

# Today's Research Development on the Application of the Superconductivity Transport System in Japan

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## Abstract

At the Miyazaki test track today, the new test vehicle, MLU002N, is under test run to obtain necessary data for Yamanashi test track where the construction is underway, the test vehicle has been ordered and the first tunnel was completed in December '93.

Superconducting magnetohydrodynamic drive ship, MHDS, "Yamato 1" has completed its experiment in '92 and it is now under preparation to exhibit to the public in '94. Furthermore, to promote the research development of MHDS, the detailed discussion is underway on the magnetohydrodynamic drive equipment as well as the research on the future scheme.

Neither an automobile nor railway but a new transport system called EQUOS LIM CAR(ELC) has been proposed. By using the rotating magnetic field, it will levitate on the aluminum like reaction plate. On the normal road, it will run by rolling the wheels like an electric car but on the highway, it will levitate on the guideway resulting to less noise, less vibration and pollution free drive. To understand the concept of the ELC, the model was built and experimented by using permanent magnet. The same model was donated to the MUSEUM OF SCIENCE AND INDUSTRY in Chicago and was displayed to the public. Today, the trial superconducting magnet has been made and the research development of the subsystem is underway.

Research development of superconducting elevator, equipment for the launching of spaceship, tube transportation system and others are in progress for the superconducting applied transportation system.

## SUPERCONDUCTING MAGNETICALLY LEVITATED RAILWAY

Today in Japan, under the supervision of the Ministry of Transportation and with the cooperation of universities and enterprises, Central Japan Railway Company, Japan Railway construction Corporation and Railway Technical Research Institute are promoting the development of the Superconducting Magnetically Levitated Railway, hereunder called SG-Maglev.

Each concerned are aiming as an immediate objective to complete the Yamanashi Test Track. On the other hand, at , Miyazaki Test Track, experiments are progressed by Railway Technical Research Institute to obtain necessary information for Yamanashi Test Track.

In September, '93, Symposium on '93 Central Super Express on the Railway Academic Conference was held at Yokohama with a theme of "Central Super Express and Community".

Miyazaki Test Track: In December '79, 10 meters long weighing 10 tons of test car, ML500, has recorded a high speed of 517 km/h at the Miyazaki test track. With this test, passengers loadable test car, MLU001 with 3 carriage cars, were trial manufactured.

By using MLU001, it has been confirmed that the travel stability will increase when the connection cars are added and also traveling characteristics were obtained. In September '82, manned testing run has started. Then in February '87, after increasing the capacity of electric power supply facilities, I was onboard on the 2 carriage car and reached the high speed of 401 km/h.

In March '87, to promote more practical use of test car, MLU002 was completed and exhibited to the domestic and international related media by Japan National Railways(JNR). In November '89, it has reached the high speed of 394 km/h.

In the case of MLU001, superconducting coils are placed equally in chain under the car while with MLU002, superconducting coils are concentrated under the front and back edge of the car. In considering the concept of the commercial cars, this was due to reduce the air resistance and the magnetic field effect to the passengers. On the other hand, instead of placing levitate coils on the running track of the guideway as an opposite direction levitation, the research on placing levitate coils at the side of the wall levitate method is under study.

Not only of the concentrated placement but also to stimulate the test of the side wall levitate method test started in June '91. As a result, the block of side wall levitate method was further extended to obtain necessary information for the Yamanashi test track but in October, same year, MLU002 had a fire accident and became inapplicable.

The fire accident of MLU002 was a regret but with the effort of the people concerned and the enthusiasm of many people related to the materialization of SC-Maglev, the new MLU002N was manufactured and started its test from January '93. MLU002N has a length of 22m, width 3m and weighs 19 tons. In February '94, MLU002N has recorded high speed of 431 km/h at Miyazaki test track.

Yamanashi Test Track: West of Tokyo between Sakaigawa Mura, Higashi Yashiro Gun, Yamanashi Pref. and Akiyama Mura, Minami Tsuru Gun, of same prefecture is the extension of 42.8 km Yamanashi test track now under construction. (Fig.1) In order to speed-up the commencement of the test run, the proceeding block of 18.4 km were decided and started its construction .

