

Human Resource Development in Radiation Protection

THE growing application of nuclear techniques in industry, agriculture, medicine and research in the developing countries has precipitated the need to build up or improve radiation protection infrastructures. In the Asian region, this trend is expected to continue as the significant advantages of nuclear techniques become increasingly and widely recognised.

Compared to the industrialized countries, however, the use of nuclear equipment in developing countries, which inevitably subjects workers to increased chances of radiation exposure, is relatively new and not as widespread. Most countries in the region use X-ray machines mainly in the medical field (India has over 40,000), with other forms of ionizing radiation being used in applications such as radiodiagnosis, nucleonic control systems, food irradiation, and imaging.

The basic infrastructure for radiation protection requires the establishment of a competent national authority, promulgation of radiation protection legislation, establishment of personnel monitoring services, licensing and inspection procedures, and manpower development.

The IAEA advisory services in radiation protection include expert missions on various topics, such as basic standards for radiation protection. These expert missions have recognised the importance of providing each Member State with proper systems and measures

to protect workers and the public from incidents arising from radiation sources — both from within and outside the country. The IAEA, in co-operation with the International Commission on Radiological Protection (ICRP), WHO and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), revised its basic safety standards for radiation protection in 1982 which define the dose limitation system. The emphasis in promoting radiation protection currently is on providing practical guidelines for implementing the protection principles. This is an important step towards the goal of keeping exposures to ionizing radiation as low as reasonably achievable, after taking socio-economic factors into account.

Radiation protection capabilities

In 1987, an important meeting was held to discuss the framework of an RCA project entitled "Strengthening of Radiation Protection". The meeting, attended by representatives from 11 countries in the Asia and Pacific region, reviewed the status of radiation protection practices, manpower, and relevant problems in the application of nuclear techniques in each Member State. Also discussed were possible ways to strengthen the radiation protection ways to strengthen the radiation protection capabilities in each country through international co-operation within the RCA framework. Noting the gener-

ally high level of equipment availability as well as the serious deficiencies in the level of manpower training in RCA countries, a concentration on human resources development was recommended.

After some preliminary work, the project was started in 1988 to carry out several activities. They included participation in the IAEA radiation protection advisory team

(RAPAT) programme; practical training in essential techniques; workshops and study tours for the dissemination of up-to-date information at an advanced level; expert assignment for addressing specific technical problems and supporting national training programmes; provision of long-term fellowships to supplement short-term training; co-ordinated research; and evaluation of the progress of the project in terms of milestones defined in the project document. These activities are being applied to industrial applications, including research and power reactor monitoring, and medical and biological applications.

The primary emphasis in the industrial area is the holding of a series of regional workshops on environmental

dose measurements. Prior to the construction of nuclear power facilities, it is necessary to establish baseline environmental radiation dose levels for later comparison under operating conditions. These workshops, therefore, study problems associated with the measurement and comparison of dose rate measurements around nuclear facilities using ionization chambers and thermo-luminescent dosimeters. Measurements obtained by each country are compared with a field point, for example, the grounds around Japan's Atomic Energy Research Institute, in order to standardize the calibrations and measurement procedures. Interim results were to be submitted in October 1989 and a final meeting is planned for October 1990.

Developments in dosimetry

An important aspect of the project is the work being carried out in medical dosimetry. It is a prerequisite of radiation protection practice that radiation dose estimates for individuals and populations should be based on the results of monitoring and measurement of radiation exposure to, or radioactivity in, the body. The ICRP has summarized its recommended system of dose limitation through three components: the justification of radiation protection, and dose limits for individuals. Currently, dose estimation is based on the ICRP Publication 23, "Reference Man", which uses a phantom representation

of the Caucasian man. This cannot be used for dose estimation in Asia, however, since there is significant variance between the physiology of Caucasians and Asians. Variations exist in physiology even in the Asian region itself because there is a range in ethnic and climatic diversity unmatched in any other region in the world. An inhabitant of the Himalayas, for example, would have much larger lungs than a man living in an equatorial area.

