

# The Origin and Evolution of Honey Bees

by Jagadish Chandra Saha

**E** VOLUTION is the major unifying and the most fundamental concept of biology. The insects comprise the largest group in the animal kingdom. Yet the insects have had a long history over geological time: only about 12,000 fossil insect species are known to day. The earliest specimens date from the Devonian period. In spite of this small number of insect fossils, the preservation of fossil bees has often been excellent. The honey bee genus *Apis* is first recognised in geological deposits of Oligocene age.

Available evidences from fossil records and other sources have been summarized here for the probable origin and evolution in geological time of honey bees.

## Origin of the Bees

The primitive *Hymenoptera* resembled modern sawflies (*Suborder Symphyta*) in plant feeding habits, caterpillar like larvae, wing venation and the saw like or piercing ovipositor for placing eggs in the plant tissues. From such insects must have arisen the main parasitic groups of *Hymenoptera*, such as the *Ichneumonidae*, *Chalcididae* and *Proctotrupidae*, from an already parasitic ancestor of which came the wasps (*Vespoidea*, *Sphecoidea*), and then the bees.

Although the stinging or aculeate *Hymenoptera* (wasps, ants and bees) show no signs of having arisen from any existing parasitic groups, they must have come from ancestors having the general characteristics of the parasites. The aculeate *Hymenoptera* have the same major body divisions as the parasites and are for this and other reasons placed in the same suborder.

Larval feeding and the delay of the midgut-hindgut connection until larval maturity are both important evidences of the origin of aculeate *Hymenoptera* from parasitic ancestors.

All bees have been placed by systematists in the super family *Apodea* on the basis of diet (plant origin) and hairy structures. They are thought to have

descended from the burrowing wasps (*Sphecoidea*, *Comstock*). But no existing *Sphecoidea* wasps can be positively identified as the ancestral group. Miller (1872), in his wellknown paper puts: The application of Darwin's theory to the Bees proved that the bees descended from the burrowing wasps.

The main evidences are thin body, mouth parts, feeding instincts of adults of lower bees with some of the wasps. The earliest bees may have arisen in the ancient continent of Gondwana where the angiosperms or flowering plants have originated. Bees may have split off from the ancestral *Sphecoidea* stock by the middle Cretaceous when angiosperms became the dominant vegetation.

Biogeographical evidence indicates that *Colletidae* and *Halictidae* (short-tongued bee families) are dating possibly from the Cretaceous in close association with the shallow flowered angiosperms common at that time. But the apparent antiquity of the *Colletidae* and *Halictidae*, however, is not supported by any hard evidence from the fossil record. No fossil *Colletidae* have yet been found. Few *Halictidae* fossils are dating from the Oligocene epoch of the Tertiary.

The first records of the fossil bees (*Andrenidae*, *Melittidae*, *Megachilidae*, *Anthophoridae* and *Apidae*) are from the Baltic amber of the upper Eocene epoch, perhaps 40 million years old.

Social behaviour among the bee probably arose early in the Tertiary. Recent discoveries have established the early development of eusociality in the bees (*Halictidae*, *Anthophoridae* and *Apidae*).

## Ancestral Lineage of the Honey Bee

Most of the known fossil *Apidae* have been referred to the tribe *Apini*. Manning (1952) and Zeuner (1952) and Manning (1976) have placed all primitive *Apini* in the extinct Eocene genus *Electrapis* having long hair found in the Baltic amber about 40 million years ago. *Electrapis* is considered to be in the line directly

ancestral to *Apis* with *E. meliponoides* (Buttel-reepen), in particular, ancestral to both the *Meliponinae* and more recent apines.

Despite its apparent affinities with other apines, however, the phyletic position of *Electrapis* has been challenged by some authorities on bee taxonomy. Kelner Pillault (1974) concluded that *Electrapis* exhibited too many of the characters of primitive apids to be regarded as the direct ancestor of *Apis*. Maa (1953) assured that the genus was not properly referable to the *Apini* and even to the subfamily *Apinae*.

However, the main characteristics of modern honey bees are believed to have evolved by Upper Oligocene times, followed by a period of relative evolutionary stability in structure from the Miocene to the present. Fossil *Apis* all appear closely related to each other and to modern species.

## The Rise of Apis

In the Oligocene epoch, true honey bees (*Apis*) probably originated in the old world with fully eusocial behaviour before the end of the epoch. Oriental region, particularly the Indian sub-continent have been taken to constitute the probable centre of origin and early evolution of *Apis*, since the natural geographic distribution of the genus shows its greatest diversity in India and adjacent areas.