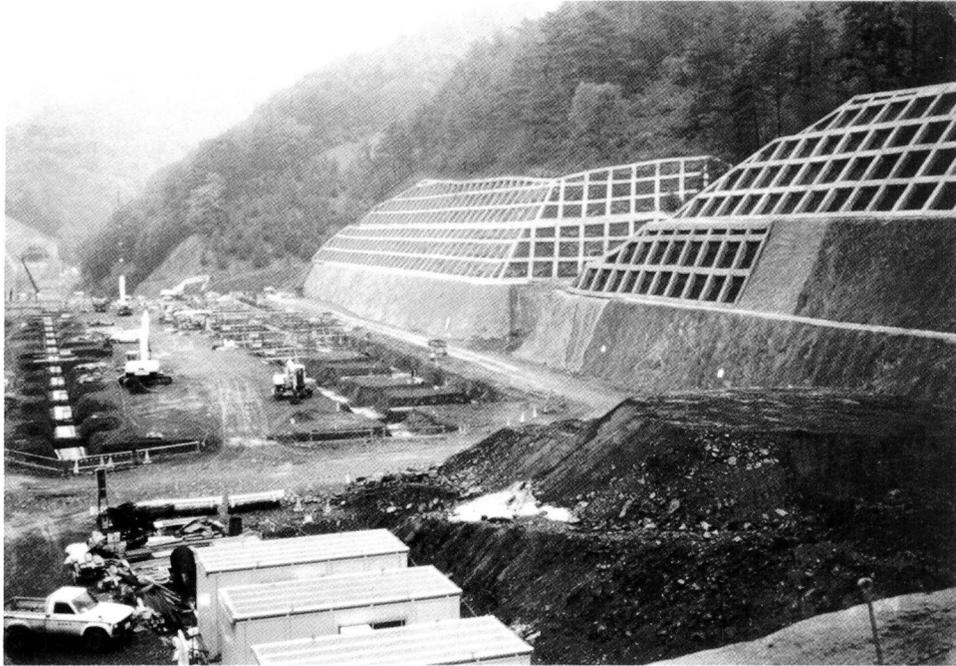


Fig.1 Yamanashi Test Track, Under construction

The standard construction technologies are, maximum speed, 500 km/h, minimum curved line radius, 8,000 m, maximum grade 4%, center track interval, 5.8 m. As to the main construction work, about 35 km are tunnels, 8 km out of tunnel, 1 test center, 2 substations and 1 train base.

According to the information as of April '94, progress of land purchase situation on the proceeding block is 92 %, tunnel excavating situation on the proceeding block is 95 %, that is, 15 km have completed its excavation out of about 16 km. Proceeding block will start its test In Spring '96 and is scheduled to complete its test by '98.

As for the test cars, the manufacturing of 2 composed train of 5 carriage cars and 3 carriage cars are underway and each are cars composed of connecting flatcar.

## TUBE TRANSPORTATION SYSTEM(TTS)

While the research development of Tokaido Super Express Line was on progress, there was a need for further research about the train's air dynamics and the space security of the train. I had the same thought while research development was in progress at the time of SC-Maglev and so I thought about running it in the vacuum tube. After a very rough estimation, the conclusion was that if the speed reaches over 600 km/h, the effect of vacuum tube will be larger and therefore the development of the SC-Maglev, aiming its maximum speed to 500 km/h, will not adopt the vacuum tube system.

But, recently the global issues of green house effect and the environmental as well as energy problems became a big issue.

So, I have proposed a Tube Transportation System (TTS) having the section as shown on Fig.2.

