X-Ray Microscopes: From Dream to Reality

he dream of building an X-ray microscope, first nurtured in the late 19th century, has turned into reality in the past few years with the advent of new X-ray microscopes that offer ten times better resolution than optical microscopes.

The world of microscopy dawned with the development of optical microscopes that use visible light to observe minute structures. It advanced further with the making of election microscopes that use electron beams to provide tiny details. Now X-ray microscopes are extending human perception still farther into the natural

Besides their higher resolution, the new X-ray microscopes can be used to map the distribution of certain chemical elements, form pictures in extremely short times and give three-dimensional images, according to a report in the journal "Scientific Amercan," y scientists Malcolm Howells, Janos Kirz and David Sayre who have collaborated on various X-ray imaging projects at Brookhaven National

tage of these new microscopes is that the biological specimens can be kept in air and water for examination, which makes it possible for scientists to study them under conditions very similar to their nat-

X-ray microscopy became possible after scientists developed sources of X-ray illumination of unprecedented brightness. These include sources based on synchroton radiation (radiation emitted by energetically charged particles accelerated by a magnetic field), Xray lasers, and X-ray emitting plasmas, all of which can produce X-rays in a single pulse in one-billionth of a second or

These rays can be brought a focus using a device known as Fresnel zone plate which consists of nested gold rings supported on a silicon nitride membrane only 1200 Angstroms thick. X-rays passing through alternating trans-

facility called Descos has pro-

vided trouble-free operation

for an Austrian mining com-

pany in the Turkish village of

Tutluca, Here, valuable ore is

extracted from a terraced

open-pit mine. Rocks and

stones which have been

blasted off are shovelled by

veyor belts, reduced in size in

giant front loaders onto con-

a crushing plant and then

transported to Descos - at a

rate of up to 120 tonnes per

separate the chaff from the

wheat: in this case, the white

mineral magnesite. It is used

for manufacturing fire-proof

bricks which are employed as

heat insulating material in en-

ergy technology, for example,

in blast furnaces. In order for

these magnesite linings to be

as durable as possible, they

must be extremely pure.

Traces of iron cause rust to

form, which is undesirable as

it leads to premature decay.

This plant is designed to

parent and opaque zones are diffracted and brought to a focus. In this way one can build X-ray lenses analogous to those used in light microscopes.

X-ray detectors, too, have improved and a new resist material, a thin layer of plastic whose resistance to etching changes when exposed to electrons or X-rays, is serving as a convenient, inexpensive Xray detector.

Scientists are already using X-ray microscopes to examine a wide variety of samples, from earthworms contaminated with heavy metals to human cancer calls, and from epidermal hairs on plants to coals, and semi-conductor devices, and in curing cement.

Current research confirms that as expected, X-ray images and electron micrographs do not look alike. X-ray microscopes are sensitive to the concentration of specific chosen elements, often carbon dioxide and nitrogen, whereas electron microscopes map the distribution of the chemical

For this reason, it is important

to separate the chaff, or

ferruginous rock, from the

magnesite during the mining

phase. As magnesite, or

magnesium carbonate, is not

magnetic - in spite of its

name - this task can be

performed by a powerful

magnet, which simply draws

the ferruginous, magnetic

material out of the mass of

crushed rock. Such magnetic

separators have been used in

ore mining for several decades.

the innovation from Cologne is

the fact that this machine uses

twice as much force to rid the

precious final product of mag-

netic material. This doubling of

power was made possible by a

technology which nobody had

yet dreamt of applying in this

sector: superconductors.

Superconducting electromag-

nets are the ideal source of ex-

tremely powerful magnetic

fields. The field is generated

A completely new feature of

groups in the sample that bind with a contrast-producing

In other words, the two produce complementary pictures on different aspects of

The main contribution of

Electron microscopes long ago surpassed the resolution of optical microscopes, providing resolutions between tow and 20 Angstroms. The resolution of the X-ray microscopes is of the order of a few hundred

three quarters of the mass of

most cells.

