robots which will be distributed to domestic enterprises. Firms
in India, Singapore and Hong Kong have also expressed interest in
purchasing the robots and the related patents.

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CSO: 4010/52

BEIJING TELECOMMUNICATIONS NETWORK NAMED BEST IN NATION

Beijing ZHONGGUO DIANZI BAO in Chinese 29 Mar 87 p 1

[Article by Shu Da [2579 6671]: "Telecommunications Stations in Beijing Now Exceed 20,000"]

[Text] There are now 22,000 transmitter-receivers, 3,000 fixed stations, and 110 telecommunication networks in Beijing, essentially covering the 19 districts and counties in the entire municipality and giving the capital the best telecommunications system in the nation. This was revealed at the experience exchange conference on radio management work and communication technical applications held in Beijing. These stations are now used in water conservancy, public security, meteorology, transportation, public health, and other areas, and have achieved tremendous social and economic results. Telecommunications in the capital is a gratifying scene where "progress is fast, applications extensive, technology new, and results good."

In recent years, as the policies of reform and opening to the outside world have become more and more thoroughgoing, a single-wire communications system alone can no longer satisfy the capital's needs in information exchange and international intercourse. Consequently there will be rising public interest in broadening the use of telecommunications, which in the past was confined to a handful of government and military agencies, to economic construction and make it serve the capital's economic construction and people's daily lives better.

The Beijing Telecommunications Management Commission recently has taken concrete measures regarding telecommunications work in the capital. It has identified the following as the primary difficulties in the development of telecommunications: while many units apply to set up telecommunications stations, frequency-band resources are limited, and while it takes a relatively high level of technical expertise to operate the stations, the quality of workers is quite low. In the future, the thrust of its work is to step up the management of existing large and medium-sized networks and stations even as it strives to solve the above two problems. In setting up new networks, we must insist on technical progress, use new technology as much as possible, and speed up the establishment of telecommunications networks in suburban counties.

12581
CSO: 4008/48

NEW COMPUTER PRODUCTS TO BE SHOWN AT BEIJING EXHIBIT

OW271422 Beijing XINHUA in English 1216 GMT 27 May 87

[Text] Beijing, 27 May (XINHUA)--The "Great Wall" 286 microcomputer and the GW220 terminal which processes both Chinese characters and the Latin alphabet--both developed by the China Computer Development Corp.--will be shown at an exhibition here tomorrow.

This was announced by Wang Zhi, general manager of the corporation, at a press conference today.

He said, "the 'Great Wall' 286 microcomputer has all the advantages of IBM's PC/AT, but its processing speed is four times greater."

As for the GW220, he told the conference, "it can be connected to the 'Great Wall' 286 computer to organize a multi-function system. And it also can be used as the high-grade terminal for a small-sized set of computers."

The corporation, established in 1986, will produce 25,000 microcomputers this year, half of China's total output.

Wang said, "the corporation exported 200 microcomputers to the United States, Australia and Thailand for a total of one million U.S. dollars and signed export contracts worth 10 million U.S. dollars in the first five months of this year."

He said, "we imported software, hardware and high-technology items from the United States and Japan at the same time. We also cooperate with technicians in the United States and Hong Kong to develop magnetic computer heads."

He added, "the corporation has agents in the United States, Thailand, Australia, and Hong Kong, and exports are expected to increase."

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CSO: 4010/1029

MEDIA TECHNOLOGY CONFERENCE PLANNED

HK300728 Beijing CHINA DAILY in English 30 May 87 p 2

[By staff reporter Lao Zhao]

[Text] China is making a massive push to modernize its media and telecommunications technology and to introduce sophisticated equipment for printing newspapers, magazines and books.

As part of it, an international exhibition and conference on media communications and photo and printing technology will be held in the Great Hall of the People in Beijing on 27 October.

The one-week show will be the first of its kind held since the founding of the People's Republic, according to Yu Xiaozhun, deputy general manager of the China Media Development Corporation.

Exhibits will cover four areas: technology and equipment for print communications; audio-video broadcast communications; photography, film and optics; and printing for newspapers and magazines.

Chinese and foreign participants from press, communications and trade circles will be able to exchange information and explore cooperation, Yu said.

The show is receiving international attention. West Germany is organizing national participation, and companies from France, Spain, Switzerland, the United States, Japan and Hong Kong have signed contracts to take part.

The show will be jointly organized by the China Media Development Corporation, the China Council for the Promotion of International Trade, Beijing Branch, and Asia Team Communication Ltd.

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CSO: 4010/1029

PATENT TECHNOLOGY TRADE FAIR, CONFERENCE

Shanghai WEN HUI BAO in Chinese 3 Apr 87 p 1

[Article by Xiong Haijun [3574 3189 6874]: "Successful Patent Technology Trade Fair"]

[Text] The "Patent Technology Trade Fair and Conference," organized by the Shanghai branch of the China Patent Bureau, this newspaper, and other units, ended in Shanghai yesterday. It was a large-scale nationwide event staged to mark the second anniversary of China's Patent Law. As many as 14,000 persons took part in the fair and 1,100 patent technologies with a combined value topping 5 million yuan were traded or were the subjects of letters of intent.

There was an endless stream of visitors throughout the 5-day trade fair. Exhibitors conducted business negotiation and cut deals on their own; fair organizers neither charged them a fee nor deducted a percentage from their earnings. This unleashed the initiative of delegations to the fair. The delegation from Zhejiang, for instance, did not have many exhibits at the fair but, according to statistics for the first 3 days alone, had clinched technology transfer deals or signed letters of intent totaling more than 50, worth 330,000 yuan in all.

Strengthened lateral ties between provinces and municipalities in information, technology, and the economy have not only smoothed the way for the outward transfer of exhibits from this province, but also attracted even more exhibits from other provinces and municipalities, advancing this region technologically. Hubei's Patent Bureau sent only 60 items to the fair but absorbed as many as 130 items from elsewhere.

Many items on display involved redeveloped technology. Because this kind of technology is more advanced and protected by the Patent Law, factories had more confidence in talking business and more deals were struck than at the regular technical market. One example is the "glass color paint technology" of Huaqiao University, which attracted many enterprises to open negotiations with the university. So far contracts have been signed with a dozen or so factories in nine provinces all over the nation. At the same time, the trade fair offered free consulting services on the Patent Law in order to publicize it, which did much to ensure successful negotiations at the fair.

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CSO: 4008/48

NATIONAL TECHNOLOGY MARKET FORUM HELD IN SHENYANG

SK250706 Shenyang Liaoning Provincial Service in Mandarin 2100 GMT 24 May 87

[Text] The national forum on technology market management was jointly held
in Shenyang on 24 May by the national leading group for technology market,
the Liaoning Provincial People's Government, and the Shenyang City People's
Government. Present at the opening ceremony were Guo Shuyan, director of the
National Coordination Group of Planning Legislation for Technology Market
and vice chairman of the State Scientific and Technological Commission; leading
comrades in charge of technology market work of 22 departments and commissions
under the party Central Committee and the State Council; and representatives
of 29 provinces, municipalities and autonomous regions and of 8 cities under
direct state control.

The forum was presided over by Lin Sheng, vice governor of Liaoning Province.
(Bai Guomo), deputy director of the National Coordination Group of Planning
Legislation for Technology Market, delivered a work report. He said: Thanks
to nearly 2 years of efforts, China's technology market has begun to embark
on the stage of stable development, and has already become an important
component part of the socialist commodity market. [Words indistinct] Accord-
ing to incomplete statistics compiled in 22 provinces, municipalities, and
autonomous regions and 17 departments, a total of 87,000 technology contracts
were finalized in 1987 with total transactions upwards of 2.06 billion yuan;
and the technology market has begun to attract general attention of govern-
ments at various levels.

At present, coordination organs for management of the technology market have
been established in 23 provinces, municipalities, and autonomous regions;
and the development of one technology market has positively promoted economic
construction and technological progress, thus manifesting its broad prospects.

At the forum, (Hou Xuechun), vice governor of Jiangxi Province; Li Baoheng,
member of the Secretariat of the China Association for Science and Technology;
[words indistinct] of the National Technology Market; and Zhang Rongmao, vice
mayor of Shenyang City, introduced their experiences in expanding and
invigorating the technology market.

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CSO: 4008/1079

SCIENTIFIC RESEARCH, PRODUCTION INTEGRATED IN SICHUAN

Beijing KEJI RIBAO in Chinese 24 Apr 87 p 1

[Article by Zhang Xiaoyuan [1728 2556 0626]: "Lateral Economic Association Benefits both Academe and Industry"]

[Text] Institutions of higher education in Sichuan today are closely weaving scientific research into production and contributing to vitalizing the provincial economy, stimulating research and development [R&D] at large enterprises, and nurturing the growth of small and medium-sized enterprises and township enterprises.

Institutions of higher education in the province have been actively cultivating lateral scientific ties with enterprises since scientific structural reform began in 1985. Data from relevant agencies show that they have established scientific and technical relations with over 1,000 enterprises, accepted to undertake 794 projects, transferred 307 specific scientific achievements, and provided all kinds of consulting services up to 1,000 times, ushering in a new age in industry-education cooperation. The high-temperature high-pressure physics research institute of Chengdu University of Science and Technology took intermediate testing in man-made diamond research to the Zigong Porcelain Plant and Deyang Diamond Plant, making factories the base for such testing so that when the factories take delivery of the research achievements, they have also mastered the technological processes and trained key technical staff. At the same time, the university also kept perfecting manmade diamond research at the factories, resulting in its early commercialization. This practice of "making available a good piece of technology to industry early" proved highly inspiring to other scientific and research units and enterprises. In cooperation with the No 2 Heavy Duty Machine Plant in Deyang and the Gongzui Power Plant, the fracture mechanics office of Southwest Jiaotong University studied the safety of the primary shaft during the period when it is in active use and in its remaining service life, freed Gongzui Power Plant from a potential problem, and saved the state almost 1 million yuan. Since 1986, moreover, some institutions of higher education have either entered into burgeoning enterprise groups through a variety of ways or teamed up with enterprises to form interindustry and interregional technical development companies.

A notable feature of the way institutions of higher education go about scientific research is that after judging the time and sizing up the situation, they take the initiative and go on the offensive. Adapting to changes in the appropriation system in science and technology, they are taking the initiative to capture key research projects designated by the ministries or state as priorities in the Seventh 5-Year Plan, organizing faculty to take part in project demonstrations, approaching the relevant agencies with offers to undertake major projects, undertaking, on their own initiative, projects commissioned by enterprises, and stepping up their applications to the national natural science foundation.

According to statistics from 30 colleges and universities including Sichuan and Chongqing universities, 4,043 new projects were initiated in 1986, up 20.14 percent over 1985. Scientific research funds from all sources totaled 45.47 million yuan, an increase of 36.38 percent compared to a year ago. After 2 years of steady development, the 30 institutions have steadily improved their standard of scientific research, with 343 scientific achievements filling gaps in China's science and technology, up 37 percent compared to 1985. Some of them are of an international standard.

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CSO: 4008/56

TONGJI UNIVERSITY STEPS UP SCIENTIFIC RESEARCH

Shanghai WEN HUI BAO in Chinese 15 Apr 87 p 1

[Article by Zhang Chengjun [4545 2052 6874]: "Tongji University Reforms Scientific Research System"]

[Text] More than two-thirds of the entire university's scientific research resources have switched from isolated "self-selected topics" to those urgently needed by national economic construction. The value of the university's lateral scientific research contracts shot up 208 percent in just 1 year. At a time when most institutions of higher education report declining incomes from scientific consulting, such earnings keep rising at Tongji University, catapulting the institution into the No 1 spot in the municipality. All these are remarkable changes wrought by the university's decision to take the lead in reform and establish a scientific research management system under which projects are selected for financial support on the basis of merit.

The introduction of a floating system to regulate the number of scientific research personnel is one measure taken to reform the scientific research management system. The number of personnel is linked to tasks. Each full-time position must try to obtain a set amount of scientific research funds from outside. If the fund target is not met, a fine will be imposed in the first and second years and, in the third, the position will be abolished in addition to the imposition of a fine. The number of positions floats once a year. Also, the topic group is empowered to select its personnel. Using scientific research funds, it may hire or borrow technical personnel inside and outside the university, retired workers, and idle personnel in society to help with short-term projects. It is also allowed to use such funds to pay over-time allowances. Moreover, it can put selected undergraduates and graduate students on a work-study program and hire graduate students as research assistants.

The university is also the first to implement an "entrepreneurial scientific research fund system" under which the university's own scientific research operating expenses and funds raised by the research units are pooled to form an entrepreneurial research fund. Apart from a small amount set aside for academic exchange activities, the rest of the fund is put on a contract system to finance projects selected on merit. Funds are given out in a number of ways; some are issued as grants, others have to be paid back in full or in

part. Should a unit which has accepted to undertake a task fail to meet the assessment targets by a set date or postpone meeting such targets, it will be fined. University research funds are spent primarily on the work of middle-aged and young researchers that is of a pioneering nature and selectively on basic research with application potential. As for scientific research personnel on Professor I level, they are in principle ineligible to apply for such funds and must go to society on their own initiative to vie for jobs as a way of securing funds.

The pressures these two reforms put on grassroots scientific research units soon became the latter's own internal driving force, compelling them to serve national economic construction. Surface structural design for high-grade highways and surface-layer skid-resistance are a difficult project that the state has incorporated into the Seventh 5-Year Plan as a priority task. Welcoming tough jobs, the university's highway and transportation engineering department has taken it up. With few funding sources, the department used to have no more than 100,000 yuan a year, including subsidies from the higher authorities. Today, instead of seeking "hand-outs" from the top, it orients itself to society and takes the initiative to accept commissioned projects. In just 1 year, its scientific research funds soared to 1.9 million yuan. The university's underground architecture and engineering department has also undertaken a string of research projects needed by the national economy, such as "the use of basements in high-rise buildings," "reliability analyses of earth-slope stability," and "applications research on harbor construction." At present the success rate of the university's scientific research projects is very high; not a single fine has been imposed.

Many scientific research personnel previously concentrated their energies on "self-selected" projects needed for their own careers. Today such projects have dropped almost 70 percent at Tongji University compared to 1985. During the same period, it accepted 86 and 115 percent more projects assigned by various central ministries and commissions, and the municipality of Shanghai, respectively.