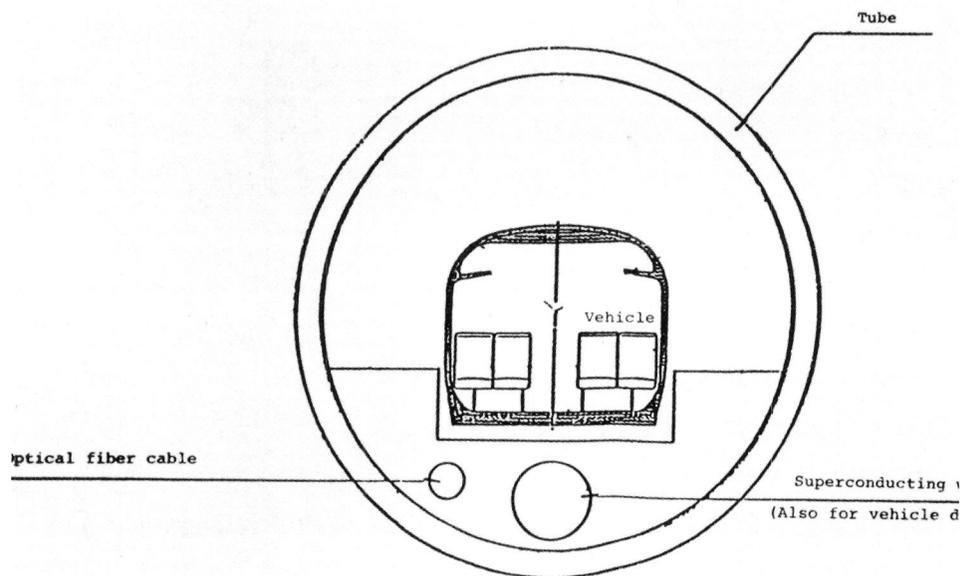


Fig . 2 Section of Tube Transportation System

This system is to store carriage of passengers and products using SC -Maglev, transfer of electric power using superconducting(SC) power transmission and transfer of information by using optical information transfer cable.

In order to examine in detail, optimistic supposition like maximum speed 3,700 km/h, minimum radius 10,000 m and maximum grade 4 % were obtained .

First, 3 routes connecting Tokyo and London was considered , via Northern route, passing through Central China' s Central route or via Yellow Sea and coast of Indian

Ocean route of South route. The route Tokyo and London is a route connecting East and West, so the route of South and North was also considered. To connect with the above studies, hypothesis of London and Buenos Aires route was considered.

Then, in order to plan the development of the countries deeply involved to Japan Sea, Pacific Rim Japan Sea Concept was proposed and investigated. Then, adding the views of those people of China and Taiwan, who have the strong interest on this Japan Sea Rim Concept, a hypothesis route shown in Fig.3 has been investigated. We call it "East Asia Corridor Route" tentatively. The total distance of this new route will be 10,000 km, the distance of mountain tunnel occupies 24.8 %, under water tunnel will be 17.0 %. The objective of time around this route will be 3 hours.

The commercialize opening of tunnel link between Britain and France channel this year will be the starting point of this concept .

In order to materialize this concept, the cooperation of professionals of superconductive and macroengineering as well as experts from many fields are essential but above all major necessity will be to raise the awareness of this concept to many people of the world.

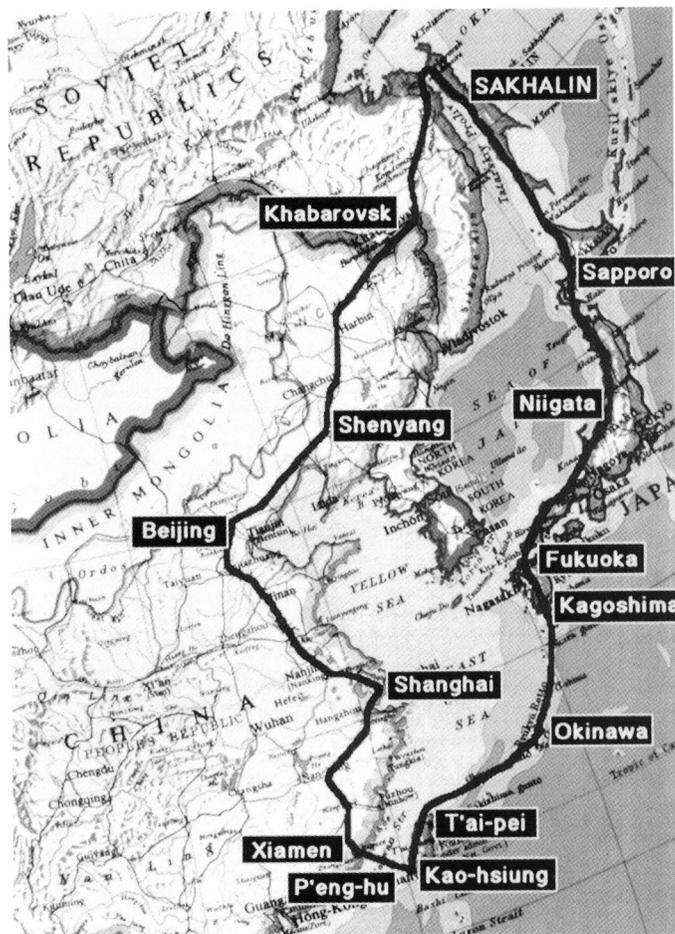


Fig.3 East Asia Corridor Route

## SUPERCONDUCTING MHD PROPELLED SHIP

Japan Foundation for Shipbuilding Advancement , later called 'Ship and Ocean Foundation" has started its research development of SC-MHDS and as result of the basic research, it has reached to the point of corroboration, building and testing the demonstration ship "Yamato 1".