X-ray images can achieve superior contrast and are not disturbed by certain background effects. They are compatible with very rapid (flash imaging), and in many cases, X-ray microscopes can yield images that are not degraded by radiation damage.

X-ray microscopy has already begun to branch out from life sciences towards surface science and trace element analysis. For surface science, scientists study the electrons emitted from atoms near the sample surface by the X-rays, using photoelectron spectroscopy to measure the energy of the freed electrons.

Combining spectroscopy with high resolution X-ray imaging will make it possible to identify and map distribution of elements and chemical bonding states near the surface of the sample.

These advances can also aid in investigations of heterogeneous surfaces, such as those of catalysts or semi-conductor devices. — PTI.

Methanol-powered Cars

Automobile makers in the United States are vying for the first commercial production of cars designed to run on a fuel other than gasoline. This time the fuel to be tried is to be methanol.

It si envisaged that the first methanol-powered model will be sold in California from 1992 onwards. Meanwhile, the Ford Motor Company is developing methanol-powered versions of its compact Escort, mid-size Taurns and full size Crown Victoria. The automobile company Chrysler also has a methanol model in an advanced stage of development as do most of the major car manufacturers in US.

The main aim of developing cars powered by alternated fuels is not only gasoline conservation but meeting air pollution standards. Here, methanol has an advantage over gasoline. It burns more cleanly than gasoline, releasing less of the smog-causing hydrocarbons and nitrogen oxides.

Methanol has other advantages also. It has an octane rating of 100, compared with 93 to 97 for gasoline, that allows engines to run at higher compression and therefore more efficiently. Then it has a better flame speed than gasoline, which speeds burning in the cylinders for a quicker pick up. Methanol also has another advantage in its high heat of evaporation which helps pull heat away from the engine. This would make it possible to reduce the weight of methanol-powered cars by using air-cooling radiator systems instead of the heavier water-cooling systems in gaso-

line-run cars. Apart from such practical benefits, methanol cars have a special appeal for drivers because they are lively. In acceleration tests conducted at the Ford Motor testing grounds near Dearborn, Michigan, the Crown Victoria car was able to go from O to 60 km per hour in 11 seconds. This is a half second improvement over the gasoline powered models.

The smaller Ford Escort when powered by methanol, was able to improve by one second in similar trials. Methanol is already the fuel of choice for many drivers of Indianapolis type race cars.

Nevertheless, methanol powered cars have still some problems. For instance, burning methanol releases about half the energy that burning gasoline does. As a result, cars can go only half as far on a tank of methanol as they can on a tank of gas.

The consumers will also not appreciate the higher price tag

on methanol vehicles, which are likely to cost 300 to 500 dollars more than the conventional vehicles. It may still take a few years to fine-tune a new

The early models will be flexible fuel vehicles (FFVs) designed to run on different ratios of methanol and gas. These cars will be equipped with sensors that access incoming fuel mixtures and then adjust fuel injection, spark plugs and emissions controls

accordingly. However, these are not likely to become the cars of the future, because they are not as efficient as cars that use a fixed mixture of methanol and unleaded gas.

The flexible fuel vehicles have about 50 per cent efficiency advantage over gasolinepowered cars. But it is hoped that a vehicle designed to run exclusively on methanol could probably achieve 30 per cent better efficiency that an

equivalent gasoline model. Another advantage would be the potential of reducing overall emissions of hydrocarbons and other pollutants by 90 per cent. With an evergrowing awareness to the problems of global warming and air pollution, this would be a major promoter for these

- PTI Feature

ITUATED in an open pit mine between Ankara and Istanbul, in the rough terrain of the Turkish highlands, a magnetic separator is operating as a raw materials processing unit. This separator could prove to be of value not only for the mining industry, but also for the environment and numerous other applications. It uses state-of-the-art technology superconducting elec-

tromagnets. This device was recently awarded the Innovationspreis der deutschen Wirtschaft (Innovation Prize of German Industry). Parties receiving this prize, which is awarded under the aegis of the Bundesminister fur Forschung und Technologie (Federal Ministry for Research and Technology), must fulfil an important prerequisite: the innovation must first be tested by experts. The new product by the Klockner-Humboldt-Deutz (KHD) company in Cologne has long since overcome this hurdle. For the last two years, this prizewinning Perhaps the biggest advan-

the sample's structure.

the new microscopes will be their ability to make quantitative measurements of biological objects with little or no modification, in conditions very close to their natural

Angstroms.