This has necessitated a co-ordinated research programme (CRP) to compile physiological and societal data, such as anatomical, metabolic, and food intake statistics. This will enable the setting up of a new "Reference Man", corresponding to the specific conditions of each Member State. This involves collecting a very large amount of data over a five-year period and will encompass the physical and physiological data from the standard population in each country, statistical data on food and nutrient intake, measurements of nutrient intake, and analysis and setting of standard values for each age and sex group.

This data will not only be valuable in the case of accidents but it can also be used by scientists and health physicists in radiology and dosimetry, and for assessment of radioactive material in food and water.

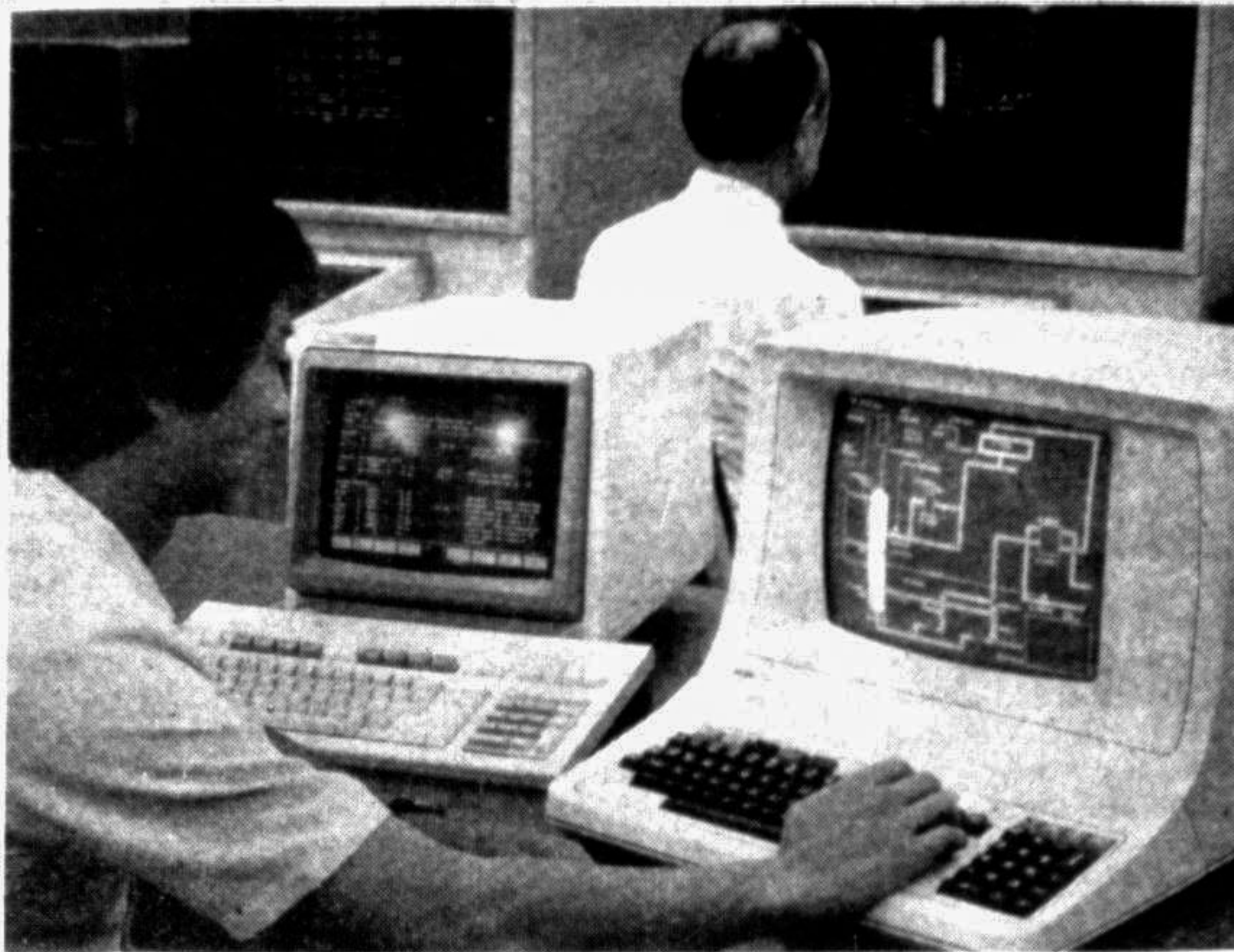
With the widespread applications of radiation, potential problems of radiological health have to be considered for