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CSO: 4008/48

RESEARCH DIRECTORS CONCERNED ABOUT ENTERPRISE VITALITY

Beijing KEJI RIBAO in Chinese 26 Apr 87 p 1

[Article by Huan Jianxin [1360 1696 2450]: "Research Directors Cite Lack of Enterprise Vitality as Major Concern"]

[Text] According to a survey on 274 research institute directors conducted by the Science and Technology Policy and Management Science Research Institute of the Chinese Academy of Sciences [CAS], the lack of enterprise vitality is a major problem facing the "double deregulations." The directors call on the proper agencies to create a favorable external environment for the "two deregulations."

As scientific and technical structural reform went under way in recent years, the number of horizontal research projects has also increased. Horizontal contracting accounts for over 46 percent of all technology transferred. However, research institutions are also acutely aware that enterprises have a long long way to go before they vitalize themselves. Moreover, there is a good deal of unevenness between them, as manifested, first of all, by the fact that small and medium-sized enterprises and township and town enterprises show a much stronger demand for technology than large enterprises. Only 37.2 and 14.4 percent of the research achievements of ministerial research institutions and research institutions in the CAS, respectively, flow toward large enterprises, even though the technical standard of their research achievements is closer to the requirements of such enterprises. Large enterprises are the primary targets of research institutions which want to make their entry into enterprises or groups of enterprises in the future. But the latter's present state has the institute directors worried.

The second manifestation is the uncertainty of enterprise vitality. In 1985, of all the avenues of technology transfer, the technical market accounted for just 6.3 percent and has been losing ground since the second half of 1985. It is not uncommon for enterprises to often scrap or terminate contracts, causing a marked drop in the horizontal earnings of a majority of research institutions in 1986. In that year 19 self-supporting units in Shanghai saw their income take a 15-40 percent plunge after enterprises terminated 57 percent of the horizontal contracts because of a lack of funds. The survey shows that it is difficult to convert technology into economic results in a vacuum. Only by combining technology with funds can we produce new added

value. This combination is absent from many enterprises at the moment.
Consequently, enterprises, whose vitality is fragile to begin with, feel the
pinch as soon as money becomes scarce. A factory director said, "If I have
money, I can go out and buy technology. If I have no money, there will be no
vitality even if the research institute is right inside."

In the opinion of the 274 research institute directors surveyed, scientific
and technical structural reform must proceed in tandem with economic
structural reform. In the midst of the "two deregulations," both research
institutions and enterprises must vitalize themselves to enable the union
between science and the economy to develop in a steady and sustained way. To
create a favorable climate for the "two deregulations" of the research
institutions, the most important thing is to grant managerial autonomy to
enterprises and invigorate them in tax, investment, profit retention, and
other areas.

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CSO: 4008/55

HAINAN OPENS MEETING ON LATERAL TIES, TECHNOLOGY EXCHANGE

HK210411 Haikou Hainan Island Service in Mandarin 1000 GMT 20 May 87

[Excerts] A Hainan regional meeting on lateral ties and technology exchange fair opened this morning. [Passage omitted] the opening from Beijing, Shanghai, Shenyang, Guangzhou, Wuhan, Nanjing, Zhejiang, Zhengzhou, Hunan, Guangxi, Jiangxi, Shandong, and Shenzhen provinces and cities, the Hong Kong and Macao regions, and Hainan areas, organs, and enterprises.

Meng Qingping, deputy secretary of the Hainan regional party committee and the principal responsible persons of the regional government: Wang Yuefang, deputy secretary of the regional party committee and a responsible person of the regional government; and others attended the ceremony.

Delivering the opening speech, Meng Qingping said that Hainan has scored notable achievements in the 37 years since its liberation. In particular, since 1983, when the CPC Central Committee and State Council stipulated the guiding principle of promoting the island's development by opening up to the world. Hainan has actively launched the work of importing from abroad and linking up with units in the interior of China, thereby promoting the development of its economy. By the end of 1986, 274 projects imported from abroad, involving a total investment of $388 million, had been approved. A total of 928 items of advanced equipment had been imported from abroad. The island had established links with 348 units in the interior of China, which had invested 381 million yuan in the island. Hainan's foreign exchange earnings were $41.75 million. In 1985, total value of the island's industrial and agricultural output was 3.679 billion yuan, an increase of 91.32 percent over 1980. Total output value in 1986 showed a rise of 8.91 percent over 1985.

Meng Qingping said: With the approval of the State Council, beginning this year Hainan is receiving separate listing in the plans, and will enjoy provincial-level economic management jurisdiction. The regional government decided to hold this exchange fair to take full advantage of the island's strong points in resources, make good use of the favored treatment allowed us by the central authorities, strengthen economic and technological ex-- changes and cooperation with all parts of the country, and promote Hainan's economic development and technological progress.

The fair will last 10 days.

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CSO: 4008/1079

QIAN XUESEN LISTS DEMANDS ON S&T JOURNALISM

Beijing KEJI RIBAO in Chinese 24 Apr 87 p 1

[Article by Chen Xunqing [7115 1852 3237]: "Scientific Journalism Must be Interesting and Based on Facts"]

[Text] Qian Xuesen [6929 1331 2773], the well-known scientist, said in a recent speech that we should require S&T journalism to be interesting, easy to understand, and based on facts. It should also identify the relevance of a matter to the national economy and S&T development. He emphasized that S&T journalists must achieve the former.

Elaborating his ideas, Qian Xuesen said S&T journalism should be materialistic and based on facts. A scientific journalist should report a thing as it is, neither exaggerating nor distorting it. He absolutely must not make assumptions. Nor can he embellish it to make it more attractive.

Qian Xuesen said that S&T journalism should make interesting reading. It must have a touch of literature in it so that people are drawn to it. It should also be comprehensible so that its readers have a general idea of what it is about. In other words, a scientific journalist should approach his work as if he were penning a piece of popular science writing. S&T journalism must be written in such a way that laymen would understand and benefit from reading it. This is something scientific journalists must accomplish. If they have problems, they can seek help from popular science writers; the latter know what to do. Popularization is a big, vital job.

Qian Xuesen said S&T journalists should not merely report a thing per se. If they can put forward an opinion or two related to the matter in question and discuss its relevance to the national economy or S&T development, so much the better. This is quite an exacting demand and may not be achievable at the moment. Still, efforts should be made in this direction.

Qian Xuesen also encouraged S&T journalists to acquaint themselves with things other than major government policies and principles. They should make an effort to acquire a smattering of Marxist philosophy and a general knowledge of the present state of science and technology overall.

They should also intensify their study of the nascent discipline of science of science. He proposed that journalists make friends with S&T personnel, understand their ways of thinking, and keep up with S&T information.

Qian Xuesen delivered this speech at the "national scientific and technical journalism course." The course was suggested by him and jointly offered by the news bureau of the central Propaganda Department, the domestic department of the All-China Journalists Association, and the organization and propaganda departments of the China Association of Science and Technology.

12581
CSO: 4008/56

SCHOLARSHIP SYSTEM FOR GRADUATE STUDENTS PROPOSED

Beijing KEJI RIBAO in Chinese 12 Apr 87 p 4

[Text] Based on the suggestions of some professors and her own experience of supervising graduate students, Professor Bian Bazhong [0593 0130 0112] of the Shandong Oceanography Institute has proposed that the State Teaching Commission replace the present graduate student wage system with a scholarship system.

She said, "A large number of graduate students do not study hard. This is because once they are admitted as graduate students, they can all pass as a rule; seldom do their instructors make things difficult for them. Graduate students also fare better than college graduates in the allocation of jobs; there is no competition between them. They insist on using the best equipment in the laboratory and look down on the teaching assistants and even the instructors."

Recalling her student days at Taiwan University, Professor Bian said, "We all began by scrubbing bottles. Since there were a lot of students, I was absolutely delighted whenever the teacher let me scrub bottles. Nowadays, many graduate students do not clean up properly after an experiment, not to mention helping the teacher scrub bottles. It is the teachers who worry about their dissertation topics. They themselves take it easy."

Professor Bian also said that if the wage system is replaced by a scholarship system under which an instructor determines the amount of a student's scholarship in the coming year, depending on his academic performance, then teachers will be able to encourage and influence a student's studies objectively to ensure quality.

12581
CSO: 4008/55

DEVELOPMENT OF FLUIDIZED-BED BOILER TECHNOLOGY IN CHINA REVIEWED

Shanghai DONGLI GONGCHENG [POWER ENGINEERING] in Chinese No 1, 15 Feb 87 pp 27-32

[Article by Shanghai Generating Equipment Institute: "Development of Chinese Power Plant Fluidized-Bed Boilers"]

[Text] Abstract: This paper reviews the development situation of China's power station fluidized combustion boilers, with emphasis on introducing results obtained in some key technological problems and proposing topics for further research.

I. Development Overview

China's research on developing fluidized combustion boilers has a 20-year history, with the primary goad being to burn various kinds of low-quality fuels, such as bone coal, brown coal, oil shale, low-quality bituminous coal and low-quality anthracite coal. It opens a new path for fully utilizing energy resources when there is no way to burn "waste materials" in conventional boilers. The development process can basically be divided into three stages:

A. Modifying old furnaces and mastery of fluidized combustion technology

In The 10 years from the mid-sixties until the mid-seventies, it was primarily transformation of old furnaces to use local resources, economize on superior quality coal and promote development of local industry. Typical fluidized combustion boilers used for generating electricity in this period are the 50t/h furnace of the Ganzhe Chemical Industry Plant in Jiangmen, Guangdong, and the 19t/h and 24t/h furnaces of the Yongrong Mining Bureau's power plant in Sichuan.

The 50t/h fluidized combustion boiler of the Ganzhe Chemical Industry Plant in Jiangmen was a Polish tuidonglu paiguolu [2236 0520 3619 2226 6938 3619] refitted in 1971. This boiler operated from December 1971 to the end of 1981, an accumulated operating time of 46,691 hours. Since 1978, the accumulated operating time was 5,155-6,592 hours, with a longest continuous operating time of 120 days from May to September 1979, when it reached 2,909 hours. When the thermal value of combustion was about 3,000 kc/kg, the boiler's thermal efficiency reached 79.22 percent. The Shanghai Generating Equipment Design Institute and the Dongfang Boiler Plant carried out a series of experimental research tasks on this boiler. They obtained much beneficial experience in mastering divided bed ignition technology, immersion rod corrosion prevention technology, boiler water circulation characteristics, boiler automated control, and improving thermal efficiency.

The several fluidized combustion boilers of the Yongrong Mining Bureau's power plant use xizhongmei [3156 0022 3561] and xigan [3156 1632] and both can operate continuously for long periods. When burning 4,000kc/kg xizhongmei, boiler thermal efficiency is 78.2-80.5 percent. Such experimental research as fluidized state ignition start up, bo [2330] coal secondary ventilation experiments, buried tube heat transfer experiments, and fluidized-bed superheater characteristics have been carried out on this boiler. On the basis of this research, the Dongfang Boiler Plant designed and manufactured a 35t/h fluidized combustion boiler and installed it in the power plant.

B. Developing new boilers and applying fluidized combustion technology

The Shanghai Generating Equipment Design Institute carried out experimental research on a series of cold and hot state test devices and industrial fluidized combustion boilers and on this basis together with the Shanghai Boiler Plant designed a 35t/h and 130t/h fluidized combustion boiler for power station use. These two boilers were manufactured by the Shanghai Boiler Plant and installed in the Yiyang Oil- and Coal-fired Power Plant and the Jixi Mining Bureau's Didao Power Plant, respectively.

Yiyang's 35t/h fluidized combustion boiler began ignition tests in March 1978, in 1980 it was in normal operation, and by January 1982 its accumulated operating time was 6,190 hours, it burned 900kc/kg local bone coal, boiler thermal efficiency reached the designed value of 62.2 percent, in November and December 1980 it operated continuously for 1,126 hours. In March 1982 it passed ministry-level technical appraisal.

Jixi's two 130t/h fluidized combustion boilers went into operation in September 1979 and March 1981; by June 1984 both boilers had accumulated an operating time of 26,949 hours, had generated a total of 440 million kWh, and burned 1.6 million tons of washed coal ore. When burning low-thermal value 1,800kc/kg washed coal gangue, the boiler's thermal efficiency can reach 70.01-72.14 percent. A single continuous operation reached 1.346 hours. In October 1984 it passed ministry-level technical appraisal.

C. Promote applications and imporve fluidized combustion technology.

On the basis of summarizing existing power plant fluidized combustion boilers, the Jiangxi Boiler Plant produced two 35t/h fluidized combustion boilers and installed them in the Pingxiang Mining Bureau's Gaokeng Power Plant. They went into operation in April and October 1982, and by 1984 the accumulated single machine operating time was 27,616 hours and gross volume of electricity generated was 160 million kWh. They burned low-grade thermal value 1,560 kc/kg coal gangue, and boiler thermal efficiency reached 71.39 percent. The annual accumulated hours of operation increased from 2,168 hours in 1982 and 4,768 hours in 1983 to 6,502 hours in 1984. The one time continuous operation was 1,474 hours. In May 1983 it passed ministry-level product appraisal. At the end of 1984 this plant had burned a total of 468 million tons of coal gangue. Economic benefits increased steadily and the 1984 profit was 1.3 million yuan.

Electricity and coal are both in short supply in China and adopting low-quality fuels to generate electricity to develop industrial and agricultural production

has already become national policy. On a current basis, power plant fluidized combustion boilers still should be vigorously expanded, and relevant institutions of higher learning and scientific research units have invested more manpower and materiel to carry out developmental research, relevant boiler plants are now carrying out research and development of new model fluidized combustion boilers which are becoming serial products to satisfy needs in many areas.

II. Some Key Technological Problems Which Are Being Solved

Fluidized combustion can imporve combustion and heat transfer, adaptability to various types of coal is good and it can desulphurize and lower nitre to reduce air pollution. And it is the promotion of just these advantages that is rapidly developing. However, to use the fluidized combustion method in power station boilers introduces a series of new problems in design configuration, operations control, dust removal, abrasion protection, combustion efficiency and calculation methods. For the past few years, with the organization and coordination of the state, scientific research, design, manufacture, and user units working together, have obtained encouraging progress and there have been improvements in the performance and level of fluidized combustion boilers.

A. Characteristics of fluidized-bed layout

The fluidized bed is the key component of fluidized combustion boilers. The task of the fluidized-bed structural layout is to make the fuel burn in a stable and fluid fashion inside it. Within the bed there are suitable heated surfaces to maintain fluidized-bed temperatures so that the boiler reaches the output power demanded and operates economically and safely.