"Yamato 1" will be mentioned at the other session. I had an opportunity to take the wheel of this ship and was surprised of its quiet and smoothness which entertained a big dream on the future of this SC-MHDS.

Research development of "Yamato 1" had a great purpose in the expansion of large superconducting magnet and cryogenic device. In order to further promote this research development to suit the lighter and powerful superconducting magnet, there still is a need to research the formation device such as cryogenic device.

The success of "Yamato 1", as a complete new propulsion system, has great expectation and concern. On the other hand, how this development will embodiment in the stage of future development, it is necessary to forecast the future view on technology, transport system, and the need of society now. Having these as a base, to establish condition to possess SC-MHDS in future, the target will be on island route for tourism and urban route for passengers. As a model of the ship, double bodied supporting type lift for tourism and submarine type for urban life and are shown as an example on Fig.4.

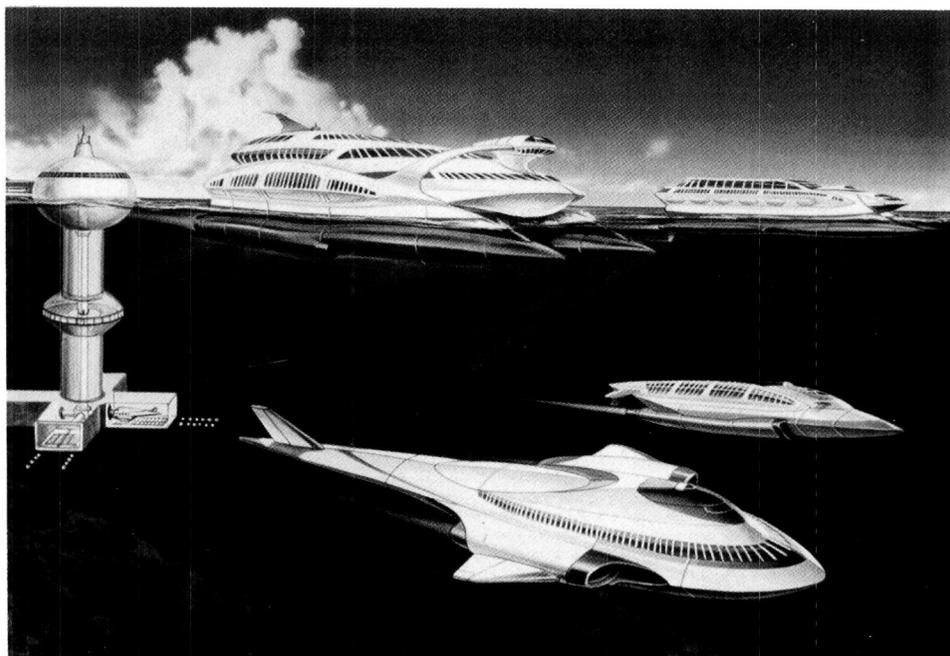


Fig.4 Future Ship

## EQUOS LIM CAR(ELC)

Railroad, in a broad sense guided ground transportation, is a transportation system that runs with something by a ground guided system and has an advantage to run safely on a high speed with connected carriage but the guided line(rail)is limited and cannot move freely. On the other hand, automobiles have an advantage to run freely but has to head the vehicle to the direction by holding the steering wheel, which has a limit to the speed in human driving. Also, it is difficult to drive connecting many cars like a carriage. So I have investigated a vehicle having the advantage of both railroad and automobile.

Intelligent of many countries are making a research and soon automobiles will be electrified and automated. This direction is without fail definite and it would be an opportunity to make research development of "new vehicle" which is neither an "automobile" nor a "railroad".

From the experience of the research development of small SC-motor with SC-Maglev, I have thought that the future automobile will be an electric car and its implant will be rotating SC-motor or linear motor and therefore, I thought of combining these two motors for this new vehicle.