One significant feature is that at wavelengths between 23 and 44 Angstroms, oxygen, and therefore water, is much more transparent to radiation than organic material. This opens up the possibility of discerning features through water, which makes up about

coil, and according to the laws

of physics, the intensity of the

magnetic field is proportional

to the current. Materials used

for making conventional coils,

like copper, are restricted in

their ability to produce

stronger magnetic fields by the

following technical limitation

the frictional heat, generated

in the wire by the passage of

the current, reaches a level

where it can no longer be dis-

stpated; in addition, the en-

ergy losses resulting from the

waste heat are extremely high,

tors, through which electrical

current can flow without in-

curring any losses due to fric-

tion, prove to be of help here.

The maximum magnetic flux

density obtainable with con-

ventional technology is roughly

two teslas - 40,000 times that

of the earth's magnetic field -

whereas coils wound from su-

perconducting wire are ca-

Materials like superconduc-

and thereby uneconomical.

Super-Cooled Drum With Attractive Force

However, superconductor technology has its price too. Superconducting materials can only function at very low temperatures, like those prevailing in outer space. The cotls of superconducting electromagnets must be cooled to a temperature approaching absolute zero. Such temperatures of around minus 269 degrees Celsius can only be maintained if liquid heltum is used as the coolant. This is precisely what has made superconductor technology not only elaborate and cx pensive but also given it a reputation of extreme susceptibility to malfunctions. In fact, up to now, these super-cooled electromagnets have only been found at high-tech establishments dealing with high-energy physics or in the clinical, sterile environment of medical diagnosis centres, where they serve as magnetic field sources in nuclear spin tomography.

this technology in a 'messy' area such as ore mining was Dr. Karl-Heinz Unkelbach, a physicist and project manager at KHD Humboldt Wedag AG. Despite all scepticism, he has now been able to successfully realize his idea, which first occurred to him as carly as the seventies. The coil of the device he conceived is wound from nearly one tonne of wire no thicker than a hair. This wire consists of a copper plated alloy of niobtum and titanium, the actual superconductor. The coil has a maximum current capacity of 500 amperes, and is thus capable of producing a magnetic field with an intensity of 3.2 teslas. The coil is immersed in he-

enough to consider applying

lium, in a tank made of nonmagnetic special steel. This unit is surrounded by a rotating, car-sized roll made of fibre-reinforced plastic. It is only this part of the device which comes into contact with crusher. The magnetic content remains clinging to the rotat ing drum, while the precious magnesite falls down. This highly sensitive, complex cooling equipment is well protected in its container.

the rubble from the stone

The sorting process using this new generation of magnetic separators provides such high yields that even the tailings are now being scoured again. Moreover - and this in naturally the main argument the separator can be used to exploit ore deposits which were hitherto considered to be unprofitable. The tee-cold separator in Tutluca reduces the content of iron oxide by a factor of roughly 13. Lumps having a diameter of up to ten centimetres, which earlier had to be separated manually, are now separated form the magnesite by Descos.

However, KIID is already looking to the future. Other, environmentally less friendly

processes involving the separation valuable raw materials from worthless rock could be replaced by this improved technique of magnetic separation. In fact, the developers see promising applications even in the field of environmental technology itself. Says Roland Pfetffer, in charge of development, "one could even desulphurize coal", as roughly half of the unwanted sulphur compounds in coal are combined with iron. This does not mean that flue gas purification plants could be dispensed with, although it would allow much smaller and cheaper designs. The engineers at KHD see possibilities of utilizing this technology for sewage treatment. Certain constituents of sewage water readily adhere to iron salt particles. These salts could be removed with the help of appropriate equipment, thus causing a decrease in water pollution.