As boiler capacity increased, the bed cross-section almost increased proportionally. This is because fluidized combustion demands that the velocity of upward air flow within the bed and the thermal intensity of the bed cross-section be controlled at suitable values. Hence, large capacity power station fluisized combustion boilers frequently use separate bed layout, i.e., the entire bed surface is divided into a certain number of small-area separate beds so that the bed material flows evenly. Furthermore, the separate beds have independent air feed systems, stoking systems, and cinder elimination systems to facilitate separate bed damping when starting up separate beds and at low load.

The 35t/h and 130t/h fluidized combustion boilers both use this layout and practice proves that this is successful. The air feed system uses an isobaric air chamber and hood-type air distribution grid. The structure is simple, air distribution is even, operation is reliable, and it is widely used. New types of air guides are being researched to reduce further air feed system resistance and save on blower electricity consumption. For example, the air distribution grid designed by Hunan University has the advantages of orifice plate and hood. Air plate resistance is low, it is difficult to overheat the ring and easy to remove cinders, and it uses a modular method to facilitate serialization and simplify installation. It has been tested in a 6-10t/h fluidized combustion boiler and has passed technical appraisal. In another example the Huazhong Engineering College has researched the aerodynamic characteristics of a guide

grid attached to the back of a hood-type air distriubtion plate. Adding the guide grid can improve fluidized quality, improve the turbulence and mixing of coarse grains at the bottom, improve heat exchange and matter exchange, and is beneficial for combustion and complete combustion; it can be suitable for lowering operating air speed, reducing fly ash volume and fly ash carbon content; it does not have a big influence on air plate resistance characteristics and critical fuel level velocity. Hot state operation tests proved that it can achieve the anticipated results.

The normal pressure screw stoking method which is currently widely used is feasible and can satisfy the stoking demands of large capacity electric power plant fluidized combustion boilers. This stoking method is used in both 35t/h and 130t/h fluidized combustion boilers. The defect is that blade abrasion is severe and the partial lack of oxygen due to the concentration of stoking volume which affects combustion. Countermeasures which have been adopted are to weld abrasion-resistant material to the places on the screw blades which are easily abraded, adding a coal distribution air current at the stoking inlet and accelerating coal particle distribution and supplementing the oxygen. For the results see Figure 1: When there is no coal distribution air current the CO content exhibits a straight line drop from the coal inlet to the center of the bed, after adding a coal distribution air current the CO peak values at the stoking inlet disappear, the CO content levels decline greatly and distribution is more even. After adding a coal distribution air current, the bed temperature at the stoking inlet rose from 700-750°C to about 900°C and promoted ignition and combustion of the coal entering the furnace.

Length of Fluidized-bed
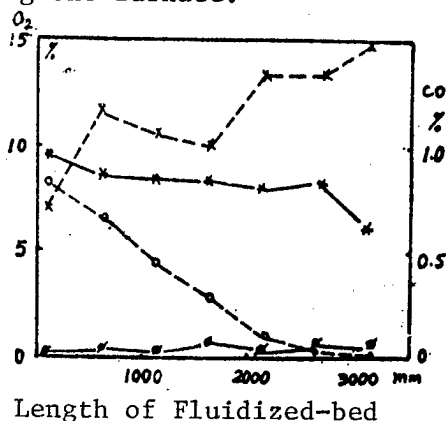
Figure 1.   Impact of addition of air distribution current on gaseous elements in the bed

...x...O_2 (without current); $-o-O_2$ (with air current)
...x...CO (without current); $-o-CO$ (with air current)

In terms of stoking methods, the Harbin Industrial University and other units, on the basis of summarizing practical experience, adopted a method of stoking by dropping coal from the coal feed tube in normal pressure of the fluidized-bed then used air currents to blow it into the bed. This both avoided the problem of complexity of the screw stoker structure and easy abrasion, and also has the advantages of the coal distribution air current. This has already been successfully operated in small-scale fluidized combustion boilers and is a stoking method with a good future.

Cinder removal systems currently mostly use such methods as continuous cinder removal through an overflow mouth, and periodic emission of large grains in the bottom of the bed by a cold cinder tube. It is then carried away by such mechanical methods as flushing with water or by truck. The Jiangmen Chemical Industry Plant and other units have used automatic control of bed material height which automatically removes cold cinders.

Air and water-cooled cinder coolers have been put into operation to use the physical heat of high temperature ash and cinders to lower the q loss. This can lower cinder temperatures from 900°C to 200-300°C. Some higher schools and scientific research units are researching new types of cinder coolers to be applied to large-capacity boilers and have obtained improved benefits.

B. Measures to improve combustion efficiency

Since power plant fluidized combustion boilers use broad screened coal grains, fine grains smaller than 1mm in the stoking and which are not burned are carried up away from the fluidized layer by the rising smoke; some larger coal grains which have not completely burned are also carried upward in the trailing vortex of gas bubbles and at the fluidized layer interface as the gas bubbles burst and spatter. In line with current crusher and sieving systems, fine coal powder smaller than 1mm in the stoking coal should make up 1/3-2/5 of the volume of stoking coal, and the carbon content is also higher and this is the primary factor in combustion efficiency. The thermal loss due to mechanical incomplete combustion in the ash and cinders by 0.2-0.5mm fly ash is most severe. Thus, how to transform the structure to improve its combustion efficiency is very important

Lower fluidized velocities and suspension stage smoke flow velocities should be used to reduce thermal loss of mechanical incomplete combustion caused by escape of fine powder. That is, expand the cross-section area of the fluidized-bed and the furnace chamber appropriately. On the basis of the demand for thermal balance within the bed and while ensuring the fluidized quality, arranging sloping buried tubes in the bed can play an obstructing role with regard to the escape of fine powder.

For burning coal which has a great deal of fine powder and high volatility content, in addition to adding a coal distribution air current at the stoker inlet, a secondary air current is added at the suspension section inlet to encourage secondary combustion. The results are as indicated in Figure 2. When a secondary air current is added the O_2 content in the flue was reduced, and without secondary air current, the CO distribution exhibited a straight line drop from the stoking side to the center of the bed, after the secondary air current was added, the overall level declined and distribution was even, and if the air current volume was larger then the peak values at 1 m could be further reduced.

To resolve the problem of large-scale scattering of wide screened coal particles in the bed, the Xi'an Thermal Engineering Institute carried out tests on a fuel-crushing--drying--air pressure sorting system at the Jiawang Power Plant which made the incoming coal go through a ventilated type reaction crusher and a houwei [0683 0143] positioned dryer tube, all the crushed material was raised

once by a pneumatic conveyer and the selection process completed. The pneumatic selection method gave the system excellent characteristics for automatic grading according to differences in grain weight. In a further hot state test, fine coal powder was transported to the bottom of the air distribution plate by wind force and the large coal grains entered from the top of the bed, thus improving the thermal efficiency of the entire fluidized-bed layout.

Length of Fluidized-bed
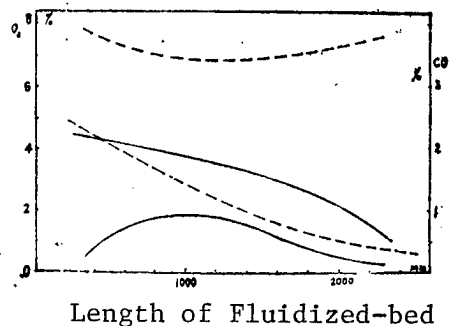
1-O_2 (no secondary current);   2-O_2 (with secondary current)
3-CO (no secondary current);   4-CO (with secondary current)
(The dashed curves in the figure read from top to bottom 1,2,3,4)

So that fly ash will completely burn, another "fly ash fluidized-bed" can be set up independently, using a lower fluidized air velocity so that fly ash smaller than 0.5mm will burn in the bed. This has been tested in some small-scale fluidized combustion boilers and can increase combustion efficiency by 10-15 percent.

C. Dust removal to satisfy emission requirements

China's fluidized combustion boilers burn a high-fly ash, low thermal value, poor quality coal; the volume of coal burned is large, so that the soot concentration is very high, reaching 60-80 g/standard m^3. When burning bone coal and coal gangue with high ash content over 70 percent, the concentration of soot at the fluidized combustion boiler flue can reach 110-170 g/standard m^3. Clearly, dust removal from fluidized combustion boiler smoke is very important.

The fly ash of boilers which burn good quality coal in conventional combustion methods generally is finer that 300 microns and the majority are 10-20 microns. But the range of fly ash grain width from fluidized combustion boilers is 0-1mm and has high combustible material content. Demands on dust removers are different for coal powder furnaces. Furthermore, it is very difficult to achieve national emission demands relying on dust removers external to the furnace for treating such a large quantity of fly ash. A large ash volume also created problems for the dust remover itself, such as abrasion and ash blockage. Thus even if we have stop gap measures and develop a variety of highly effective dust removers, there also should be permanent solutions, improving fuel crushing systems and equipment, furnace structure, stoking method and drying methods to arrange for better fluidized combustion to reduce the volume of fly ash which escapes.

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In mine areas, coal washing plants or suitable local facilities carry out fuel crushing and sifting, and provide "coal for fluidized combustion" in accordance with the demands for caloric capacity and sieving ration, the overall economic benefits should be higher than units carrying out their own crushing and sifting, now only lowering the processing expenses of the fuel itself, but also will be advantageous for improving the fluidized combustion efficiency and lowering fly ash volume.

Dust removal inside the furnace is necessary and effective not only in small-scale fluidized combustion boilers but also in medium and large-scale fluidized combustion boilers. For example:

Cold and hot state tests conducted by Harbin Industrial University on a cyclonic barrel inside the furnace of a brown coal fluidized combustion boiler prove that the separation efficiency of the cyclonic barrel was 40-48 percent, the carbon content of the separated ash was greatly reduced, being only 0.93.1-1.76 percent.

The Yiyang petroleum and coal utilization test power plant's 35t/h fluidized combustion boiler counter-current constrains the smoke and changes its direction of flow. The customary volume of ash that is separated and settles out reach 9.2t/h, making up 63 percent of the ash volume that escapes the fluidized bed, and 70 percent of the settled ash is 0.4-1.6mm coarse ash.

A superheater counter-current smokstack high-temperature ash trap and a tail section smokestack outlet low-temperature ash trap were added to the 130t/h fluidized combustion boiler of the Jixi Mining Bureau's Didao Power Plant which was clearly effective in collecting fly ash. The high temperature ash bucket ash volume reached 4.39t/h, the lower temperature ash bucket ash volume reached 9.97t/h, accounting for 14.5 percent 33.3 percent of the ash respectively.

From the above examples it is clear that using dust removal inside the furnace can eliminate approximately half of the overall fly ash volume, greatly reduce the dust concentrations emitted by small boilers and improving the working conditions of dust removers outside the furnace.

Generally in line with the characteristics of the large volume and broad screening of fluidized combustion boiler fly ash, two levels of dust removers are used: the first level eliminates particles larger than 0.2-0.5mm and the second level eliminates powder. As to which type of dust remover should be used, that must take into consideration smoke volume, dust concentrations, sieving characteristics, resistance demands, local climatic conditions, investment and operating and maintenance expenses as well as adapting to local conditions.

The 130t/h fluidized combustion boiler uses dry dust removal system made up of an advance settling chamber and multi-tube cyclonic wind sub-group second level arranged serially. Its dust removal efficiency can reach 94.2-95 percent. The ash removal volume of the settling chamber makes up about 61 percent. The grains in the settled ash larges than 0.2mm make up about 80 percent, indicating that is has a high trap ability for large particle fly ash. In future we will continue to make improvements in structure in order to obtain better dust removal results.

D. Measures to reduce abrasion

The problem of fluidized combustion boiler abrasion is a major concern and threatens safe operation. In the initial stages, there were accidents when immersion heated surface abrasion burst the tubes. Qinghua University reported that the rate of abrasion of immersion heated surfaces (lateral tubes) in the bed reached 6.0-7.92mm/yr. Jiangmen Ganzhe Chemical Industry Plant measured the rate of abrasion of the curved part of ϕ83x4 vertical tubes at 1.0-1.2mm/thousand hours. The rate of abrasion of 57x5 horizontal tube incoming air flow surfaces reached 1.31mm/thousand hours. The cross section of an abraded tube was analyzed and the abraded surface was discovered. The most severe horizontal tube abrasion was that the rate of the lowest rank of tubes was over 4 times that of the two after tubes and the circumferential abrasion was uneven, with the most severe being incoming airflow surface area at the bottom 2/5 of the tube. This is a kind of exidation abrasion under conditions of high temperature oxidation and low velocity, large solid grain washing.

For this reason, a test of welding anti-abrasion plates to the immersion tubes in a horizontal slope arrangement was carried out at the Jiangmen Ganzhe Chemical Industry Plant. A better structural arrangement was obtained and applied in 35t/h and 130t/h fluidized combustion boilers so that the period of use exceeded 8,000 horus and the anticipated results were achieved.

In addition to the above configuration, we should also begin with abrasion resistance of materials to develop better anti-abrasion results. These materials should have oxidation resistance and wash abrasion resistance at 500-600°C and should also require sulphur corrosion resistance in sulphur-bearing atmospheres. Currently, the Ministry of Metallurgy's Iron and Steel Research Institute and the Chinese Academy of Sciences' Shenyang Metals Institute are carrying out experimental research.

Attention should also be devoted to abrasion of heated surfaces. This is due to the flow of smoke containing dust concentrations as high as 100-200gr/standard m^3 (general coal dust furnaces are only 15-35gr/standard m^3) over convection heated surfaces and grains with large diameters and sharp angles increase tube abrasion, thus low smoke velocities (less than 8m/sec) should be used, anti-abrasion plates should be added to incoming airflow surfaces, and tube layout should check the smoke corridor all of which should be considered in the light of fluidized combustion characteristics and at the same time, dust removal inside the furnaces should be adopted.

One thing worth mentioning is the abrasion caused by leaks in the tube-type air preheaters. Since fluidized combustion requires that high-pressure air be introduced to overcome the resistance of the bed materials and fluidize it, the pressure differential between the air in the air preheater and the smoke is very large. If there are leaks between the tubes and the tube plates in the preheater, between the tube box and the supports or in the expansion joints, the high velocity air which escapes picks up smoke with high dust concentrations and can cause severe abrasion of the tube plate and tubes in the preheater. Therefore, in the design, manufacture and installation process, corresponding structural measures should be adopted in the light of this characteristic.