those who work in nuclear-related occupations. Radiation protection problems involve the study of various radiation qualities (mainly electromagnetic and particulate) and a wide range of cumulative dose levels, depending on the type of radiation source and the nature and duration of exposure. Improving knowledge and skills in the biological and physical dosimetry aspects of radiological health problems is one way of strengthening radiation protection in the region.

This is being pursued through training and co-ordinated research. In October 1989, a regional workshop was scheduled on environmental sampling and measurement of radioactivity for monitoring purposes. The aim is to emphasize the principles and practice of environmental surveillance, including sample collection, processing, radioactivity measurements, interpretation, and exchange of information and experience.

Other regional workshops are planned since they are effective means for the dissemination of information at a high level and encourage the free exchange of ideas from acknowledged regional experts.

Planned workshops will cover areas such as radioactivity analysis for environmental monitoring, the establishment of an educational system in radiation protection, and environmental impact assessment before construction of a nuclear facility. — RCA



Control room simulators are used in energy planning and training activities

The Gene that Makes Men

By G. S. Mudur

THE three-decade long hunt for the genetic switch that determines whether an embryo will develop into a male or a female seems to be coming to a close. Biologists have tracked down the gene that decides the sex of the embryo located in a tiny segment of the Y chromosome.

Scientists believe a switch mechanism determines the sex of an embryo and the switch can be controlled by different factors in different animals. In alligators, for example, temperature is the controlling factor. The sex of the young alligator depends on the temperature at which the eggs are incubated. In humans, as in certain other mammals, scientists believe the switch is controlled by a gene or a group of genes.

It was only in 1959 that scientist demonstrated for the first time that in humans as well in mice, it is a single chromosome, the Y chromosome, that is the male determining chromosome. Some years later, the search for the male determining gene in humans was narrowed down to the short arm of the Y-chromosome.

The sex chromosomes X and Y of most mammals are strikingly different from one another in their genetic content. While many essential genes are present on the X chromosome, the Y chromosome which is much smaller than X largely lacks identifiable

genes. In fact it appears the Y chromosome is not essential for normal development and, in its absence, an embryo will develop into a female. The formation of ovaries and subsequent development of a female embryo can be regarded as a normal or a default pathway. But the presence of Y and the male determining gene within it has a profound impact on development, the XY combination invariably leading to the development of testes and other features of the male.

Experimental studies have shown that sex determination in certain mammals can be regarded to be equivalent to the formation of the testes in an embryo. All other differences between the male and female are secondary effects that result from hormones and other factors produced by the male and female gonads.

A breakthrough in the search for this gene was achieved last year when British scientists reported the discovery of a new gene on the short arm of the Y chromosome. Reporting their findings in the journal *Nature*, they said it is the best candidate for the male sex determining gene in humans. The gene has been called SRY — for sex determining region, Y chromosome.

The researchers working at the Imperial Cancer Research Fund and the National Institute of Medical Research in London also reported finding counterparts of the gene on some

other mammals including chimpanzees, rabbits, horses, cattle and tigers. In their experiments, the team of scientists showed that the equivalent of the SRY gene in mice which they called SRY is active only in the testes. This strongly indicates that the SRY gene is the long sought after testis determining factor (TDF).

It serves as the genetic switch that activates a chain reaction of events in the developing embryo that will lead to the formation of the testes, the male reproductive system and ultimately a complete male. Writing in their paper, the scientists said "understanding the mode of action of TDF may provide a general model for genetic control of development decisions in mammals".

The researchers also showed that the gene becomes active in embryonic male mice 10.5 days after conception in a region of the embryo called the urogenital ridge. This is the region where the testes are formed 11.5 days after conception followed subsequently by the development of the male reproductive tract.