The field of microelectronics offers particularly farreaching perspectives. Dr. Bernd Schuh

AUTOMATIC

RESEARCH

STATION

FOR climate and environ-

ment researchers, measure-

ment data from the Antarctic

is of great importance, but in-

vestigations are particularly

tedious because the transport

of supplies for the manned re-

search stations in rough ter-

rain is expensive and very ar-

ever, an automatic measure-

ment station, developed by

scientists at the Alfred-We-

gener Institute for Polar and

Marine Research AWI in Bre-

merhaven, will offer assistance.

In is currently being tested in

North Sweden and is to be

employed without personnel in

the Filchner Ice Shelf in the

As a precaution, the most

important instruments are

present in duplicate so that

this fully-automatic station.

which is to provide continuous

information regarding the be-

havior of the ice as well as of

the ocean currents un-

derneath, can operate troublefree and maintenance-free for

a whole year. The energy sup-

ply, which also encompasses

an emergency power unit, is

provided by two diesel genera-

tors, for which a total of 18

probes, sensors and data

gathering systems necessary

for the measurement pro-

cesses are housed in a central

measurement container and

the temperature of each can be

regulated separately by means

the direct and constant

transmission of the measure-

A small-scale satellite for

of an air conditioning system.

tons of fuel are available. The

Antarctic at the end of 1991.

In the near future, how-

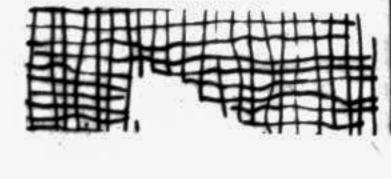
TRACING OZONE BREAKDOWN

EXACT measurements which provide a picture of the layer structure as well as the geographic distribution of trace gases such as carbon dioxide, ozone, methane, nitrogen oxides or chlorofluorocarbons, are an important prerequisite for assessing the state of the atmosphere. With the help of a new measuring instrument, it has become possible for the first time to record the concentrations simultaneously and continually.

For the determination of these atmospheric gases, the measuring instrument MIPAS (Michelson Interferometer for Passive Atmospheric Sounding has been developed in the Institute for Meteorology and Climate Research at the Kernforschungszentrum Karlsruhe (Nuclear Research Center Karlsruhe) with the support of the Bundesministerium for Forschung und Technologie (Federal Ministry for Research and Technology); this enables all trace gases to be recorded simultaneously and continually for the first time, from just above the earth's surface to heights of several 10,000 meters as well as from satellites.

Their distribution can be determined with a single measurement of infrared radiation, whereby initially, only a mean value of the concentrations of the gases contained in the atmosphere is obtained. With the help of a computer, the concentrations of the individual trace gases can be calculated. Just as in computer tomography, images of layers are pos-

The high-precision, shockresistant measuring instrument has already been used successfully in Kiruna, North Sweden to study the ozone hole over the Arctic. Furthermore, the American space agency NASA would like to employ the Karlsruhe instrument on Space Shuttle missions. Definite plans exist for its use on the polar platform of the European Space Agency ESA as well as in the Atmospheric and Oceanographic Research Satellite ATMOS, which is to be put into orbit around the earth in 1995.



by a current flowing through a pable of producing about twice The first person bold Diagnosis Through Biomagnetism

gnetic poles, "through which it can exercise influence over distances and develop all of the features of the magnet." as the German doctor and miracle healer" Franz Anton Mesmer speculated at the close of the 18th Century, was not altogether false. For it has been established that biomagnetism really does exist. Furthermore, it has even shown the way to a new diagnostic method.