In addition, there is severe abrasion of cursher hammers, stoker blades, cinder pump impellers, and air intake vanes. Although periodic replacement can maintain production, the main tenance expenses are high. Thus, development of abrasion resistant materials suited for use in these components has become a topic for research and experimentation, and has achieved anticipated results in laboratory tests and awiats trials in long-term industrial tests.

Abrasion of furnace walls in the fluidized combustion bed protion is severe. After 3,000 hours of operation where abrasion is severe, the high alumina brick was abraded over 100mm. The unevenness of the abrasion is a function primarily of collision and scraping abrasion accompanied by corrosion. Another cause is damage caused by particles striking the furnace walls when gas bubbles burst at the interface. The degree of damage is determined by the size of the particles and their velocity. To resolve this problem, the Tangshan Branch of the Coal Sciences Institute has developed a high alumina brick with an abrasion resistant layer. After 3,000 hours of tests in an actual furnace, the ordinary high alumina brick was abraded 40-60mm, the surface was pitted and in some areas it reached 90-100mm. But the abrasion resistant layer of the test brick was abraded only 1-2mm, the surface was smooth, and there cracks only in places with abrasion reaching 3-5mm. It awaits further research to improve abrasion resistance performance.

III. Problems Worthy of Further Exploration and Research

In order to further improve the performance and level of existing power station fluidized combustion boilers and develop power station fluidized combustion boilers with larger capacities and suited to different types of coal, there are still many problems in theory and applications technology which need to be researched in depth. For example the following:

A. Exploration of methods of calculating thermal power

There is not yet any generally accepted method of calculating the thermal power of power station fluidized combustion boilers. The existing boilers use the thermal calculation standards for coal furnaces and some experimental data, but in practice it has been discovered that there are more heated surfaces and the air temperature tends to be high and the 35t/h and 130t/h furnaces cuts out for the most part the superheater tubes and the immersion tubes in the bed.

Through research on mechanisms and industrial tests the thermal transmission coefficient of the heated surfaces in the fluidized-bed, combustion portion of the fluidized-bed, pollution coefficient of convection heated surfaces, and the method of calculating fluidized beds and suspension section should be determined. And calculation programs could be written.

B. Automatic control of power station fluidized combustion boilers

Power station fluidized combustion boilers which are currently operating are at the level of manual remote control. Only individual items such as bed temperature and bed material height are automatically controlled in some surfaces. Systematic experimental research of fluidized combustion boiler operation

performance and dynamic characteristics should be carried out to obtain mathematical models of dynamic characteristics to write a control program. The boiler control systems, centralized operations monitoring system developed can realize open and closed loop automatic safety control of power station fluidized combustion boilers.

C. Experimental Research on high-speed circulating beds

Some universities have set up test sites and are carrying out research on the mechanisms. This new type of fluidized-bed has the advantages of high combustion efficiency and is easy for large scale development and has a great future. In the past few years there has been much research on this abroad.

D. Experimental research on fluidized bad desulphurizing

The proportion of high sulphur coal in the coal China mines is increasing. Fluidized combustion boilers can desulphurize in the bed to reduce SO_2 pollution of the atmosphere, can burn high sulphur coal and this is an important goal abroad in developing fluidized combustion boilers. In the past only a few units in CHina has undertaken research in this area and in the future work in this area should be intensified to satisfy the need for large capacity fluidized combustion boilers to burn high sulphur coal.

E. Complete sets of auxiliary machinery for power stations

For some special auxiliary machinery for fluidized combustion boilers, such as crushing and sieving equipment for coal supply system, cinder removal equipment, cinder coolers, and dust removers in cinder systems; and blowers and exhaust fans of the ventilation systems existing products are used indiscriminately, there is low efficiency and there are problems with high power consumption and serious abrasion. This should be made a research topic and speicalized plants designation for production.

8226/12232
CSO: 4008/40

BRIEFS

SHANGHAI 'SPARK PLAN' UPDATE--Shanghai Municipality has further established its "spark plan" and this year's projects will increase fourfold over last year. Helping towns and rural areas in the suburbs to carry out technological development is the key to this year's "spark plan." One hundred twenty medium and small projects such as high speed elevator equipment and horizontal ring-type feeder groups have already been determined; most are projects which can achieve results within a year or two. China's third large island, Zongmingdao, has also been made an intensive region for technological development in Shanghai's "spark plan." Development of large area eel culture, large area crab culture, prawn culture, and asparagus processing technology will be in continuous development on the island within the year. [Text] [Beijing KEJI RIBAO in Chinese 17 Feb 87 p 1] 8226/9604

HUNAN SOFT SCIENCES RESEARCH ASSOCIATION--The Hunan provincial soft sciences research association was set up at a gathering in the provincial hall of science and technology on 14 May. Provincial Party Committee deputy secretary Liu Zheng, well-known Hunan experts and professors such as the scientist (Hou Zhenting), and nearly 100 scientific workers engaged in soft sciences research attended the gathering. Liu Zheng made an important speech. Hunan has already achieved more than 300 results in applied research in soft sciences. The systematic development of agriculture in Taoyuan County and the formulation of plans for five prefectures, cities, and counties including Zhuzhou, Changde, and Liuyang, have made a great impact. More than 20 provinces and municipalities have sent people to Hunan to investigate the method of formulating these plans and the situation in implementing them. Results have already been produced from the implementation of the development plan for Yuanjiang County. Following the readjustment of the rural production structure there, average rural per-capita income has increased by some 160 yuan. [Text] [Changsha Hunan Provincial Service in Mandarin 0000 GMT 21 May 87] /8309

BURGEONING TECHNOLOGY MARKET--Information from the All-China Technology Market Management Symposium held in Shenyang on 24 May shows that in 1986 alone there were some 87,000 technology-related contracts concluded in China, totalling over two billion yuan. China now has more than 5,000 various technology management agencies dealing with technological commodities. In addition, there are nearly 10,000 scientific research units, as well as nearly 10,000 privately-run research units and technology development organizations. As for technology exports and opening up the international technology market, in a few short years China has succeeded in putting more than 50 major technological items on the international market, and is beginning to join the ranks of technology exporting countries. [Text] [Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 27 May 87 p 4] /8309

RADIOACTIVE WASTE DEPOTS SET UP--Our station reporter (Jin Ruji) obtained
the following information recently from the national meeting on urban
radioactive waste management: At present, six radioactive waste management
depots have been set up in Beijing, Jilin, Nei Monggol and Heilongjiang.
The management depots conduct unified disposal of urban radioactive wastes.
They play an important role in preventing environmental pollution by
radioactive waste and in protecting the people's health. With the develop-
ment of science and technology, radio isotopes and radiology have been
widely applied in industry, agriculture, and medical treatment and teaching
in China, producing about 300 metric tons of radioactive waste yearly. In
accordance with the instructions of leading comrades of the State Council
and the decision of the departments concerned, we will successively set up
urban radioactive waste management depots in 28 provinces, municipalities,
and autonomous regions during the Seventh Five-Year Plan. [Text] [Beijing
Domestic Service in Mandarin 0930 GMT 23 May 87 OW] /12858

NEW WEATHER RADAR STATIONS--Beijing, 23 May (XINHUA)--Today's economic
news briefs: Electronics Fair--China's first large electronics technology
fair opened in Shanghai today. On display are 1,800 electronic products from
360 research institutes, manufacturers and colleges throughout the country.
Shandong Exports--Coastal Shandong Province earned one billion U.S. dollars
from exports in the first quarter of this year, up 26.7 percent from the same
period in 1986. The province now trades with 140 countries, and Hong Kong
and Macao. Sino-Australian Oil Venture--The drilling of the first exploratory
oil well in a Sino-Australian joint exploration area on Hainan Island, Guang-
dong Province, is expected to begin in September. Drilling will be undertaken
jointly by the Hainan branch of the China Petroleum Development Company and
the CSR Petroleum Group of Australia. Radar Station--A new weather radar
station went into operation in Changle County, Fujian Province, today, as
part of Fujian's efforts to improve typhoon forecasts over the Taiwan Straits.
The Chinese-built radar is capable of making accurate forecasts of typhoons
within a radius of 500 km. [Text] [Beijing XINHUA in English 0710 GMT
23 May 87 OW] /9274

UNDERWATER-SIMULATION LAB IN SHANGHAI--Beijing, 25 May (XINHUA)--
China's first laboratory, which simulates being 300 meters underwater, has
been built in Shanghai, today's GUANGMING DAILY reported. China's Ministry
of Communications and the Institute of Underwater technology affiliated with
the Petroleum Industry Ministry are in charge of the experiment, in which four
"divers" enter a pressurized room and stay there for seven days. The experi-
ment, conducted in China's first laboratory of this kind just built in Shang-
hai, uses pressurized rooms and an automatic control system, which were all
manufactured in China. Researchers said, the experiment will study physio-
logy and assess underwater equipment, and is important in tapping ocean re-
sources and salvaging. [Text] [Beijing XINHUA in English 1040 GMT 25 May 87
OW] /9274

TIANJIN TO EXPORT COMPUTER TECHNICIANS--Tianjin, (CEI)--Tianjin plans to ex-
port nearly 100 computer software technicians this year. They will work in
joint ventures, Chinese companies established abroad, or on contract. The
Tianjin New Technology Development Group sent about 30 software technicians
to England, France, Federal Germany and Japan last year. [Text] [Beijing
XINHUA in English 0615 GMT 25 May 87 OW] /9274

NATIONAL COMPUTERIZED DATA SYSTEM--Beijing, 27 may (XINHUA)--In a bid to facilitate information distribution, China will set up a national computerized data system which will index information from the country's media channels. According to today's overseas edition of the PEOPLE'S DAILY the project is essential to improving the country's media structure, and is a key project during the State's Seventh 5-Year Plan period. (1986-1990)." At present, feasibility studies on the system are being discussed by related departments, and an engineering, technological group is coordinating the project. "To make the project a joint effort, the national media restructing and planning office is hoping to work with an tap into the information and data systems all sectors of the Chinese media," the paper reported. The plan calls for combining the information and data systems of XINHUA News Agency and the Ministry of Radio, Film and Television, which are now conducting reform to prepare for the project. "The information and data system of the PEOPLE'S DAILY, the country's leading newspaper, will have to be readjusted to suit the project," the paper said. [Text] [Beijing XINHUA in English 0944 GMT 27 May 87 OW] /12913

WIRING DIAGRAM TECHNIQUE DEVELOPED-- Beijing, 2 June (XINHUA)--The Institute of Semiconductors, affiliated with the Chinese Academy of Sciences, has succeeded in making the wiring diagram for large-scale integrated circuits, according to today's PEOPLE'S DAILY. Some companies of the United States, Britain, Japan and Italy have asked to cooperate with the institute. The institute has developed ties with an American company. The wiring system completed by the 41 year old associate research fellow, Zhuang Wenjun, is suitable to many kinds of technology. According to the demands of the users, the system can automatically design a large-scale integrated circuit. Compared with the man-made designs, the system raises efficiency 30 times, the paper says. [Text] [Beijing XINHUA in English 0639 GMT 2 Jun 87 OW] /12913

CSO: 4010/1029

GLIMM CONVERGENCE METHOD FOR COMBUSTION MODEL SYSTEM

[Text] Abstract: In this paper, the Glimm convergence method in the treatment of the initial value problem of a combustion model system with infinite reaction rate is demonstrated.

$$\begin{cases} \dfrac{\partial(u+qz)}{\partial t} + \dfrac{\partial f(u)}{\partial x} = 0, \\[2mm] z(x,\, t) = \begin{cases} 0, & \sup\limits_{0 < \tau < t} u(x,\, \tau) > 0, \quad t > 0, \ -\infty < x < \infty, \\[2mm] z(x,\, 0), & \sup\limits_{0 < \tau < t} u(x,\, \tau) < 0, \end{cases} \end{cases}$$

$$u(x,\, 0) = u_0(x),\ z(x,\, 0) = z_0(x),\ 0 \leqslant z_0(x) \leqslant 1,\ -\infty < x < +\infty,$$

where $f'(u) > 0,\ f''(u) \geqslant \delta > 0(u \geqslant 0)$. The constant q > 0 and when $u_0(x) > 0$, $z_0(x) = 0$.

1. Introduction

The Glimm method not only is important in the theoretical treatment of hyperbolic conservation equations [1] but also has been developed into an effective computation technique in recent years [2]. In the computation of the aerodynamic equations involving infinite reaction rates, the Glimm method is capable of showing the discontinuities through a series of Riemann solutions, which is difficult to accomplish with ordinary difference methods. The two Riemann solutions for an intense blast wave and a weak combustion wave were described in the references [2,3]. Furthermore, the Glimm method was used to calculate the transition of a flame from a combustion wave to a blast wave. However, the convergence of the Glimm method in treating combustion equations has not been established. The mathematical treatment is not even clear. In reference [4] we defined the general solution to the initial value problem of the simple combustion model

$$\begin{cases} \dfrac{\partial(u+qz)}{\partial t} + \dfrac{\partial f(u)}{\partial x} = 0, \\[2mm] \dfrac{\partial z}{\partial t} = -K\phi(u)z \end{cases} \qquad (1.1)$$

when the reaction rate $K = +\infty$ and proved the existence of the solution. In Equation (1.1), $0 \leq z \leq 1$ represents the concentration of uncombusted gas and u is a combined variable which represents density, velocity and temperature. q and K represent the binding energy and chemical reaction rate, respectively, and they are positive numbers. f and ϕ satisfy the following:

$$f''(u) > 0, \ f''(u) \geqslant \delta > 0 \ (u \geqslant 0), \ f' > 0, \ f(0) = 0, \qquad (1.2)$$

$$\phi(u) = \begin{cases} 0, & u < 0, \\ 1, & u > 0. \end{cases} \qquad (1.3)$$

The model system (1.1) reflects many important characteristics of the combustion equations such as shock wave, intense blast wave, weak blast wave, C-J blast wave and matter interface [5]. This paper will prove the Glimm convergence method in the treatment of the initial value problem of the model (1.1) when $K = +\infty$. Consequently, it serves as another proof that the generalized solution exists.