Before the great age of European exploration and colonization, *Apis* was not found anywhere in the Western Hemisphere, Australia, or the Pacific except on continental islands, such as Japan, Formosa, the Philippines and Indonesia.

Armbruster (1938) described some Miocene material from Germany. Maa stated that the two extinct genera *Synapis* (comprising Oligocene specimens) and *Hauffapis* (containing the Miocene fossils) bear a close physical resemblance to the modern giant honey bee *A. DORSATA* with *SYNAPIS* more primitive than *HAUFFAPIS*. Zeuner and Manning (1976) consigned *SYNAPIS* to subgeneric rank

and placed *HAUFFAPIS* into Synonymy with the subgenus *APIS*.

Wilson (1971) stated that *A. mellifera* have originated in the African tropics or subtropics at the end of Tertiary, later migrating to colder climates. The modern form has been found in East African copal (a fossil resin similar to amber) of pleistocene age.

Cockerell (1909) mentioned specimens in amber reportedly discovered in England, but expressed doubts as the fossils might have come from Africa.

Zeuner (1951) suggested that, *polyplody* is responsible for the origin of the genus *Apis*. Speciation by *polyplody* is rare in animals, other than those exhibiting *parthenogenesis* or *hermaphroditism*. At least 65% of known species of bees are believed to be either *polyplod* or of *polyplod* origin. A *FLOREA* shows the greatest number of ancestral characters have a diploid chromosome number of 16.

This suggests a *polyplod* constitution for *A. mellifera* and *A. cerana* both of which possess a diploid complement of 32, a doubling of chromosome number presumably being the primary event in causing these two species to diverge from *A.*

*FLOREA* of from an ancestor common to the three. Michener (1974) has postulated that an ancestral *Apis* species probably gave rise to two main phyletic lines: one leading to *A. FLOREA*, the other to the remaining three living species of the genus. The latter line supposedly divided again, one branch giving rise to an ancestor of *dorsata* and the other to a common ancestor of *cerana* and *mellifera*.

Moreover, due to similarities in their cytology, morphology and behaviour, a merger has been suggested between the two (*cerana* and *mellifera*) in to a single species.

On the other hand Fahrnhorst (1977), conclusively demonstrated a diploid chromosome number of 32 in

*A. FLOREA* and discarded the hypothesis of a *polyplod* origin for *A. mellifera* in particular. But the role of *polyplody* in the origin of the honey bee genus remains plausible.

The honey bee genus *Apis* exhibits a history to respectable extent, being first recognised in Oligocene age. There were a number of con-

traversial point and argument regarding the exact time of origin and evolution of honey bee. Yet, by its incomplete nature, it cannot establish with any degree of certainty an exact time of origin: The fossil record does, nonetheless, allow a reasonable estimate of the antiquity of the genus *Apis*, revealing a history of this group spanning perhaps as many as 35 million years.

Chromosomal changes and selective pressures accompanying the development of eusociality may have played an important role in the origin and evolution of the genus.

*A. dorsata* and *A. florea* are considered more primitive and restricted to tropical regions of Asia. On the otherhand *A. CERANA* and *A. MELLIFERA* are not very primitive in origin, and are phylogenetically very close. The former is restricted to tropical regions of Asia as well and the latter ranges well into temperate zones.

Nevertheless, it is noteworthy to mention that, by all indications, *A. mellifera* has appeared relatively recently on the apine evolutionary scene, its apparent point of origin predating that of another social animal, *Homo*, by only a slight interval.

Honey bees and man perhaps arose within a short time of each other on their respective phylogenetic trees and within the same geographic region. So their obvious close relationship may prove to be a significant factor in the future evolution of this honey bee species.

(The writer is a specialist at the Beekeeping Project of Bangladesh Small and Cottage Industries Corporation)

# Invention, Thy Name is Japan

by Philip Short

**A** canned drink called Calpis Water that sold 20 million cases of 24 cans, and a futuristic train linking metropolitan Tokyo with Narita airport in "about 53 minutes," were among the winners at the February Nikkei Awards for Creative Excellence in Products and Service in 1991.

Missing from the event, sponsored by Japan's leading economic media organisation, were a plethora of products and services introduced last year that ranged from the creative to the exorbitant to the downright zany.