Magnetic fields arise wherever electric currents flow. And as every organ of the human body, as well as the entire musculature, is crisscrossed by a fine neural network through which electrical pulses propagate, every person is an emitter of magnetic fields. Naturally, these emissions are extremely weak in comparison with the magnetic "noise" of the environment. The magnetic field of the earth alone. which aligns the compass neenetic signals generated by, for example, a beating heart. Even worse are the magnetic disturbances brought about by every electrical device. Filtering the body's own signals out of all this "noise" is thus a measuring problem, which entails an unimaginable degree of diffi-

Nevertheless, the impossible is no longer an insurmountable hurdle for modern medical technology. On the one hand, medical technology has had access to ultra-sensitive magnetic field sensors in superconductor technology. the so-called SQUIDS, since the seventies. On the other hand, special state-of-the-art technology provides shielded measurement chambers with meter-thick walls which can suppress the finest external magnetic disturbances. From the shielded chamber to the SQUIDS and including the entire biomagnetic measurement

and evaluation system, the human body has ma- stronger than the fine mag- world's best system of this tors at the Heart Centre of the kind was developed and realized by experts from the Physikalisch-Technische Bundesanstalt PTB (Federal Physical-Technical Institute)

> The latest version of the system contains 37 SQUIDS arranged in a circular configuration, which allows their signals to be evaluated independently of each other. Thus the magnetic fields of entire body parts like the head or the chest cavity can be recorded in a single measurement and translated into coloured contour images for improved evalua-

"It is actually the time characteristics of the magnetic fields, the changes in the magnetic polarity, which are interesting", explains Dr. Sergio Erne, Director of the PTB Department of Medical Technology, as only they provide conclusive results.

The physicists provide doc-Free University of Berlin with so-called magneto-cardiograms(MCG), the magnetic counterpart to the ECG, the diagram containing the characteristic curve of the heart muscle currents. The MCG has proven very useful for heart patients with a very special disorder of the conductive system, the so-called WPW syndrome. In this heart disorder. a group of nerve fibres are in the wrong location. There they function as an "interference transmitter", which, however, can be localized with the aid of

This, in turn, simplifies the operation which this disorder frequently requires.

an MCG.

In the opinion of Dr. Erne and his associates, the MCG will be capable of even greater applications, for example in post-operative care of heart transplant patients. Up to now, tissue samples have had to be

taken as a consequence of this University Clinic Erlangen. operation, in order to achieve Unlike an EEG, which proearly recognition of the onset of organ rejection. However the researchers now believe it possible to recognize this from The new sensors appear to

be an indispensable aid in pre ventative medicine as wellthat is . if results which until now have only been demonstrated on a very small group of patients are confirmed: i.e. that the magnetic signals emitted from the heart indicate certain life-threatening abnormalities well in advance of disease and before they can be recognized using other meth-

Furthermore, the magnetic activity of the brain is also to

be evaluated using the measurement system Krenikon developed by Siemens AG in the newly erected biomagnetic diagnosis centre at the

vides information about the electrical currents at the surface of the skull, the MEG or magneto-encephalogram. permits insight into deeper

areas of the brain. The MEG is

especially useful for the locali-

sation of diseased excitation centres where epileptic disturbances originate. Moreover, studies at the

Institute for Experimental Audiology of the University of Munster have impressively demonstrated that the MEG is also very suitable for tracing certain dysfunctions in the

This is how the reseachers around Professor Manfred Hoke were able to obtain a kind of "finger print" of susurrus aurium, a ringing in the ears.

Dr. Bernd Schuh

Tracing Ozone Breakdown

which provide a picture of the layer structure as well as the geographic distribution of trace gases such as carbon dioxide, ozone, methane, nitrogen oxides or chlorofluorocarbons, are important prerequisite for assessing the state of the atmosphere. With the help of a new measuring instrument, it has become possible for the first time to record the concentrations simultaneously and continually. For the determination of

these atmospheric gases, the measuring instrument MIPAS (Michelson Interferometer for Passive Atmospheric Sounding has been developed in the Institute for Meteorology and Climate Research at the Kernforschungszentrum Karlsruhe (Nuclear Research

Centre Karlsruhe) with the support of the Bundesministerium fur Forschung und Technologie (Federal Ministry for Research and Technology); this enables all trace gases to be recorded simultaneously and continually for the first time, from just above the earth's surface to heights of several 10,000 metres as well

as from satellites. Their distribution can be determined with a single measurement of infrared radiation and also from aircraft by means of several measurements from different angles to the horizon. Just as in computer tomography, images of layers are pos-

sible. Every gas absorbs or emits radiation in its own unique way. consequently, characteristic radiation patterns or spectra are obtained, for example, for pure gases. The degree of absorption or emission of infrared radiation is determined with the Karlsruhe interferometer, whereby initially, only a means value of the concentrations of the gases contained in the atmosphere is obtained. With the help of a computer, the concentrations of the individual trace gases can be calcu-

The high-precision, shockresistant measuring instrument has already been used successfully in Kiruna, North Sweden to study the ozone hole over the Arctic. Furthermore, the American space agency NASA would like to employ the Karlsruhe instrument on Space shuttle missions.