Let us integrate the second function in Equation (1.1) from 0 to t and make $K \to +\infty$. Thus, we get the model corresponding to $K = +\infty$.

$$\begin{cases} \dfrac{\partial(u+qz)}{\partial t} + \dfrac{\partial f(u)}{\partial x} = 0, \\[2mm] z(x,\ t) = \begin{cases} 0, & \sup_{0 < \tau < t} u(x,\ \tau) > 0, \\ z(x,\ 0), & \sup_{0 < \tau < t} u(x,\ \tau) < 0. \end{cases} \end{cases} \qquad (1.4)$$

We will study the initial value problem of Equation (1.4)

$$u(x,\ 0) = u_0(x), \ z(x,\ 0) = z_0(x), \ 0 \leqslant z_0 \leqslant 1 \qquad (1.5)$$

where Equation (1.5) satisfies the condition that $u_0(x) > 0$, when $z_0(x) = 0$.

The generalized solution to Equations (1.4) and (1.5) was defined in reference [4] as follows: u(x,t) and z(x,t) are bounded measurable functions defined in the range $t > 0$ where $\lim\limits_{h \to +0} \dfrac{1}{h} \int_{x-h}^{x} u(\xi,\ t)d\xi \equiv \bar{u}(x,\ t)$ exists with respect to all x,t. With respect to any smooth function $\varphi(x,\ t)$ in a bounded subset where $t \geqslant 0$, we have

$$\iint\limits_{t>0} \left\{ \frac{\partial \varphi}{\partial t}(u+qz) + \frac{\partial \varphi}{\partial x} f(u) \right\} dx\,dt + \int_{-\infty}^{\infty} \{u_0(x) + qz_0(x)\}\varphi(x,\ 0)dx = 0 \qquad (1.6)$$

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With respect to any non-negative smooth function $\varphi(x, t)$ in a bounded subset with $t \geqslant 0$, we have

$$\iint_{t>0} \frac{\partial \varphi}{\partial t} z \, dx \, dt + \int_{-\infty}^{\infty} z_0(x) \varphi(x, t) dx \geqslant 0.$$
(1.7)

Furthermore, let

$$v(x, t) = \sup_{0 < \tau < t} u^-(x, \tau),$$
(1.8)

then

$$z(x, t) = \begin{cases} 0, & v(x, t) > 0, \\ z_0(x), & v(x, t) < 0. \end{cases}$$
(1.8')

If we use $u = U(x, t; w_l, w_r)$, $z = Z(x, t; w_l, w_r)$ (or $w = (u,z)$, $W = (U,Z)$ in abbreviation) to express the solution of the Riemann initial value problem of Equation (1.4)

$$(u, z)|_{t=0} = \begin{cases} w_l \equiv (u_l, z_l), & x < 0, \\ w_r \equiv (u_r, z_r), & x > 0 \end{cases}$$
(1.9)

where u_l, u_r, z_l, z_r are constants, then (U,Z) has the following structure (see references [4,6]):

1) $u_l < u_r$,

$$U = \begin{cases} u_l, & \frac{x}{t} \leqslant f'(u_l), \\ (f')^{-1}\left(\frac{x}{t}\right), & f'(u_l) < \frac{x}{t} < f'(u_r), \\ u_r, & \frac{x}{t} \geqslant f'(u_r), \end{cases} \quad Z = \begin{cases} z_l, & x \leqslant 0, \\ z_r, & x > 0. \end{cases}$$
(1.10)

2) $0 > u_l > u_r$ or $u_l > u_r$ and $z_l = z_r = 0$,

$$W = \begin{cases} (u_l, z_l), & \frac{x}{t} \leqslant \frac{f(u_l) - f(u_r)}{u_l - u_r}, \\ (u_r, z_r), & \frac{x}{t} > \frac{f(u_l) - f(u_r)}{u_l - u_r}. \end{cases}$$
(1.11)

3) $u_l > 0 > u_r$ and $u_l > g(u_r, z_r)$, $z_r \neq 0$,

$$W = \begin{cases} (u_l, 0), & \frac{x}{t} \leqslant \frac{f(u_l) - f(u_r)}{u_l - u_r - qz_r}, \\ (u_r, z_r), & \frac{x}{t} > \frac{f(u_l) - f(u_r)}{u_l - u_r - qz_r}. \end{cases}$$
(1.12)

4) $u_l > 0 > u_r$ and $u_l \leqslant g(u_r, z_r)$, $z_r \neq 0$,

$$W = \begin{cases} (u_l, 0), & \frac{x}{t} \leqslant f'(u_l), \\ \left((f')^{-1}\left(\frac{x}{t}\right), 0\right), & f'(u_l) < \frac{x}{t} \leqslant f'(g(u_r, z_r)), \\ (u_r, z_r), & \frac{x}{t} > f'(g(u_r, z_r)), \end{cases}$$
(1.13)

where the function u* = g(u,z) satisfies

$$f'(u^*) = \frac{f(u^*) - f(u)}{u^* - u - qz}, \quad u^* \geqslant u. \tag{1.14}$$

The discontinuity in Equation (1.12) is an intense blast wave. The discontinuity in Equation (1.13) is a C-J blast wave (C-J point). Both discontinuities are combustion interruptions. The point before that is the combustion point. It is easy to derive the following lemma from Equation (1.14).

Lemma 1.1.   g(u,z) is unique and satisfies

$$\frac{\partial g}{\partial u} = \frac{f'(g) - f'(u)}{f''(g)(g - u - qz)} > 0, \quad \frac{\partial g}{\partial z} = \frac{f'(g)q}{f''(g)(g - u - qz)} > 0. \tag{1.15}$$

2. Glimm Difference Scheme

Let $\{\alpha_n\}_{n=1}^{\infty}$ be an evenly distributed sequence over $(-1,1)$; i.e. choose $\gamma \in (-1,1)$ and let $N_n(\gamma)$ represent the number of $\alpha_k (k = 1, \cdots, n)$ which meet the condition $-1 < \alpha_k < \gamma$. If

$$\lim_{n \to +\infty} \max_{\gamma} \left| \frac{N_n(\gamma)}{n} - \frac{1+\gamma}{2} \right| = 0, \tag{2.1}'$$

Then, $\{\alpha_n\}_{n=1}^{\infty}$ is a sequence evenly distributed over $(-1,1)$.

Let $s = \Delta t$, $h = \Delta x$, and $\lambda = \frac{s}{h}$ is a constant. The approximate Glimm solution $w^\lambda(x, t) \equiv (u^\lambda(x, t), z^\lambda(x, t))$ is defined as follows:

1) $w^\lambda(x, 0) = w_0^\lambda(x) \equiv (u_0(jh), z_0(jh))$, $(j-1)h < x \leqslant (j+1)h$, $j =$ odd number

(2.1)

2) $w^\lambda(x, t) = W(x - jh, t; w_0^\lambda((j-1)h, w_0^\lambda((j+1)h))$, $(j-1)h < x \leqslant (j+1)h$, $j =$ even number, $0 \leqslant t < s$,

3) $w^\lambda(x, t) = W(x - jh, t - ns; w^\lambda((j-1+\alpha_n)h, ns-0), w^\lambda((j+1+\alpha_n)h, (ns-0))$, $(j-1)h < x \leqslant (j+1)h$, $n+j =$ even, $ns \leqslant t < (n+1)s$, $n \geqslant 1$

(2.2)

The mesh step satisfies Courant's stability condition

$$\lambda = \frac{s}{h} \leqslant \frac{1}{\max\limits_{x,t} f'(g(w^\lambda))} \tag{2.3}$$

Lemma 2.1. The Glimm approximate solution $w^h(x, t)$ satisfies

$$\inf_x u_0(x) \leqslant u^h(x, t) \leqslant \max\{\sup_x u_0(x), g(0, 1)\}$$

$$0 \leqslant z^h(x, t) \leqslant 1.$$

It is easy to obtain the above inequality based on the structure of the solution.

We will define two families of approximate characteristic curves in the following.

The first family of approximate characteristic curve $x = x(t; x_0, t_0)$:

1) Assume $(n-1) < t_0 \leqslant ns$, $(j-1)h < x_0 \leqslant (j+1)h$, $n + j = $ odd, then at a non-combustion point $(t \in [(m-1)s, ms))$

$$x(t; x_0, t_0) = j_m h + \begin{cases} f'(u^h(x_0, t_0))(t - (m-1)s, & u^h_{j_m-1,m-1} \leqslant u^h_{j_m+1,m-1}, \\ \dfrac{f(u^h_{j_m+1,m-1}) - f(u^h_{j_m-1,m-1})}{u^h_{j_m+1,m-1} - u^h_{j_m-1,m-1}} (t - (m-1)s), & u^h_{j_m-1,m-1} > u^h_{j_m+1,m-1} \end{cases}$$

$$(2.5_1)$$

where $j_n = j$; when $m = n - 1, n - 2, \ldots$

$$j_m = \begin{cases} j_{m+1} - 1, & \alpha_m \leqslant f'(u^h(x_0, t_0)) \dfrac{s}{h}, \\ j_{m+1} + 1, & \alpha_m > f'(u^h(x_0, t_0)) \dfrac{s}{h}, \end{cases} \qquad (2.5)'$$

Here $u^h_{j_m,m} = u^h(j_m h, ms)$.

2) On the combustion point, i.e.

$$u^h_{j_m-1,m-1} > 0, \quad z^h_{j_m+1,m-1} \neq 0, \qquad (2.6)$$

if $u^h(x_0, t_0) > 0$, then $x(t, x_0, t_0)$ terminates there. If $u^h(x_0, t_0) \leqslant 0$, then

$$x(t; x_0, t_0)$$
$$= j_m h + \begin{cases} \dfrac{f(u^h_{j_m-1,m-1}) - f(u^h_{j_m+1,m-1})}{u^h_{j_m-1,m-1} - u^h_{j_m+1,m-1} - qz^h_{j_m+1,m-1}} (t - (m-1)s), & u^h_{j_m-1,m-1} > g^h_{j_m+1,m-1}, \\ f'(g^h_{j_m+1,m-1}, z^h_{j_m+1,m-1})(t - (m-1)s, & u^h_{j_m-1,m-1} \leqslant g^h_{j_m+1,m-1}. \end{cases}$$

$$(2.5_2)$$

The second family of characteristic curves $y(t; x_0, t_0)$:

1) Assume $(n-1)s < t_0 \leqslant ns$, then

$$y(t; x_0, t_0) = \begin{cases} x_0, & (n-1)s < t \leqslant t_0, \\ y(ms + 0; x_0, t_0) + \text{sgn}(\alpha_m)h, & (m-1)s < t \leqslant ms, \end{cases} \qquad (2.7)$$

where

$$m = n-1,\ n-2,\ \cdots,\ \operatorname{sgn}(\alpha) = \begin{cases} 1, & \alpha \geqslant 0, \\ -1, & \alpha < 0. \end{cases}$$

2) When $y(t; x_0, t_0)$ meets the combustion point, the curve ends.

The approximate characteristic curves have the following properties:

Lemma 2.2

1) u^h is a constant along the first family of characteristic curves:

$$u^h(x(t; x_0, t_0),\ t) = u^h(x_0, t_0), \tag{2.8}$$

2) Two first family characteristic curves do not intersect each other.

3) When $u^h(x_0, t_0) > 0$, $x(t\ x_0, t_0)$ either intersects the x-axis or stops at the C-J combustion point. When $x^h(x_0, t_0) \leqslant 0$, it must intersect the x-axis.

Proof:

Conclusion 1): Let us consider a non-combustion point first. If $u^h_{j-1,n-1} \leqslant u^h_{j+1,n-1}$, then the Riemann solution of $(jh, (n-1)s)$ is a sparse wave. Thus

$$u^h_{j-1,n-1} \leqslant u^h(x_0, t_0) \leqslant u^h_{j+1,n-1}. \tag{2.9}$$

Therefore, the approximate characteristic curve on $(n-1)s \leqslant t < t_0$ is also an exact characteristic curve and Equation (2.8) is valid. The following formula remains valid based on the structure of the solution.

$$u^h_{j_{n-1}-1,n-2} \leqslant u^h(x_0, t_0) \leqslant u^h_{j_{n-1}+1,n-2} \tag{2.10}$$

Hence, Equation (2.8) is verified to be true.

If $u^h_{j-1,n-1} > u^h_{j+1,n-1}$ (let us assume $x_0 < x(t_0-0; x_0, t_0)$), then the Riemann solution at $(jh, (n-1)s)$ is a shock wave. $x(t; x_0, t_0)$ is the shock wave orbit from $(jh, (n-1)s)$. Therefore, the left side of (2.8) is considered as the left limit. Then, the formula remains valid. From the structure of the characteristic curve and the solution, we can prove the following inequality:

$$u^h(x_0,\ t_0) = u^h_{j_{n-1}-1,n-2} > u^h_{j_{n-1}+1,n-2} \tag{2.11}$$

or

$$u^h_{j_{n-1}-1,n-2} \leqslant u^h(x_0, t_0) \leqslant u^h_{j_{n-1}+1,n-2}$$

Consequently, Equation (2.8) remains valid.

With respect to a combustion point, we only have to consider the case $u^h(x_0, t_0) \leqslant 0$. Let us assume that $x((m-1)s; x_0, t_0) = J_m h$ is a combustion point

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and $u^h(J_{m+1}h,\ ms) = u^h(x_0,\ t_0)$. By definition we can prove that $u^h(x(t;x_0,\ t_0),\ t) = u^h(x_0,\ t_0)$, $\forall t\in ((m-1)s,\ ms)$. Conclusion 1) can be arrived after repeated deduction.

Conclusions 2) and 3) can also be easily derived from the definition of the solution.

End of Proof.

Lemma 2.3. If $u^h(x_0,\ t_0)\geqslant -M,\ u^h(x_0,\ t_0)\leqslant 0$, then

$$x(0;\ x_0,\ t_0) = x_0 - f'(u^h(x_0,\ t_0))t_0 + s(h),$$

where $s(h)\to 0(h\to 0)$, $\varepsilon(h)$ is only related to M, λ and f.

Proof: Because $u^h(x_0,\ t_0)\leqslant 0$, the characteristic curve $x(t;x_0,\ t_0)$ intersects the x-axis. By definition of Equation (2.5)', we get

$$x(0;\ x_0,\ t_0) = jh + \left(n - 2N_n\left(f'(\bar{u})\frac{s}{h}\right)\right)h,$$

where j, n satisfies the following: $(n-1)s < t_0 \leqslant ns$, $(j-1)h < x_0 \leqslant (j+1)h$, $n+j=$ odd. Rewrite the above equation with $\bar{u} = u^h(x_0,\ t_0)$

$$x(0;\ x_0,\ t_0) = x_0 - f'(\bar{u})t_0 + (jh - x_0) - f'(\bar{u})(ns - t_0)$$
$$+ \left(\frac{f'(\bar{u})\frac{s}{h}+1}{2} - \frac{N_n\left(f'(\bar{u})\frac{s}{h}\right)}{n}\right)\frac{2}{\lambda}\cdot ns. \qquad (2.13)$$

Based on the stability conditions $\gamma = f'(\bar{u})\frac{s}{h} < 1$ and Equation (2.1), the first factor in the last term of the above equation approaches zero when n $\to +\infty$ (i.e. h $\to$ 0). The third and fourth terms on the right are small quantities of the same order of magnitude as h. The dependence of their coefficients on the parameters is also well known.