Consider underwear. Wacky designers at Wacoal, the country's top lingerie maker, developed a computer system which analyses customer's curves, and then tells them which style and size of underwear

**Japan's ever-inventive electronics industry is the envy of many. It has developed a computer system which analyses customer's shape and then tells them which style and size of underwear suits them best. Sanyo has introduced a portable press that clips into trousers and creates them in five seconds, while another company, reports Gemini News Service, has invented a talking pillow intended to bring relief to insomniacs.**

Roughly 30-40 shops sprouted in Tokyo alone selling used American jeans to teenagers and twenty-somethings. The best selling jeans were from the States, retailing at around 100,000 yen. One pair of unworn jeans from the early Fifties had a price tag of 700,000 yen.

Japan's ever-inventive electronics industry came up with more goodies last year for the nation's hard-to-please consumers. Sanyo Electric Co. introduced a hand-held portable press that clips into your trousers and creates them in five seconds, whereas Victor Sound Equipment Co's talking pillow was intended to bring relief to thousands of insomniacs.

A hidden speaker in the pillow plays the sound of breaking waves, dripping water, a moving train or a chorus of frogs (not all at the same time).

"Fragrant" watches made their debut, with wearers being able to insert their favourite perfume into a special compartment in their watch, then sniff it for several hours.

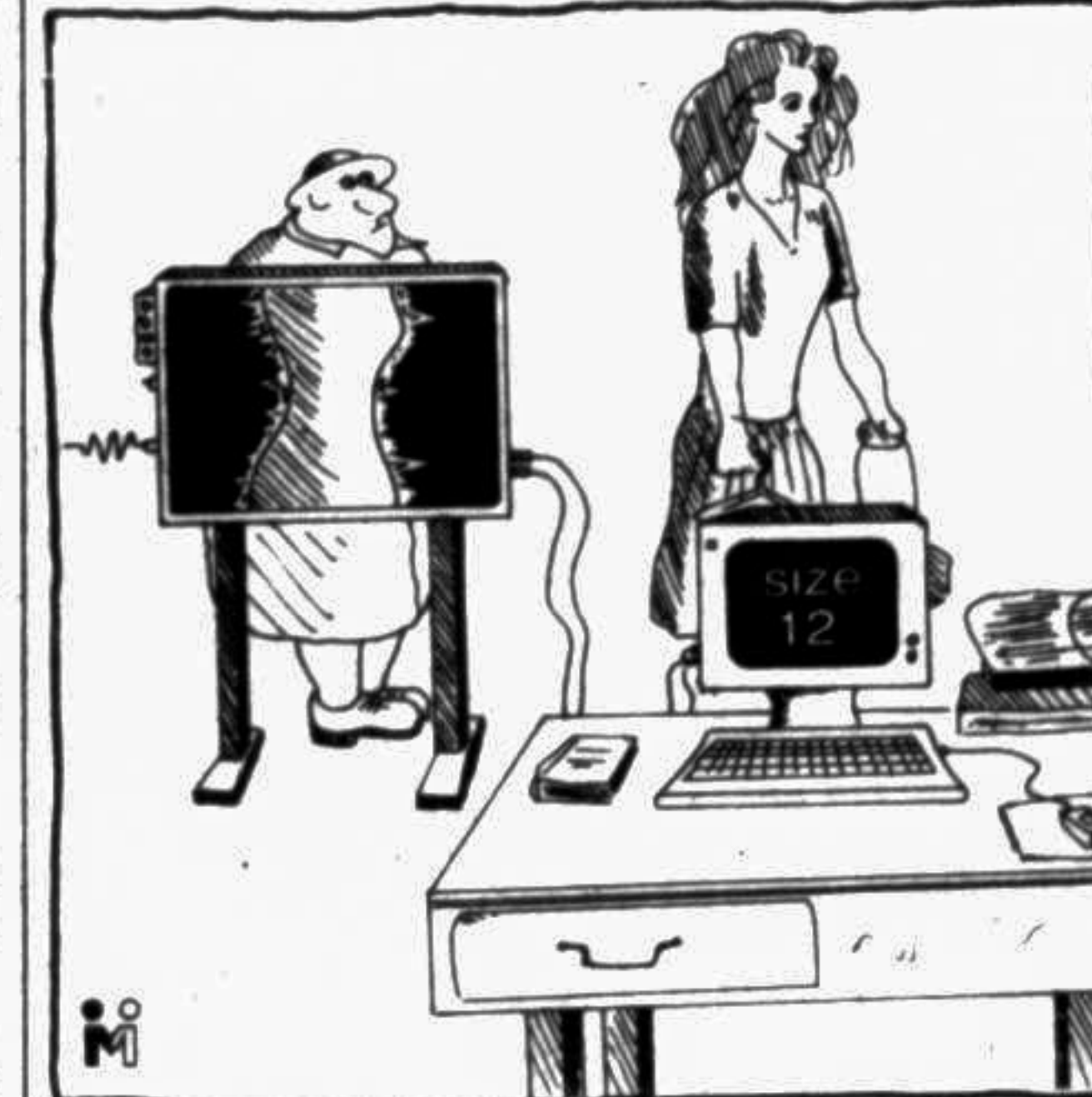
Mitsubishi Electric introduced its "disobedient" carpet, a heated rug that is programmed to lower the temperature set by the user by 0.5 degrees.