Liquid Manure to Combat Smog and Acid Rain? University of Essen believe

IQUID manure containers at animal husbandries are overflowing. In Germany, 340 million tonnes of liquid excrement flow out of cow barns and pig-sties every year - much more than what farm-land can absorb in the way of fertilizer. So far, there have hardly been any other applications or disposal possibilities. Now a large-scale experiment involving the use of liquid manure to rid exhaust gases from power plants of nitrogen, thus solving two environmental problems at once, has attracted attention.

Actually, liquid manure is an economical natural fertilizer, highly valued by farmers.

According to conservative estimates though, the amount of manure produced in the Federal Republic exceeds the agricultural sector's demand by ten to 20 per cent. Overfertilising the soil is not only harmful to plants, but also leads to major environmental problems.

Researchers from the

Institute for Environmental

Process Technology at the

that they have now found a possibility of utilizing liquid manure. In co-operation with VEBA Krastwerke Ruhr AG, a power supply company, they have converted the denitrifying equipment at the Dampfwerk Zweckel, a steam power plant near Gladbeck, to "run" on liquid manure. The fact that the foul-smelling liquid manure is to contribute toward air purification only appears paradoxical. After all, the agent used to reduce nitrogen emissions at power plants is a constituent of liquid manure.

In order to neutralize the nitrogen oxides (NOx) which are generated during combustion and are responsible for ozone smog in summer, as well as being a contributing factor toward acid rain, the hot stream of exhaust air is injected with ammonia (NH₃), which reacts with NOx to form water vapour and molecular nitrogen (N₂).

At Zweckel, this expensive ammonia solution has been replaced by liquid manure which, depending on its

"grade", contains from two to nine per cent of nitrogen compounds like urea or ammonium: up to four tonnes of excrement are propelled through the jets every hour. In this process, the water, the main constituent of liquid manure, evaporates and the organic constituents are burned; what remains are the mineral contents, which are retained by dust filters in the form of ash. The nitrogen compounds in the liquid manure purify 60 per cent of the flue gases emitted.

However, that is not enough to achieve the limit of 150 milligrams of nitrogen oxides per cubic metre of waste gas, specified by the Large Furnace Ordinance for oil-fired power plants with an output of over 300 megawatts (MW). For this reason, large power plants must stick to the conventional method of purification, which neutralizes more than 90 per cent of the nitrogen oxides.

However, there is another difficulty which restricts the application of liquid manure to small plants. "The main problem arising from this process

in one of logistics", says Dr Peter Gillmann from the Institute.

Even the two to four tonnes of liquid manure required every hour by the small Zweckel power plant - about equal to the oil needed for combustion — constitute a substantial transport and storage difficulty. Considering that the problem posed by liquid manure is largely one of distribution anyway, transporting such quantities appears impractical.

The Bundesministerium fur Forschung und Technologie (Federal Ministry for Research and Technology) which aided the development of this process with 1.1 million DM, recently estimated that 20 million tonnes of liquid manure could be "burned off" every year, if all 5000 plants under the 300 MW limit used manure for nitrogen removal.

- Martin Schneider



ment data was developed by studen's of the Technical University of Berlin and provides the opportunity for the scientists in Bremerhaven to monitor and control the instruments in the Antarctic from a distance. A further advantage

of this automatic measurement station, which is also more environmentally-friendly, will be that its equipment corresponds to just one percent of the supplies required for the manned AWI research station Geory von Neumayer with a total weight of approximately 2,000 tons.