When driving in the city it will run as an usual automobile, rotating the wheels with rotating superconductive motor which will result to no vibration, noiseless and pollution, free. But on the highway, when the rotation of wheel is speeded, vehicle will levitate and run with high speed. At this moment the guide power works in between the ground and the car and it will direct without anyone touching the steering wheels. It is not a dream to reach maximum speed of 500 km/h.

This concept is possible because of the combination of Linear Induction Motor (LIM) and Electro-Dynamic Levitation (ED) using rotating magnetic field. But on the ground an arrangement of a electric conductor plate like aluminum plate is required.

A vehicle with this new concept is called EQUOS LIM CAR and in order to confirm the possibility of this concept, we have made and experimented a model shown in Fig.5 with EQUOS RESEARCH CO. On this experiment, permanent magnet was used to see the wheel travelling, ED, rotating magnetic field transfer with LIM propulsion

We have confirmed the condition of wheel travelling, levitation, levitated travelling, landing, wheel travelling with the experiment device of about 26 m.long guideway with a model car of 50 cm in length and 4 kg in weight.

So far, we made research investigation on cryogenic device, onboard electric source as well as research on superconducting magnet needed for the future vehicle. Even for the guide, the research and experiment on the basic experiment device have only started. In order to make practical use of ELC, the best solution will be to make further research development and to let many people to know and be acquainted with this new vehicle. As a result, it is necessary to continue the research development of superconducting magnet, cryogenic device, electric source device, simultaneous use of permanent magnet and to make use of this concept, for example by promoting the development of a vehicle at the amusement park and to develop racing cars .

Also, to design the model of this concept is not as difficult to produce as it is thought. It is like remodeling the commercialized automobile. As to the guideway, it is more simple than producing railroad model. If a circuit race course with the model automobile could be made, it will be more enjoyable.

As for the automobiles, we are approaching to the age of genuine object. Not only electrified but without stirring wheel automobile free to travel anywhere with super high speed levitated travelling which will be enjoyable. ELC can make this dream come true and what is more, it can also run on non conductive guideway.

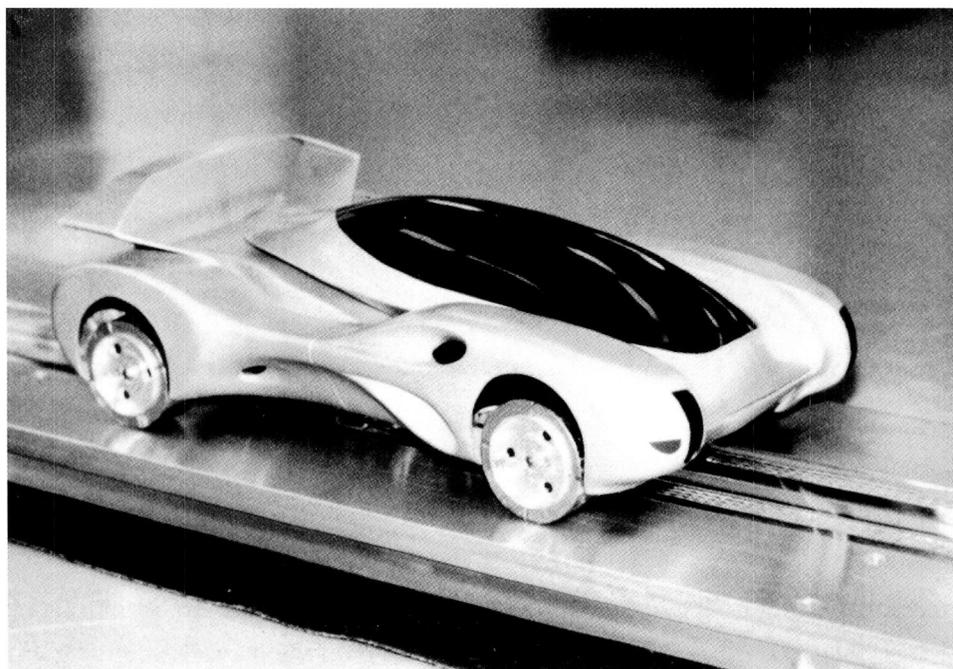


Fig . 5 Conceptual Model of EQUOS LIM CAR

## SUPERCONDUCTING CORRIDOR

So far I have mentioned the major transportation system applying superconductive. For the development of large machinery as well as transportation system, the sustenance test of actual structure is needed. Since the same thing could be said for the applied equipment of superconductive, the large scale test installation and support of big financial capital are needed.