End of Proof.

The second family of characteristic curves has the following properties:

Lemma 2.4. 1) z^h is constant on the second family of approximate characteristic curves and

$$y(t;\ x_0,\ t_0) = x_0 + s(h), \qquad (2.13)'$$

where s(h) $\to$ 0 (when h $\to$ 0).

2) Two approximate characteristic curves of the second family are parallel in their mutually defined domain.

Lemma 2.5. If $u^h(x, t) \geqslant -M$, and $u^h(x_0, t_0) \leqslant 0$, at (x_0, t_0), then with any $\xi_0 < x_0$ we have

$$u^h(x_0, t_0) - u^h(\xi_0, t_0) \leqslant \frac{c}{t_0}(x_0 - \xi_0 + s(h)), \qquad (2.14)$$

where $s(h) \to 0(h \to 0)$, and $s(h)$ and c only depend on M and f.

Proof: Let us arbitrarily choose $\xi_0 < x_0$, if $u^h(\xi_0, t_0) \leqslant 0$, we get the following from Lemma 2.3.

$$x_0 - x(0; x_0, t_0) = f'(u^h(x_0, t_0))t_0 + s_1(h)$$

$$\xi_0 - x(0; \xi_0, t_0) = f'(u^h(\xi_0, t_0))t_0 + \varepsilon_2(h),$$

Let us subtract these two equations and use the relation $x(0; x_0, t_0) \geqslant x_0(0; \xi_0, t_0)$, we get

$$x_0 - \xi_0 \geqslant f'(u^h(x_0, t_0))t_0 - f'(u^h(\xi_0, t_0))t_0 + s(h)$$

$$= f''(\tilde{u})(u^h(x_0, t_0) - u^h(\xi_0, t_0))t_0 + s(h)$$

or

$$u^h(x_0, t_0) - u^h(\xi_0, t_0) \leqslant \frac{x_0 - \xi_0 + s(h)}{f''(\tilde{u})t_0}$$

Because $\tilde{u} \geqslant -M$ is a certain value in it, we can only choose a c value which is related to M and f to make (2.14) valid. If $u^h(\xi_0, t_0) > 0$, (2.14) is obviously valid.

Based on the value of $z^h(x,t)$, we define the region (x,t) in which $z^h(x,t) \neq 0$ as the non-combustion region and the region $z^h(x,t) = 0$ as the combustion region. Because the initial value $z_0^h(x)$ is a constant in each section, it is therefore possible to use $(j_k h, J_k h)$ $(k = 0, \pm 1, \pm 2, \dots)$ to represent the non-combustion region on the x-axis. Here, j_k, J_k is an even number series (either finite or infinite) which satisfies the condition $\dots < j_k < J_k < j_{k+1} < \dots$. Two boundary lines, $x_k(t)$ and $y_k(t)$, are drawn from each end point of a region $(j_k h, J_k h)$. They are defined as follows.

1) Choose $x_k(0) = j_k h$, $y_k(0) = J_k h$ on $ns \leqslant t < (n+1)s$ with $(n = 0, 1, 2, \dots)$

$$\begin{cases} x_k(t) = x_k(ns) + D_n(t - ns) \\ x_k((n+1)s) = x_k(ns) + \begin{cases} -h, & \alpha_n > D_n \frac{s}{h}, \\ h, & \alpha_n \leqslant D_n \frac{s}{h}, \end{cases} \end{cases} \qquad (2.15)$$

$$\begin{cases} y_k(t) = y_k(ns) \\ y_k((n+1)s) = y_k(ns) - \text{sgn}(\alpha_n)h, \end{cases} \qquad (2.16)$$

where

$$u_{x_k-0,n}^h \leqslant 0,$$

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$$D_n = \begin{cases} 0, \\ \dfrac{f(u^h_{x_k-0,n}) - f(u^h_{x_k+0,n})}{u^h_{x_k-0,n} - u^h_{x_k+0,n} - z^h_{x_k+0,n}}, & u^h_{x_k-0,n} \geqslant g(u^h_{x_k+0,n}, z^h_{x_k+0,n}), \\ f'(g(u^h_{x_k+0,n}, z^h_{x_k+0,n})), & 0 < u^h_{x_k-0,n} < g(u^h_{x_k+0,n}, z^h_{x_k+0,n}), \end{cases}$$

$$u^h_{x_k \pm 0,n} = u^h(x_k(ns) \pm 0, ns), \quad z^h_{x_k+0,n} = z^h(x_k(ns)+0, ns).$$

2) Once $x_k(t)$ intersects with $y_k(t)$, the two boundary curves end.

Based on the above definition, we can derive the following lemma.

Lemma 2.6. The non-combustion region on the (x,t) plane can be expressed as

$$\Omega = \bigcup_k \Omega_k = \bigcup_k \{(x, t) \mid x_k(t) < x < y_k(t)\}.$$

Deduction: A combustion point on the plane must be located on a $x_k(t)$ curve.

Lemma 2.7. If t_0 is a combustion point on $x_k(t)$, then all points greater than or equal to t_0 are all combustion points on $x_k(t)$.

Lemma 2.8. If two characteristic curves $x(t; x_0, t_0)$ and $x(t, x_1, t_0)$ of the first family both intersect with the combustion point of the same $x_k(t)$, and $x_0 < x_1$, then

$$0 < u^h(x_0, t_0) \leqslant u^h(x_1, t_0) \tag{2.17}$$

Proof. From Lemma 2.2 we know that their intersect is the C-J point and $u^h(x_0, t_0) > 0$, $u^h(x_1, t_0) > 0$. Let us assume that the two characteristic curves intersect with $x_k(t)$ at τ_0 and τ_1, respectively. It is easy to know that $\tau_0 \leqslant \tau_1$. The following is to prove Equation (2.17). 1) If $\tau_0 = \tau_1$, then both characteristic curves intersect with $x_k(t)$ at the same C-J point. Since it is in the neighborhood of $t \geqslant \tau_0$, $x(t; x_0, t_0) \leqslant x(t; x_1, t_0)$. In addition, both are the exact characteristic curves of the Riemann solution at the intersect. Therefore, $u^h(x_0, t_0) \leqslant u^h(x_1, t_0)$. 2) If $\tau_0 < \tau_1$, let $\xi_1 = x_k(\tau_1) - h$. Since the intersect is a C-J point as well as an integer mesh point, therefore,

$$u^h(\xi_1, \tau_1) = u^h(x_k(\tau_1)-0, \tau_1) \leqslant u^h(x_1, t_0). \tag{2.18}$$

Also, because $\tau_0 < \tau_1$, we have

$$x(\tau_1; x_0, t_0) < \xi_1 < x_k(\tau_1). \tag{2.18'}$$

Equation (2.18)' guarantees that the intersect τ_2 between $x_k(t)$ and the first family characteristic curve passing through (ξ_1, τ_1) is less than τ_1. If $\tau_2 > \tau_0$, then let $\xi_2 = x_k(\tau_2)-h$. Furthermore, (ξ_2, τ_2) has similar relation as (2.18) and (2.18)'. We can continue to draw an approximate characteristic curve of the first family from (ξ_2, τ_2) which intersects with $x_k(t)$ at τ_3

which is less than τ_2. After repeating the above procedure for a finite number of times, there must be a characteristic curve which passes through (ξ_p, τ_p) and intersects $x_k(t)$ at τ_0. In analogy to 1), $u^h(x_0, t_0) \leqslant u^h(\xi_p, \tau_p)$. In addition, it is possible to derive from (2.18) that $u^h(\xi_p, \tau_p) \leqslant \cdots \leqslant u^h(\xi_1, \tau_1) \leqslant u^h(x_1, t_0)$. Thus, we proved that (2.17) is true.

End of Proof.

Lemma 2.9. If $x(t; x_0, t_1)$ and the x-axis meet, $x(t; x_1, t_0)$ intersects with a combustion point of $x_k(t)$, and $x_0 < x_1$, then there is a point $\bar{x} \in [x(0; x_0, t_1), x_k(0)]$ where $0 \leqslant u_0^h(\bar{x}) \leqslant u^h(x_1, t_0)$.

Proof: The method and procedure is similar to that used to prove Lemma 2.8. The detailed proof is omitted.

In order to demonstrate the convergence of Glimm's scheme, we will first introduce several important lemmas.

Lemma 2.10. $\overset{\infty}{\underset{-\infty}{\bigvee}} u^h(\cdot, t) \leqslant \overset{\infty}{\underset{-\infty}{\bigvee}} u_0 + 2 \overset{b}{\underset{a}{\bigvee}} g(0, z_0)$, where $\overset{b}{\underset{a}{\bigvee}} F$ represents the bounded variation of $F(x)$ on $[a,b]$.

Proof: The bounded deviation of u^h in $(-\infty, \infty)$ is expressed as

$$\overset{\infty}{\underset{-\infty}{\bigvee}} u^h(\cdot, t) = \sum_i \overset{x_{k_{i+1}}(t)+h}{\underset{x_{k_i}(t)+h}{\bigvee}} u^h(\cdot, t) + \overset{x_{k_l}(t)+h}{\underset{-\infty}{\bigvee}} u^h(\cdot, t) + \overset{\infty}{\underset{x_{k_r}(t)+h}{\bigvee}} u^h(\cdot, t), \qquad (2.19)$$

where $x_{k_i}(t)(i=0, \pm1, \cdots)$ presents all combustion points at time t. They are sequentially arranged. $x_{k_l}(t)$ and $x_{k_r}(t)$ represent the far left and far right combustion points. Let us estimate the bounded deviation of $u^h(\cdot, t)$ term by term. Let us arbitrarily divide the region $[x_{k_i}(t)+h, x_{k_{i+1}}(t)+h]$ as:

$$x_{k_i}(t) + h = x_0 < x_1 < \cdots < x_{L-1} < x_{k_{i+1}}(t) < x_L = x_{k_{i+1}}(t) + h,$$

From the structure of $x_k(t)$ we know that

$$u^h(x_0, t) = u^h(x_{k_i}(t) + 0, t) \leqslant 0, \quad u^h(x_J, t) = u^h(x_{k_{i+1}}(t) + 0, t) \leqslant 0$$

Therefore, the first family characteristic curve that passes through these two points intersect the x-axis. 1) If there is no combustion point in the region $\{(\xi, \tau) \mid x_{k_i}(\tau) < \xi < x_{k_{i+1}}(\tau), 0 < \tau \leqslant t\}$, then it is easy to prove that a characteristic curve of the first family either intersects the x-axis or a combustion point on $x_{k_{i+1}}(\tau)$. Let us assume that (x_p, t) is the first point from the left to make $x(\tau; x_p, t)$ and $x_{k_i}(\tau)$ meet. Then, $x(\tau; x_{p+1}, t), \cdots, x(\tau; x_{J-1}, t)$ all intersect with the combustion point of $x_{k_{i+1}}(\tau)$. Also, according to Lemma 2.8, we have

$$u^h(x_p, t) \leqslant u^h(x_{p+1}, t) \leqslant \cdots \leqslant u^h(x_{J-1}, t), \qquad (2.20)$$

All characteristic curves from other points intersect the x-axis. Furthermore,

$$x(0; x_1, t) \leqslant x(0; x_2, t) \leqslant \cdots \leqslant x(0; x_{p-1}, t)$$

Hence,

$$
\begin{aligned}
I_k &= \sum_{j=0}^{L-1} |u^h(x_{j+1}, t) - u^h(x_j, t)| \\
&= \sum_{j=0}^{p-2} |u_0^h(x(0; x_{j+1}, t)) - u_0^h(x(0; x_j, t))| + |u_0^h(0; x_{p-1}, t) - u^h(x_p, t)| \\
&\quad + \sum_{j=p}^{L-2} |u^h(x_{j+1}, t) - u^h(x_j, t)| + |u^h(x_{L-1}, t) - u_0^h(x(0; x_L, t))|.
\end{aligned}
$$

From Equation (2.20) we know that the absolute sign in the third summation term in the above equation can be dropped. Since $u^h(x_{L-1}, t) > 0$ and $u_0^h(x(0; x_L, t)) = u^h(x_L, t) \leqslant 0$, the absolute sign in the last term can also be dropped. As for the second term, based on Lemma 2.9, there is $\bar{x} \in [x(0; x_{p-1}, t), x_{k_{i+1}}(0)]$ which makes $u^h(x_p, t) \geqslant u_0^h(\bar{x}) \geqslant 0$. Thus,

$$|u_0^h(x(0; x_{p-1}, t)) - u^h(x_p, t)| \leqslant |u_0^h(x(0; x_{p-1}, t)) - u_0^h(\bar{x})| + u^h(x_p, t) + u_0^h(\bar{x}).$$

Hence,

$$
\begin{aligned}
I_k &\leqslant \sum_{j=0}^{p-2} |u_0^h((x(0; x_{j+1}, t)) - u_0^h(x(0; x_j, t))| + |u_0^h(x(0; x_{p-1}, t)) - u_0^h(\bar{x})| \\
&\quad + |u_0^h(\bar{x}) - u_0^h(x(0; x_L, t))| + 2u^h(x_{L-1}, t). \tag{2.21}
\end{aligned}
$$

If $\bar{t}$ is used to represent the intersect between $x_{k_{i+1}}(\tau)$ and the characteristic curve of the first family from (x_{L-1}, t), then

$$
\begin{aligned}
u^h(x_{L-1}, t) &\leqslant g(u^h(x_{k_{i+1}}(\bar{t}) + 0, \bar{t}), z^h(x_{k_{i+1}}(\bar{t}) + 0, \bar{t})) \\
&\leqslant g(0, z^h(x_{k_{i+1}}(\bar{t}) + 0, \bar{t})).
\end{aligned}
$$