The firm says this results in a 15 per cent energy saving. Gardeners who thought they had everything, discovered they didn't. A design company invented an instant miniature garden, complete with 1.8cm-thick fibre-reinforced plastic stones, a snip at the price of 495,000 yen.

Competition in space-starved Japan was particularly fierce last year in the funeral business. Ingenuity and creative new products were the key for those firms hoping to make to make a good profit. Morticians jazzed up funerals with laser light shows, motorised coffins and big screen videos of the dear departed.

Funeral directors point out that smaller families, crowded housing and reduced felling of community have made funerals less fun than in the past.

— GEMINI NEWS



The system has already been installed at a dozen big department stores across the country, and, says a Wacoal spokesman, sales have risen ten per cent. According to the innovative firm, "The time has come to use high technology to choose undergarments."

Choosing the right clothes was expensive business for Japan's dedicated followers of fashion. The Award for Inventive Marketing — or perhaps Hoodwinking the Youthful and Spendthrift — should surely have gone to the creator of the "retro" craze for Americana of the Fifties and Sixties, in particular second-hand denim jeans.

# Irrigating Farms with Less Water

by Li Xinrui

**F**OR thousands of years China's farmers have irrigated their fields by regulated flooding — letting water stored in ponds or ditches flow over waiting cropland.

But the pressures of a huge population, severely limited water resources and the development of new technologies for water conservation have led the Chinese to introduce water-saving techniques that save 4.4 billion cubic metres of water a year. By the year 2000, officials hope, the savings will rise to 10 billion cubic metres of water.

Water conservation is crucial to China's development. Although China has water resources of 2.8 trillion cubic metres, only 17 per cent of the water has been tapped because of inadequate storage and supply facilities.

Many parts of the vast country, without underground water reserves of access to rivers, results, starvation often follows.

"Water will be the number one problem hindering the development of agriculture in China in the next decade," said State Council member Chan Junsheng. "Therefore we must take every possible measure to economise on water in land irrigation. This is not an expedient, but a protracted task."

Of China's tapped water resources, 450 billion cubic metres, or 95 per cent, are used to irrigate 40 million hectares of crops. The remaining 5 per cent is designated for industrial production and domestic use. Thus, the annual amount of water available for a hectare of land is 11,250 cubic metres, only half the world's average of available water per hectare.

Water-saving technique, introduced in the 1970s and 1980s, now irrigate more than 3 million hectares of cropland, or 3 per cent of the country's total. The most common are irrigation by pipe, sprinkler and drip.

The pipe method, which uses water from wells, has been effective in about million hectares of land on the outskirts of Beijing and Tianjin and in 16 provinces, including Hebei and Shanxi in the north, Shandong in the east and Henan in central China.

ing water for some 6,600 hectares of wheat, m corn and cotton — or one-fifth of the country's total cropland.

Between 1987, when the technique was introduced, and 1991, Xionglan has saved 7.75 million cu metres of irri-

## Water will be the number one problem hindering the development of agriculture in the next decade

gation water and 1.4 million kwh of power, reduced the acreage of land occupied by irrigation ditches by 330 hectares, and increased grain output by 6,250 tons, according to Zhou Shunsheng, an official of the country's Water Conservancy Bureau.

Sprinkler irrigation, which draws on underground water, was introduced in the mid-1970s and is used mainly in

Hebei province, prefer small, portable sprinkling units that use only half the water needed for flood irrigation. Crop output is 20 to 40 per cent higher.