SRY is expressed in the urogenital ridge at a time consistent with its having a role in testis determination," the scientists said, reporting their findings in the same issue of the journal. The best way to test the function of SRY or SRY is to introduce it into XX or

female embryos, which if left to themselves would develop as females, and see if they turn out to be males. The scientists microinjected fertilised eggs with the sequences of the SRY gene and transferred them into recipients. Of the 11 mice transgenic for the SRY gene, three were sex-reversed males and eight were females.

Reporting their findings in a paper in *Nature* last month, the scientists said SRY is sufficient to induce testis differentiation and subsequent male development when introduced into chromosomally female mouse embryos. One question that arises is why only three changed sex and not the others.

The experiments have shown that SRY alone can promote testicular development in the absence of other Y-linked genes. But sex reversal does not always occur.

The scientists said that SRY gene initiates testis development through other genes that must be present elsewhere on the genome because SRY has been shown to be "the only Y-linked gene required to bring about male development in mice".

Mutations in these other genes could explain why there are rare cases of XX individuals lacking SRY developing as males instead of females, and XY individuals with SRY developing as females instead of males.

PTI Feature.

Chorion Villus Sampling : Safe or Unsafe ?

CHORION villus sampling, a pre-natal diagnostic test for genetic disorders which is generally considered to be quicker to perform than amniocentesis, is now raising new controversies. The British medical journal "Lancet" has cited at least three independent clinical trials that yield information on the comparative risks of chorion villus sampling and amniocentesis.

Unlike amniocentesis which is not usually done before the 15th week of pregnancy, chorion villus sampling, which tests fluids from chorion, the outermost of the membranes surrounding the embryo, may be carried out from eight completed weeks of gestation to about 13 weeks.

Thus, if pregnancy has to be terminated late in the second trimester, as is the case with amniocentesis, it means a higher risk of both physical and psychological complication to the mother.

This major disadvantage of amniocentesis is the prime consideration of many doctors who prefer recommending chorion villus sampling to detect cytogenetic disorders in the unborn.

Two of the trials reported in "Lancet" were conducted in Canada and Europe on women allocated randomly to amniocentesis or chorion villus sampling. Both trials were large

enough to ensure that the findings reflect a true comparison of the risks of the two techniques, and both involved women who had been advised CVS or amniocentesis because they were of 35 years of age or more.

The European trials showed that a woman allocated CVS had a 4-6 per cent less chance of a successful pregnancy than a woman advised second trimester amniocentesis. In the Canadian study, this difference was 1.7 per cent.

In both the trials, the differences related to all losses of pregnancy, spontaneous and induced.

"Consequently, because in both trials all losses were regarded as risks of the procedure, a woman choosing CVS during the first trimester has, a priori, a lower chance of achieving a successful pregnancy than a woman waiting until the second trimester and choosing amniocentesis," the "Lancet" report says.

A second significant finding is that infants born to women receiving CVS in the European trial spent longer time in hospital than those born after amniocentesis.

The European studies also showed that there was virtually no difference in the rate of loss of pregnancy in trans-cervical and trans-abdominal CVS.

A more disturbing feature of CVS is the several number of

reports of congenital abnormalities in infants after CVS. Earlier this year, limb defects were reported in four babies among 289 pregnancies sampled between 56 and 66 days of gestation.

Another four cases of limb defects in babies born to mothers who had undergone chorion villus sampling in the eighth or ninth week of gestation were reported later.

However, other reports on the risk of increased limb abnormalities after CVS have been inconclusive and "Lancet" concludes the "possibility of some risk of vascular disruption following CVS carried out very early in gestation cannot be dismissed, and it would be prudent not to undertake the procedure at this early stage of gestation, pending further analysis."

From the point of view of accuracy of cytogenetic results too, new doubts have been raised. The European and Canadian trials have shown that accuracy is acceptable for both techniques, but better for amniocentesis than for CVS.

Two reasons have been cited for this reduced accuracy of CVS — chromosome abnormalities are confined to placental villi and not found in the foetus per se; and secondly, there is an increased risk of maternal contamination in the CVS specimens.