Then, the approximate characteristic curve of the second family can be derived from $(x_{k_{i+1}}(\bar{t}) + 0, \bar{t})$. Because it is within $\Omega_{k_{i+1}}$, it is thus possible to extend it to a point $\tilde{x} \in (x_{k_{i+1}}(0), y_{k_{i+1}}(0))$ on the x-axis. By substituting $z^h(x_{k_{i+1}}(\bar{t}) + 0, \bar{t}) = z_0^h(\tilde{x})$ into the right side of the above formula, we have

$$u^h(x_{L-1}, t) \leqslant g(0, z_0^h(\tilde{x})) - g(0, 0) \leqslant \bigvee_{x_{k_{i+1}}(0)-h}^{y_{k_{i+1}}(0)-h} g(0, z_0^h) \leqslant \bigvee_{y_{k_i}(0)-h}^{y_{k_{i+1}}(0)-h} g(0, z_0^h).$$

From Equation (2.21) and the above formula, we get

$$I_k \leqslant \bigvee_{x(0; x_{k_i}(t)+h, t)}^{x(0; x_{k_{i+1}}(t)+h, t)} u_0^h + 2 \bigvee_{y_{k_i}(0)-h}^{y_{k_{i+1}}(0)-h} g(0, z_0^h). \tag{2.22}$$

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2) If there are combustion points in the region $\{(\xi,\tau)\,|\,x_{k_i}(\tau)<\xi<x_{k_{i+1}}(\tau),\ 0<\tau\leqslant t\}$, then they must be located on certain $x_k(\tau)$ curves, where k satisfies the condition $k_i<k<k_{i+1}$. Let us divide $\{(x_j,t),\ j=0,\cdots,L\}$ into several groups so that the first family characteristic curve from each group can intersect the combustion point of one $x_k(\tau)$. An estimate similar to that of (2.22) can be obtained with I_k in each group. We still get (2.22) by adding them up. Since the right side of (2.22) is independent of the dividing point, we have

$$\bigvee_{x_{k_i}(t)+h}^{x_{k_{i+1}}(t)+h}\cdot u^h(\cdot,\ t)\leqslant \bigvee_{x(0;x_{k_i}(t)+h,t)}^{x(0;x_{k_{i+1}}(t)+h,\,)} u_0^h+2\bigvee_{y_{k_i}(0)-h}^{y_{k_{i+1}}(0)+h} g(0,\ z_0^h),$$

The conclusion of the lemma can be reached by summing over k_i.

Lemma 2.11. $\displaystyle\bigvee_{-\infty}^{\infty} z^h(\cdot,\ t)\leqslant\bigvee_{-\infty}^{\infty} z_0.$

Proof: Assume $(x_{k_i}(t),\ y_{k_i}(t)),\ i=0,\pm1,\cdots$ is the non-combustion intervals at time t. The second family characteristic curve derived from a point in the interval must intersect with the non-combustion region on the x-axis. Therefore,

$$\bigvee_{-\infty}^{\infty} z^h(\cdot,\ t)<\sum_i\bigvee_{x_{k_i}(0)-0}^{y_{k_i}(0)+0} z_0^h<\sum_k\bigvee_{x_k(0)-0}^{y_k(0)+0} z_0^h<\bigvee_{-\infty}^{\infty} z_0,$$

End of Proof.

In analogy to the treatment in reference [1], it is possible to reach the following conclusions from this lemma.

Lemma 2.12

$$\int_{-\infty}^{\infty}|u^h(x,\ t)-u^h(x,\ \tau)|\,dx\leqslant(|t-\tau|+4s)\left(\bigvee_{-\infty}^{\infty} u_0+2\bigvee_{-\infty}^{\infty} g(0,\ z_0)\right).$$

Lemma 2.13

$$\int_{-\infty}^{\infty}|z^h(x,\ t)-z^h(x,\ \tau)|\,dx\leqslant(|t-\tau|+4s)\bigvee_{-\infty}^{\infty} z_0.$$

Finally, let us introduce a lemma of partial convergence [7].

Lemma 2.14. If a non-decreasing function series $F_i(x)(i=1,\ 2,\ \cdots)$ converges to F(x) at R, then $F_i(x)$ is partially converging to F(x) at R. This means that given $\varepsilon>0$, with the exception of a few points, for every x_0 we have $\delta>0$ and I > 0 so that $|F_i(x)-F(x)|<\varepsilon$ when $|x-x_0|<\delta$ and $i\geqslant I$.

Deduction: If $\{F(x)\}$ is consistently bounded by R and the bounded deviation is also a consistent family of bounded functions, then there is a sub-series $F_i(x)(i=1,\ 2,\ \cdots)$ which is almost partially convergent everywhere at R.

Proof: Based on Helly's Selection theory [8], there is a convergent sub-series $F_i(x)(i=1,\ 2,\ \cdots)$ and it can be decomposed into the difference of

two series of non-decreasing functions. The conclusion can be obtained from Lemma 2.14.

3. Convergence Theorem

If $(x)^0 n$ and $g(0, z_0(x))$ are bounded variation functions, then there is a series $h_i \to 0 (i \to \infty)$ which makes the Glimm approximate solution $w^h(x, t)$ converge toward the generalized solution of (1.4) and (1.5) almost everywhere.

Proof: Let us first prove that $z_0(x)$ is a bounded variation function. Let $g^{-1}(\zeta)$ be the inverse function of $\zeta = g(0, z)$. Based on (1.15), we know that $(g^{-1})'$ is bounded on $\zeta \geqslant 0$. Hence, since $g(0, z_0(x))$ is a bounded variation function, $z_0(x)$ is also a bounded variation function.

Based on Lemmas 2.1 and 2.10-2.13, it is estimated that there must be a series $h_i \to 0 (i \to \infty)$ which makes $\{u^h(x, t)\}$ and $\{z^h(x, t)\}$ converge in the space $C([0, T]; L(-M, M))$ for any given $T > 0$ and $M > 0$. $u(x,t)$ and $z(x,t)$ are used to represent the corresponding limiting functions. If we change the value of the set on the zero side at a fixed time t, it is possible to make $u(x,t)$ and $z(x,t)$ functions with bounded variation which are continuous toward the left. We can prove that $u(x,t)$ and $z(x,t)$ satisfy (1.6) by using the standard Glimm program ([1,7]). Since z^h and $z^h \leqslant 0$ are non-increasing functions of t on $[ns, (n+1)s)(n=0, 1, \ldots)$, (1.7) is valid on every $[ns, (n+1)s)$. The validity of equation (1.7) can be extended to any region by using the Glimm program again.

Finally, let us prove equation (1.8)'. Let us choose a fixed $t > 0$. Based on Lemma 2.14 we know that it is possible to choose a sub-series from $\{(u^h(x, t), z^h(x, t)\}$ so that it converges to u and z' almost anywhere. Let us still denote this sub-series as $\{u^h(x, t), z^h(x,t)\}$. The set of points that fail to converge locally is N_1. If $v(x,t) > 0$, there is a $t_1 \leqslant t$ to make $u(x,t_1) > 0$. Since $\delta > 0$ due to continuity to the left, $u(\xi, t_1) > 0$ when $\xi \in (x-\delta, x)$. However, $u^h(x, t_1)$ converges to $u(x_1, t_1)$ under L_1. Let us choose a sub-series which is convergent almost anywhere. Let us assume that ξ is a converging point. When i is sufficiently large, $u^h(\xi, t_1) > 0$. Hence, $z^h(\xi, t_1) = 0$. In analogy to (2.7), let us draw the characteristic curve $\bar{y}(\tau; \xi, t_1)(t_1 \leqslant \tau \leqslant t)$ of the second family upward from (ξ, t_1). It remains zero along $\bar{y}(\tau; \xi, t_1) z^h$. In addition, $\bar{y}(t; \xi, t_1) = \xi + \varepsilon(h_i)$, therefore $z^h(\xi + \varepsilon(h_i), t) = 0$. Because $\varepsilon(h_i)$ is independent of ξ, we have

$$0 \leqslant z(x, t) \leqslant |z(x, t) - z(\xi + \varepsilon(h_i)t)| + |z(\xi + \varepsilon(h_i), t) - z^h(\xi + \varepsilon(h_i), t)|.$$

Due to the left continuity of $z(x,t)$, for a given $\varepsilon > 0$ it is possible to choose $\xi \in (x-\delta, x) \backslash N_1$ to make it sufficiently close to x and to make i sufficiently large. Thus, the first term on the right hand side of the above equation is less than ε. Based on the choice ξ is a locally converging point, therefore, as long as i is sufficiently large, the second term is also less than ε. From the arbitrariness of ε we get $z(x,t) = 0$. Thus we proved the first equation of (1.8)'.

If $v(x,t) < 0$, we will prove that there exists a condition that $\delta > 0$ and $I > 0$ under which $u^{h_i}(\xi, \tau) < 0$ when $\xi \in [x-\delta, x]$, $\tau \in [0, t]$ and $i \geqslant I$. If not, then there must be a series $\{h_{ij}\} \subset \{h_i\}$ and an array of points $(x_j, \tau_j) \rightarrow (x, \tau)$, $(j \rightarrow +\infty)$, where $x_j \geqslant x, \tau_j \leqslant t (j=1, 2, \cdots)$. For a given $\varepsilon > 0$, when j is sufficiently large,

$u^{h_{ij}}(x_j, \tau_j) \geqslant -\varepsilon$. If $\tau > 0$, then $\tau_j \geqslant \dfrac{\tau}{2}$ when j is sufficiently large. Based on

Lemma 2.4 we know that for all $\xi \leqslant x_j$ we have

$$u^{h_{ij}}(\xi, \tau_j) \geqslant -\varepsilon - \frac{2c}{\tau}(x_j - \xi + \varepsilon(h_{ij})).$$

Let us choose $\xi \in \left(x - \dfrac{\tau}{c}\varepsilon, \ x - \dfrac{\tau}{2c}\varepsilon\right)$ and also select J so that $x_j \geqslant x - \dfrac{\tau}{2c}\varepsilon$

and $|\varepsilon(h_{ij})| < \dfrac{\tau}{2c}\varepsilon$ when $j \geqslant J$. Because $u^{h_{ij}}$ is consistently convergent with

respect to t under the definition of L_1, therefore we have the following relation almost anywhere:

$$u(\xi, \tau) \geqslant -4\varepsilon, \ \xi \in \left(x - \frac{\tau}{c}\varepsilon, \ x - \frac{\tau}{2c}\varepsilon\right)$$

From the arbitrariness of ε we can choose $\varepsilon_k \rightarrow +0$, $\xi_k \rightarrow x + 0 (k \rightarrow \infty)$ to make $u(\xi_k, \tau) \geqslant -4\varepsilon_k$. Based on its left continuity, $u(x, \tau) \geqslant 0$. This is in contradiction with $v(x, t) < 0$. Therefore, the conclusion is proven. If $\tau = 0$, from $u^{h_{ij}}(x_j, \tau_j) \geqslant -\varepsilon$ we know that the approximate characteristic curve of the first family passing through (x_j, τ_j) intersects the x-axis at ξ_j. In addition, $u_0^{h_{ij}}(\xi_j) \geqslant -\varepsilon$, where $\xi_j \in [x_j - (f'(u^{h_{ij}}(x_j, \tau_j)) + \varepsilon(h_{ij}))\tau_j, x_j]$. From the left-hand continuity of $u_0(x)$ and the local convergence of $u^{h_{ij}}(x)$, $u_0(x) \geqslant -\varepsilon$. Since ε is arbitrary, $u_0(x) \geqslant 0$ is also in contradiction with $v(x, t) < 0$.

End of Proof.

Finally, let us prove that when $v(x, t) < 0$, $z(x, t) = z_0(x)$. It was proved earlier than $\delta > 0$ and $I > 0$ exist to make $u^{h_i}(\xi, \tau) \leqslant 0$ when $\xi \in (x-\delta, x)$ and $i \geqslant I$. Let us choose a ξ, and draw the second family approximate characteristic curve $y(\tau, \xi, t)$ of $w^{h_i}(x, t)$ from (ξ, t) downward, then $y(\tau; \xi, t) = \xi + \varepsilon(h_i)$. After i becomes sufficiently large, $y(\tau; \xi, t) \in (x-\delta, x)$. Therefore, $u^{h_i}(y(\tau; \xi, t), \tau) < 0$. Hence, $y(\tau; \xi, t)$ can be extended to the x-axis and $z^{h_i}(\xi, t) = z_0^{h_i}(y(0; \xi, t)) = z_0^{h_i}(\xi + \varepsilon(h_i))$. We get

$$|z(x, t) - z_0(x)| \leqslant |z(x, t) - z(\xi, t)| + |z(\xi, t) - z^{h_i}(\xi, t)|$$
$$+ |z_0^{h}(\xi + \varepsilon(h_i)) - z_0(\xi + \varepsilon(h_i))| + |z_0(\xi + \varepsilon(h_i)) - z_0(x)|.$$

Based on the left-hand continuity of $z(x, t)z_0$ and $z_0(x)$, and the local convergence of z^{hi} and z_0^{hi} we know that for a given $\varepsilon > 0$ there exists $\delta > 0$ and I_1 to make the first and fourth terms on the right-hand side of the above equation smaller than ε when $|\xi - x| \leqslant \delta$ and $i \geqslant I_1$. Choose ξ, and I_2

to make the second and third terms also smaller than ε when $i \geqslant I_2$. Thus, we proved that $z(x, t) = z_0(x)$.

End of Proof for the theorem.

REFERENCES

[1] Glimm, J., Solution in the Large for Nonlinear Hyperbolic Systems of Equations, Comm. Pure Appl. Math., 18(1965), 697-715.

[2] Chorin, A.J., Random Choice Methods With Application to Reacting Gas Flow, J. Comput. Phys., 25(1977), 253-272.

[3] Teng Zhenhuan, Chorin, A.J. and Liu Taiping, Riemann Problems for Reacting Gas, With Applications to Transition, SIAM J. Appl. Math., 42 (1982), 964-981.

[4] Ying Lungan and Teng Zhenhuan, A Hyperbolic Model of Combustion, U.S.-Japan Seminar on Nonlinear Partial Differential Equations in Applied Science, Lecture Notes in Num. Appl. Anal., 5(1982) 409-434.

[5] Majda, A., A Qualitative Model for Dynamic Combustion, SIAM J. Appl. Math., 41(1981), 70-93.

[6] Teng Zhenhuan and Ying Longan, Riemann Problems for Hyperbolic Combustion Model Equations, SHUXUE NIANKAN [CHINESE ANNALS OF MATHEMATICS], 6A:1(1985), 13-22.