The cities in the past have collected all kinds of functions and many people gathered to make use of its convenience which formed a city. There are cities developed as a center for politics, administration, economics, commercial, industries, transportation and tourism. Furthermore in order to develop the region, countries around the world are considering to form a distinguished city furnished with special faculty. For example, Hong Kong has developed as the free port for economy and the second and the third Hong Kong are considered.

High technologies and new materials as well as superconductive will provide affect on future technology, industry or even in a broad sense economy. The research development of high technologies and new materials must be opened to the public all over the world for the need to promote further research development.

Gathered the thoughts as mentioned above, I have proposed a thought of one city and named and announced it as a "Superconducting City".

Later, part of content was published in a magazine and I have received a commission on research investigation as to the application of superconducting city from Iwaki City in Fukushima Prefecture and as an interim report, I drew a superconducting city concept based on Iwaki City. With this concept drawing, adding the result of investigation research related to the underground development and superconducting magnetically propulsion ship from Power Reactor And Nuclear Fuel Development Corporation, Ship and Ocean Foundation, the revised concept drawing is shown on Fig. 6.

Below SMES is SC-Maglev and down left is the picture of superconducting linear elevator. The building under the water is the terminal for submarine type SC-MHDS and the link to the ground for passengers and cargoes will be SC-linear elevator. The sky scraper building in the center has a height over 1,000m, and the former elevator will have the problem of rope weight and have to change on the way. If SC-linear elevator is used, there will be no need to change lift on the way because there will be no rope used and also, it can pass over like a railroad and can reduce the surface area occupied. In Japan, other than SC-linear elevator research development of normal conducting linear elevator is in process.

The small picture at the right top of the drawing is the amusement park applying superconductive and the building at the right is the hospital equipped with superconductive applying equipment and the building on the left to the amusement park is the information transmission center equipped with superconductive applied equipments.

It is my dream to build a city where research development is free and I would like to open this city to the world as a liberal city of technologies where any people are free to enter for the happiness of the humankind around the World.

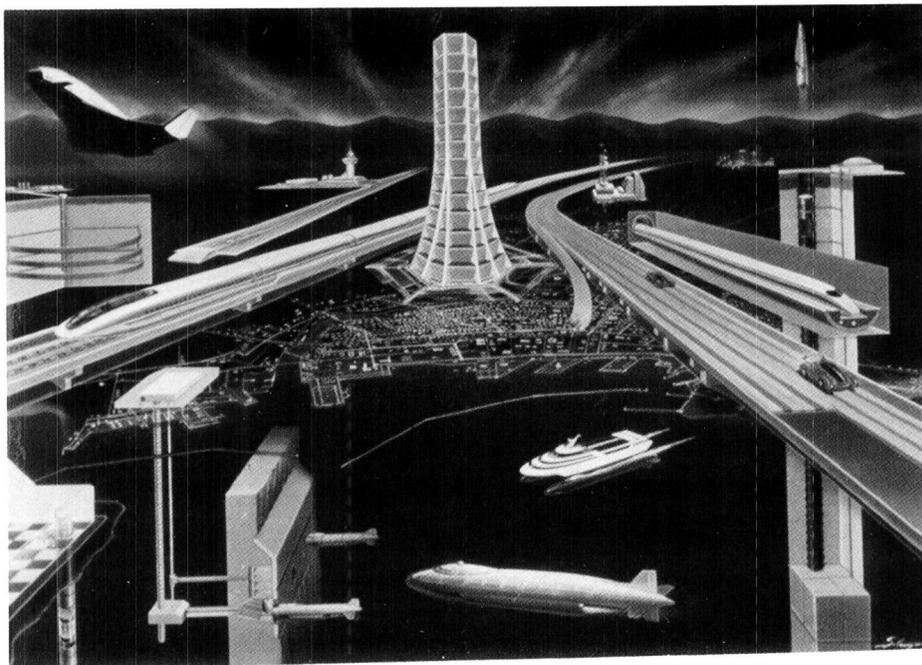


Fig.6 Superconducting Corridor

## CONCLUSION

The application of superconductive is ranging in the wide field. Especially the transportation field is expected to make a big change. If the high temperature superconductive is to materialize, the change will make further development. It will be my most concerned and appreciation, if the application of superconductive leads to the solution of the global issues of environment and energy.