A small proportion of women, about 4 per cent in the Canadian trials, required a second test to confirm the cytogenetic results, or risk or termination of normal pregnancy following an ambiguous first CVS analysis. This will lead to increased anxiety among the women concerned, and an increased burden and cost to the cytogenetic laboratory, the report in "Lancet" concludes.

In women at low-risk, therefore, CVS has been shown to be potentially less safe than amniocentesis and more prone to error. It is unlikely that a woman choosing to undergo CVS will have as high a chance of achieving successful pregnancy as one undergoing amniocentesis, or that the cytogenetic result will be as accurate, the journal says.

— PTI Feature.

Distress Radio Call System

Dornier GmbH in Friedrichshafen, a subsidiary of Deutsche Aerospace, has developed a system for receiving marine distress signals within minutes via the satellite-aided Distress Radio Call System (DRSC). Now that the test phase has been completed, the system commissioned by the Bundesministerium für Forschung und Technologie (Federal Ministry for Research and Technology) and funded by the Bundesverkehrsministerium (Federal Ministry of Transport), is to be put into service in the ground radio station in Raisting.

New Tilt Coupling Device

An investigation into ways of maintaining things like cameras, theodolites, telescopes and satellite dishes at the right angle has led to a new tilt-coupling device that scientists believe could be scaled up to stabilise large vehicles such as fire engines, mechanical diggers and earth moving vehicles, reports London Press Service.

The device which has won a 5000 pound UK national technology competition and been named the Invention of the Year is the result of inventor Michael Summerfield's research into ways of adjusting the angle of a work surface and levelling objects on uneven ground or in other situations.

The device embodies two identical flat rings in a mirror image configuration, coupled together by a hollow universal joint, with a pair of circumferentially-toothed wedge-shaped cams and a slip ring between them, enabling the rings to be tilted to an angle of 20 degree relative to each other in all directions, while they are retained in rotationally the same position. An operating shaft with a pinion engaging both sets of cam teeth extends through the slip ring.

When the base ring is secured to a mounting, the operating shaft is rotated radially to a point opposite the desired direction of the tilt. The shaft is then rotated axially, which turns the cams in opposite directions. This tilts the top ring relative to the lower one until a desired angle of up to 40 degree of arc is set.

Water-based Paint for Automobiles

A Japanese company, Nippon Paint Co Ltd, has succeeded for the first time in the world in using a water-based paint for automobiles, reports the journal *TechnoJapan*.

This follows the development of new hardening system and viscosity control by ultra-fine grains, to prevent atmospheric contamination by conventional organic solvents.

Nippon Paint has started negotiations with Japanese car makers to apply the new technology to their coating lines, the journal reported.

Automobile coating includes a prime coat, middle coat and two types of final coat (base coat and top coat). The use of water-based paint for the middle and top coats has not yet been developed worldwide. Water-based paint generally undergoes degradation in coating quality in high humidity, while the new development provides good quality at a humidity of 85 per cent. For the top coat, microgel and a new hardening material are used to form a beautiful, hard surface which can withstand acid rain and pollution. With the base coat, metallic tone coating superior in appearance to that done by the organic solvent method has been developed.

Hot Days for Refrigerators

by K. S. Jayaraman

THE principle that foods can be preserved by lowering their temperature had been put into practice in old days by storing food in deep caves along with blocks of ice and snow.

The modern equivalent of this is the domestic refrigerator. It has been in use of decades but the refrigerator industry is now in for a shakeup.

Refrigerators and air conditioners are among the household items under attack by environmental scientists because they use chemicals that destroy the protective ozone layer enveloping the earth. Manufacturers worldwide are now compelled to replace these harmful chemicals with ozone friendly substitutes and redesign the refrigerators.

The refrigerator is an apparatus in the form of a rigid thermally insulated cabinet/door assembly within which is an evaporator for extracting heat from the cabinet at a low temperature. Coupled to the evaporator, through the insulation, is a condensing unit whose function is to discard the heat from the evaporator into the surroundings at a higher temperature.

A working fluid — the refrigerant — is used as the medium to transfer the heat. Because the heat has to flow from the cold interior to hot

exterior, a compressor is used to pump the cold, low pressure gaseous refrigerant from the evaporator into the condenser at high pressure and high temperature.