[7] Liu Taiping, Approximation and Qualitative Behavior of Admissible Solution of Hyperbolic Conservation Laws, Amer. Math. Soc. Memoirs, 240(1981).

[8] Na Tangsong [6719 3282 2646], Variation Function Theory, Higher Education Publishing Co. (1955).

AVERAGE DISTANCE CONSTANTS OF SOME COMPACT CONVEX SPACES

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[Text] Abstract

This paper is inspired by the research of the so-called "average distance property" which interests many authors nowadays. Let (X,d) be a compact connected metric space. Then there is a uniquely determined constant $a(X,d)$ with the following property: For each positive integer n, and for all $x_1, \cdots, x_n \in X$, there exists $y \in X$ for which

$$\frac{1}{n} \sum_{i=1}^{n} d(x_i, y) = a(X, d)$$

In this article, an explicit expression of $a(X,d)$ is discussed for the compact convex subsets of a class of symmetric spaces including Banach spaces and Lobachevsky spaces. It is given for such a compact convex subset X which is considered as a subspace (X,d) that

$$a(X,d) = \min_{x \in X} \max_{y \in X} d(x,y)$$

This is useful to evaluate the values of $a(X,d)$ for some concrete examples.

Key words: average distance constant, straight symmetric space, normal segment.

1 Introduction

Recently a result concerning the compact connected metric spaces interests many authors, [5,6,7,9,21], that is

Theorem A Let (X,d) be a compact connected metric space. Then there is a uniquely determined constant $a(X,d)$ with the following property: For each positive integer n, and for all $x_1,\cdots,x_n \in X$, there exists $y \in X$ for which

$$\frac{1}{n}\sum_{j=1}^{n} d(x_j,y) = a(X,d) \tag{1}$$

This is the so-called "average distance property". The corresponding constant is known as "average distance constant" (a.d.c.) of the space. It is a surprising fact that though the class of compact connected metric spaces is wide, the "average distance property" owned by the class is quite strong. Stadje [6] remarks that "this property of compact connected metric spaces is nontrivial even in the simplest examples".

It is rather difficult to find an explicit expression for a.d.c. for a given space. As far as we know, there are only a small number of results for a few spaces such as the spheres in E^n. No other explicit expression for a.d.c. are known even for the planar polygons.

In this paper the authors show that

$$a(X,d) = \min_{x \in X} \max_{y \in X} d(x,y) \tag{2}$$

for some compact convex spaces including the compact convex subsets of Banach spaces and Lobachevsky spaces. In this way, for example, the a.d.c. of a planar convex N-polygon can be evaluated in a time of $O(N)$.

2. The Statement of Results

Definition 1 A metric space (M,d) is called a straight symmetric space, provided

i) An isometry $f_p: M \to M$ is defined for each $p \in M$, with $f_p(x) = x$ if and only if $x = p$;

ii) A subset $L(x,y)$ called "a straight line" is defined for $x \in M$, $y \in M$ and $x \neq y$, such that $x,y \in L(x,y) \subset M$ and $L(x,y)$ is the image of the whole real axis under an isometry;

iii) Every straight line L to wtich the point p belongs is an invariant set with respect to f_p.

Obviously, Banach spaces and Lobachevsky spaces are straight symmetric, for which f_p is a symmetry with respect to p.

Definition 2 A compact connected subset of a straight line in a straight symmetric space is called "a normal segment" and denoted by $[x,y]$ where x and y are its endpoints.

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Definition 3 A subset X of a straight symmetric space is "convex" if every normal segment $[x,y]$ with endpoints $x \in X$ and $y \in X$ is contained by X.

Busemann pointed out that the class of straight spaces contains more members than Banach spaces and hyperbolic spaces. Other interesting examples of such spaces can be found in [1]. It is, therefore, certainly worthwhile to observe them in general.

A main result of this paper is following.

Theorem 1 Let X be a compact convex subset of a straight symmetric space (M,d). Then, the a.d.c. of the subspace (X,d) is given by

$$a(X,d) = \min_{x \in X} \max_{y \in X} d(x,y)$$

Since Banach spaces are straight symmetric, it follows that

Corollary 1 Let X be a compact convex subset of a Banach space and d be the derived metric by the norm. Then the a.d.c. of the subspace (X,d) is given by

$$a(X,d) = \min_{x \in X} \max_{y \in X} d(x,y)$$

In terms of geometry, that is

Corollary 2 Let X be a compact convex subset of a Banach space and d be the derived metric by the norm. Then $a(X,d)$ equals the radius of the smallest Banach sphere enclosing X and having the centre contained by X.

It is easy to show for a compact convex subset X of Euclidean space that the centre of the smallest sphere enclosing X (namely, the spanning sphere of X) must belong to X, so we have

Corollary 3 The a.d.c. of a compact convex subset of Euclidean space is equal to the radius of the smallest sphere enclosing the subset itself.

Recently, an algorithm was given in [4], spending a time of $O(N)$ to find the spanning circle of a planar N-polygon, so we have

Corollary 4 The a.d.c. of a planar convex N-polygon can be evaluated in a time of $O(N)$.

On the other hand, by the well-known Jung's theorem:[3] "A subset of E^n with diameter D must be enclosed by a sphere with radius

$$\sqrt{\frac{n}{2(n+1)}} D, \text{ "}$$

and by Corollary 3, we obtain

Corollary 5 Let X be a compact convex subset of E^n. Then

$$a(X,d) \leqslant \sqrt{\frac{n}{2(n+1)}} D(X,d) \tag{3}$$

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where $D(X,d)$ is the diameter of X. This result can be found in [7].

Since the n-dimensional hyperbolic space H^n is straight symmetric, we have

Corollary 6 Let X be a compact convex subset of H^n and d be the metric in H^n. Then,

$$a(X,d) = \min_{x \in X} \max_{y \in X} d(x,y)$$

Corollary 7 The a.d.c. of a compact convex subset of a hyperbolic space equals the radius of the smallest sphere enclosing the subset itself.

On the other hand, since the authors have proved in [8] that "A subset of H^n with diameter D must be enclosed by a sphere with diameter

$$\frac{2}{\sqrt{-K}} \mathrm{sh}^{-1}\left(\sqrt{\frac{2n}{n+1}} \mathrm{sh} \sqrt{-K} \frac{D}{2} \right) \qquad (4)$$

where $K<0$ is the curvature of the space", it follows that

Corollary 8 Let X be a compact convex subset of H^n. Then

$$a(X,d) \leqslant \frac{1}{\sqrt{-K}} \mathrm{sh}^{-1}\left(\sqrt{\frac{2n}{n+1}} \mathrm{sh}\left(\frac{1}{2} \sqrt{-K} D(X,d) \right) \right) \qquad (5)$$

where $K<0$ is the curvature of the space and $D(X,d)$ is the diameter of X.

The proof of Theorem 1 is postponed till Section IV.

3 Lemmas

In order to prove Theorem 1, we need the following lemmas.

Lemma 1 Let $[x_1, x_2]$ be a normal segment in a straight symmetric space (M,d) and x be the mid-point of $[x_1, x_2]$. Then it holds for all $y \in M$ that

$$d(x_1, y) + d(x_2, y) \geqslant 2d(x, y) \qquad (6)$$

Proof Since (M,d) is straight symmetric, there is an isometry described in Definition 1, $f_x: M \to M$, (namely, the symmetry with respect to x,) such that

$$x_2 = f_x(x_1) \qquad (7)$$

put

$$y' = f_x(y) \qquad (8)$$

then

$$d(x,y) = d(x,y') = \frac{1}{2} d(y,y') \qquad (9)$$

and

$$d(x_2, y) = d(x_1, y') \qquad (10)$$

Thus

$$d(x_1, y) + d(x_2, y) = d(x_1, y) + d(x_1, y')$$
$$\geqslant d(y, y')$$
$$= 2d(x,y)$$

Lemma 2 Let $[x_1, x_2]$ be a normal segment in a straight symmetric space and $x \in [x_1, x_2]$ such that

$$d(x_1, x) : d(x_2 x) = m \tag{11}$$

where m is a positive integer. Then it holds for all $y \in M$ that

$$d(x_1, y) + m d(x_2, y) \geqslant (m+1) d(x, y) \tag{12}$$

Proof Make use of induction on m. The proposition holds for $m = 1$ because of Lemma 1.

We take a point $x' \in [x_1, x] \subset [x_1, x_2]$ such that

$$d(x_1, x') : d(x', x) : d(x, x_2) = (m-1) : 1 : 1 \tag{13}$$

If it holds for any $y \in X$ that

$$d(x_1, y) + (m-1) d(x, y) \geqslant m d(x', y) \tag{14}$$

by combining it with the following inequality from Lemma 1,

$$m d(x', y) + m d(x_2, y) \geqslant 2m d(x, y) \tag{15}$$

we have

$$d(x_1, y) + m d(x_2, y) \geqslant (m+1) d(x, y)$$

The induction is completed.

Lemma 3 Let X be a compact convex subset of a straight symmetric space (M, d). Given n points $x_1, \cdots, x_n \in X$. Then there exists a point $x^* \in X$ such that

$$\sum_{i=1}^{n} d(x_i, y) \geqslant n d(x^*, y) \tag{16}$$

holds for all $y \in X$.

Proof Let x^2 be the mid-point of $[x_1, x_2]$. Take $x^j \in [x^{j-1}, x_j] \subset X$ for $j = 3, 4, \cdots, n$, successively, such that

$$d(x_j, x^j) : d(x^{j-1}, x^j) = j - 1 \tag{17}$$

The convexity of X implies the existence of these normal segments and all x^j.

Make use of induction on n. The propersition holds for $n = 2$ clearly. Assume

$$\sum_{i=1}^{n-1} d(x_i, y) \geqslant (n-1) d(x^{n-1}, y) \tag{18}$$

then by combining it with the following inequality from Lemma 2,

$$d(x_n, y) + (n-1) d(x^{n-1}, y) \geqslant n d(x^*, y) \tag{19}$$

we have

$$\sum_{i=1}^{n} d(x_i, y) \geqslant n d(x^*, y)$$

The induction is completed.

4 Proof of Theorem 1

Proof of Theorem 1 Let X be a compact convex subset of a straight symmetric space (M, d). Given n points $x_1, \cdots, x_n \in X$. Take a point $x^* \in X$ satisfying

$$\max_{y \in X} d(x^*, y) = \min_{x \in X} \max_{y \in X} d(x, y) \qquad (20)$$

Then it holds for $j = 1, \cdots, n$ that

$$d(x^*, x_j) \leqslant \max_{y \in X} (x^*, y) = \min_{x \in X} \max_{y \in X} d(x, y) \qquad (21)$$

hence

$$\sum_{j=1}^{n} d(x^*, x_j) \leqslant n(\min_{x \in X} \max_{y \in X} d(x, y)) \qquad (22)$$

On the other hand, by Lemma 3, there exists a point $X^* \in X$ for which

$$\sum_{j=1}^{n} d(x_j, y) \geqslant nd(x^*, y)$$

holds for all $y \in X$. Since

$$\max_{y \in X} d(x^*, y) \geqslant \min_{x \in X} \max_{y \in X} d(x, y), \qquad (23)$$

there exists a point $y^* \in X$ satisfying

$$d(x^*, y^*) \geqslant \min_{x \in X} \max_{y \in X} d(x, y) \qquad (24)$$

hence

$$\sum_{j=1}^{n} d(x_j, y^*) \geqslant n(\min_{x \in X} \max_{y \in X} d(x, y)) \qquad (25)$$

Because (22), (25) and the connectivity of X, there exists a point $\bar{y} \in X$ such that

$$\sum_{j=1}^{n} d(x_j, \bar{y}) = n(\min_{x \in X} \max_{y \in X} d(x, y)) \qquad (26)$$

By the uniqueness of a.d.c., the proof of Theorem 1 is completed.

5. Remark

The expression (2) would hold for the compact convex subsets of more metric spaces which need not be straight if we restrict these subsets to suitable size. For example, we have a similar result on spherical spaces as follows:

Theorem 2 Let X be a compact convex subset of spherical space S^* with

curvature r^{-1} and d be the metric of S^*. Then the a.d. c. of the subspace (X,d) is given by

$$a(X,d) = \min_{x \in X} \max_{y \in X} d(x,y)$$

if
$$\max_{x,y \in X} d(x,y) \leqslant \frac{1}{2}\pi r \tag{27}$$

The proof of Theorem 2 is analogous to that of Theorem 1 since the reasoning as Lemmas 1-3 is available.

References

[1] Busemann, H., The geometry of geodesics, Academic Press, New York, 1955, 345—347.

[2] Gross, O., The rendezvous value of a metric space, *Ann. of Math. Studies*, **52** (1964), 49—53.

[3] Hadwiger, H.; et al., Combinatorial geometry in the plane, Holt, Rinehartand Winston, 1964, 46.

[4] Megiddo, N., Linear-time algorithms for linear programming in R^3 and related problems, *SIAM J. Comput.*, **12** (1983), 759-776.

[5] Morris, s. A., Nickolas, P., On the average distance property of compact connected metric spaces, *Arch. Math.*, **40** (1983), 456-463.

[6] Stadje, W., A property of compact connected spaces, *Arch. Math.*, **36** (1981), 275-280.

[7] Strantzen, J., An average distance result in Euclidean n-space, *Bull. Austral. Math. Soc.*, **26** (1982), 321-330.

[8] Yang Lu and Zhang Jingzhong, Spanning-radius of a compact set of hyperbolic space, *Scientia Sinica(A)*, **Vol. XXVI** (1983).

[9] Yost, D., Average distances in compact connected spaces, *Bull. Austral. Math. Soc.*, **26** (1982), 331-342.

BRIEFS

RESEARCH INSTITUTES' STATISTICS--Beijing, 8 Jun (XINHUA)--China had a total of 9,162 scientific research and technological development institutes by the end of 1986, with a total employment of 342,600 scientists and engineers. The latest statistics provided by the State Science and Technology Commission show that some 5,800 of the institutes are under the administration of governments above the county level, with a total employment of 336,400. Among these institutes, more than 5,270 are engaged in natural science research with a total employment of 324,800; the rest are in social science research, with a total employment of 11,700. Last year, the total expenditure of the country's institutes reached 11.148 billion yuan, according to the statistics. As part of the ongoing scientific and technological reform, many of these institutes have implemented the technical contract system to encourage the initiative of scientists and engineers. [Text] [Beijing XINHUA in English 1353 GMT 8 Jun 87] /9604

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