Meanwhile, farmers in Beijing and other developed areas favour large, stationary sprinklers that can be used for many years.

In Shunyi county in the suburbs of Beijing, for example, 1,400 such sprinklers irrigate 23,000 hectares of cropland. Large sprinklers are also used in some dry, hilly areas in south China to irrigate orchards and tea plantations.

Drip irrigation, a complicated technique introduced from Mexico in 1974, is currently used on only about 16,000 hectares of land. But, officials say, thanks to a series of innovations by Chinese engineers, drip irrigation has become the most cost-effective

crop roots.

Officials and farmers say the technique uses 40 per cent less water than flood irrigation and produces high crop yields. Through drip irrigation, farmers can tap streams, wells and ponds unusable by other irrigation methods.

Use of the water-saving techniques will no doubt increase. They have been listed by the Ministry of Water Conservancy as among the eight major agrotechniques to be popularised in China starting in 1990.

According to a ministry plan, the acreage under pipe, sprinkler and drip irrigation in the country will be expanded by 4 million hectares in the next 10 years, with special attention being given to the suburbs of three major cities: Beijing, Tianjin and Shanghai.

In addition, more than 500,000 agrotechnicians and government officials have been dispatched to help farmers apply the water-saving irrigation techniques.

The agriculture Bank of China will grant credits totalling 300 million yuan (US\$57.7 million) during the 1990-94 period for the extension of cropland using new irrigation methods in rural China.

— *Deptsview Asia*



Beijing and the provinces of Hebei in the north, Shandong and Zhejiang in the east, Hubei in Central China, Hunan in the south and Sichuan in the southwest, as well as in the central Asian region of Xinjiang covering about 667,000 hectares of cropland throughout the country.

Farmers in Luoting county, and efficient irrigation method in China.

Drip irrigation consists of an underground network of polyethylene pipes of different diameters buried underground. Through a series of tiny emitters at the end of the pipes, water from wells, rivers and ponds is delivered directly to the subsurface soil around

# Machine Tool Industry Prospers in India

by S S Kshatriya

**T**HE volume of machine tools production is generally taken as an index of industrialisation of a country. It is also a fact that large machine tools producers are also the consumers. Thus machine tools production, together with consumption, is a good index to status of a country in the industrialised world.

In India, the industry started developing in the thirties with then British government importing a large number of machine tools to strengthen its war effort. Soon to follow was the organised production of machine tools in the country with assistance from the United States and Britain.

However, the exercise was short-lived. After World War II had ended, the ready market for machine tools collapsed rendering redundant a large number of manufacturing units set up for the purpose.

The modern era in machine tools production is said to have started in 1954-55. The country was witnessing rapid industrialisation all over. With demand for machine tools increasing, manufacturing units entered into collaboration agreements with industrialised countries in the West. A range of lathes, turning, milling and drilling machines, indigenously made their appearance.

are located around Bombay, Calcutta and Madras, and other large cities.

The contribution of the unorganised sector to the national output of machine tools is in the region of 20 per cent in terms of value. As for the organised sector, about 20 units produce up to 75 per cent of its total output, the balance being shared by the remaining units. This is contrary to the practice prevailing in industrialised countries where the smaller manufacturers account for the bulk of national output in machine tools.

For the past two decades or so, IMTMA has been organising Indian Machine Tools Expositions (IMTEXs) every three or four years, which aim at bringing the industry and consumers together. At the seventh exposition in the series, held at Bombay in February 1989, business worth Rs 500 million was transacted.

On display were 1,500 machine tools, of which 220 were CNC (computerised numerical control) machines. Participation was 15 to 20 per cent higher than at IMTEX '86 in New Delhi.

IMTEX '92 is being held from March 7 to 16 at New Delhi.

Over the years, the machine tools industry has kept pace with developments such as in nuclear and aerospace science by improvements in design and manufacturing technology. Accordingly, the seventies saw the introduction of numerical control (NC) machine tools, while the eighties were devoted to CNCs that are not only

high precision and sturdy but also equipped with special built-in features that can be operated by electrical signals.

When two or more NC machines are connected to a single computer, it is called FMC (flexible manufacturing cell). Loading and unloading of parts being machined is done by robots while movement of parts from one machine to another is guided by computer commands. This arrangement is described as Flexible Manufacturing System (FMS).

In India, the industry started developing in the thirties with then British government importing a large number of machine tools to strengthen its war effort. Soon to follow was the organised production of machine tools in the country with assistance from the United States and Britain.