Without exception the refrigerant used in today's refrigerators is dichlorodifluoromethane also known as CFC 12. This is one of the chlorofluoro compounds (CFC) identified as causing depletion of ozone in earth's atmosphere.

The refrigerators also use a rigid polyurethane (PU) foam for efficient thermal insulation. This foam is blown with a gaseous compound called trichlorofluoro-methane also known as CFC11. This compound has been chosen by refrigerator manufacturers because of its chemical inertness, stability, non-flammability and non-toxicity. Unfortunately CFC11 is also one of the gases that destroy ozone.

The Montreal protocol revised in June 1990 is an international agreement that seeks to reduce the use of CFCs in stages and finally eliminate them by the year 2000. This will have a major impact on the domestic refrigerator industry since the two vital products — CFC11 and CFC 12 — will quickly be in short supply and will not be available at all after 2000 A. D.

Current annual production of all CFCs is about one million tonnes. The total CFC con-

sumption in India — mainly by the refrigeration industry — is 7000 tonnes although installed capacity is over 15000 tonnes. All the CFCs used in refrigerators and freezers will eventually be released into the atmosphere unless means for their destruction or recovery of the CFCs at the end of refrigerators' life are developed. The requirement is therefore to find and develop alternative methods or materials that have minimal harmful effect on ozone without increase in energy consumption.

Absorption cycles that use ammonia and other compounds as refrigerant have been studied but give up because of the low efficiency. Attempts were also made to develop refrigerators where the air inside the refrigerator will be directly cooled in some sort of expansion/compression system. But no practical system could be developed due to mechanical inefficiencies. Thermo-electric cooling, at one time, appeared very attractive. The technique uses "peltier" effect whereby the passing of an electric current through junctions of dissimilar materials causes one side to become cold and the other side hot. While small portable refrigerated cabinets were made using this principle, nobody could use it for building refrigerators or freezers. All this led to the conclusion that

'Smart' Polymer Reacts to Light

Over the past decade, a number of research teams around the world have been searching for "intelligent polymers", materials that can change their shapes and other characteristics in response to a variety of external stimuli. This work, which has been particularly intense in Italy, Japan and the United States, could lead to some important applications, including switches, memory devices and drug delivery systems.

Now, two scientists at the Massachusetts Institute of Technology (MIT) — Toyochi Tanaka, a professor of physics, and Atsushi Suzuki, a visiting researcher from Yokohama National University in Japan — have synthesized a polymer gel that responds to visible light. When illuminated by a laser beam, this material quickly shrinks to a fraction of its original size; when the laser is turned off, the gel returns to its original state.

This development may eventually lead to the creation of a number of new medical devices. Such a substance could, for example, be used to construct artificial muscles. Light, which can be transmitted through hair-thin optical fibers, is safer and less obtrusive than electric current. It can also be controlled easily by computer microchips. Thus MIT is planning to patent the new material, and a company is being formed to explore its commercial value.

Mr. Tanaka began studying the properties of gels in the

1970s, when he came to MIT as a postdoctoral fellow. Although anyone who has sat before a bowl of seemingly inert Jell-O dessert might find little to get excited about, in a chemical sense gel-like substances are actually quite dynamic. All of them, from the natural gelatin derived from animal proteins to sophisticated synthetic materials, are composed of long-chained polymers meshed together in a three-dimensional network.

Under normal conditions, this network is swollen in water, which explains the soft, bouncy texture that is typical of most gels.

The swelling results from the mutual repulsion of electrically charged atoms, called ions, which are found throughout the polymer molecules. The chains try to keep their distance from each other, and thus the entire gel expands. How much it expands depends upon the degree of ionization, that is, the number of ions in the gel; this, in turn, is controlled by the temperature, acidity and solvent composition, among other factors.

In earlier work, Mr. Tanaka found that if he gradually replaced some of the water with the industrial solvent acetone, he could decrease the extent of ionization to the point that the repulsive charges were almost completely overcome.

"There is a competition of two forces," said Mr. Tanaka.