However, the exercise was short-lived. After World War II had ended, the ready market for machine tools collapsed rendering redundant a large number of manufacturing units set up for the purpose.

The modern era in machine tools production is said to have started in 1954-55. The country was witnessing rapid industrialisation all over. With demand for machine tools increasing, manufacturing units entered into collaboration agreements with industrialised countries in the West. A range of lathes, turning, milling and drilling machines, indigenously made their appearance.

are located around Bombay, Calcutta and Madras, and other large cities.

The contribution of the unorganised sector to the national output of machine tools is in the region of 20 per cent in terms of value. As for the organised sector, about 20 units produce up to 75 per cent of its total output, the balance being shared by the remaining units. This is contrary to the practice prevailing in industrialised countries where the smaller manufacturers account for the bulk of national output in machine tools.

For the past two decades or so, IMTMA has been organising Indian Machine Tools Expositions (IMTEXs) every three or four years, which aim at bringing the industry and consumers together. At the seventh exposition in the series, held at Bombay in February 1989, business worth Rs 500 million was transacted.

On display were 1,500 machine tools, of which 220 were CNC (computerised numerical control) machines. Participation was 15 to 20 per cent higher than at IMTEX '86 in New Delhi.

IMTEX '92 is being held from March 7 to 16 at New Delhi.

Over the years, the machine tools industry has kept pace with developments such as in nuclear and aerospace science by improvements in design and manufacturing technology. Accordingly, the seventies saw the introduction of numerical control (NC) machine tools, while the eighties were devoted to CNCs that are not only

novative in character, but is very good at assimilating and following a new development.

This has well accounted for an impressive growth rate for the industry over the past three decades. Production at its infancy in 1962 was Rs 104 million which shot up to Rs 255 million in three years and Rs 370 million by 1970. In 1980, it had touched Rs 1.86 billion and by 1990, annual production of machine tools in the country was valued at Rs 7.5 billion.

However, these growth figures do not necessarily mean that volume of production has risen proportionately. It is possible that equipments have become costlier over the years. Also, far more superior and capital-intensive machine tools are being manufactured in later years.

On the export front, India has been in competition with China, Taiwan and South Korea at capturing the European market for conventional machine tools.

A bulk of its exports were directed at the Soviet bloc of countries; but with the changed political scenario and countries of eastern Europe depending on the industrialised west, India is having to revise its marketing strategies.

So far as imports are concerned, the volume of purchases has been fluctuating over the years. Till 1978, imports had been on a decline and stood at one-third of domestic production. Thereafter, it has been rising such that the value of imports presently stands at around half that of the national production.

Consequently, the India machine tools industry is caught in a state of flux. Nevertheless, big opportunities exist. It has been estimated that if India could raise its share from the existing 0.13 per cent to barely one per cent of the world machine tools market, it would surpass present production figures.

With a little foresight and radical thinking, attaining this should not be very difficult.

To begin with, a number of manufacturers can join hands and set up export-oriented units under the aegis of IMTMA. Some large industrial houses, including those in the public sector, would also have to play a leading role, not necessarily dictated by business interests.

— (PTI Feature)

# Science Briefs

## Test Success for New Vehicle Transmission

A new vehicle transmission system now on test in two Rover 820 Si saloons has achieved significant progress over the past year, according to the British Technology Group (BTG) backing the project, reports *London Press Service*.

The Torotrak continuously variable transmission (CVT) is claimed to represent a new and improved generation of vehicle transmissions. Whereas current manual and automatic transmissions use a set of fixed-step ratios, the Torotrak transmission provides an infinite number of ratios ranging from standstill to high overdrive.

## Ideal Washer for Textiles

Researchers at the British Textile Technology Group have devised what is claimed to be "virtually the ideal continuous fabric washer" for use in the

## Textile Finishing Industry

A BTG team says its new design for such a machine offers dramatic improvements in energy efficiency and space saving while retaining washing performance of the best machines currently available.

The BTG design embodies a large number of identical stages with the water pumped through the fabric at each stage by a pressure slot throughflow and then used again at the counterflow stage.

In addition, for hot water usage, the machine would have insulation and heat recovery to the highest standards, plus pre-heat and after-cool sections.

An 80-slot configuration would have a path length of only 1.2 metres arranged vertically. In contrast to an equivalent conventional washer with a path length of 48 metres and a floor space six metres long.