AN EXTENSION TO THE 350KV NEGATIVE ION INJECTOR FOR THE JAERI TANDEM ACCELERATOR

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ABSTRACT

An extension to the 350KV negative ion injector for the JAERI tandem accelerator has been constructed and tested recently. Purpose of the extension is discussed and every part of the extension is described here in detail. Results of the first running over this 3 months are reported in comparison with the experiences summarized from the old ones.

INTRODUCTION

An extension to the 350KV negative ion injector for the JAERI tandem accelerator has been constructed and tested recently. Purpose of the extension is described in the following:

1) Increasing reliability of all devices in the extended injector,
2) Completely excluding any unsafe tuning and running in the injector and
3) During a certain ion source running, tuning other ion sources.

In order to realize these three items, we had to add a high voltage platform, to develop several devices and to improve most of the ones used in the old injector. They are summarized in the following:

1) An about 9 m^2 rectangular platform extended to the cylindrical and old injector,
2) A SF_6 insulated high voltage isolation transformer (ITX as an abbreviation),
3) Electrostatic cages, high voltage insulation racks and ducts,
4) Turbomolecular vacuum pump stations,
5) Ion source gas handling systems,
6) High voltage and low voltage power supplies, and
7) A control system for simultaneous running of the ion sources.

In the following chapters, we describe every part of the extension and discuss the first experience of the running in comparison with the old ones.

HIGH VOLTAGE PLATFORM

The platforms of the extension and the old injector are illustrated in fig.1. Area of the platforms including the connecting parts of them is about $19m^2$. Heights of the ceiling and the floor are 3.4m and 1.2m, respectively. The extension has a lower column only as it is shown in fig.1. On the other hand, the old injector has both upper and lower columns.

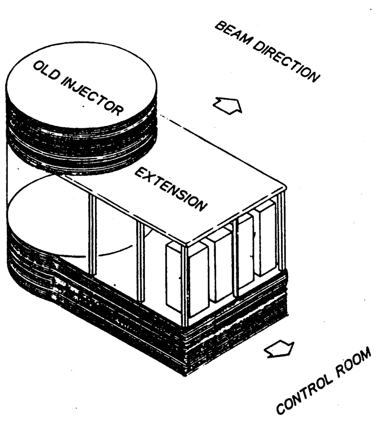


Figure 1. An illustration of the extension jointed to the old injector.

ISOLATION TRANSFORMER

Originally, electricity of the old injector was fed by a vendor-supplied motor-driven generator(MG as an abbreviation)which was isolated by a lucite rotating shaft. The MG continuously made a lot of noise and vibration with large amplitude damaging or affecting seriously to human bodies and devices in the old injector. The vibration usually shortens the life times of the devices, especially that of the bearings used in turbomolecular vacuum pumps(TMP as an abbreviation).

In order to increase the life times of the TMP and other devices, the ITX was made and has been successfully used for feeding to the extended injector for one and half years with no trouble. Outlines and a cross section of the ITX are illustrated in fig.2. The core, primary and secondary windings, stem, corona shield ring and cable terminal of the ITX are all contained within a pressure vessel filled with SF_6 gas at a positive pressure of approximately $2kg/cm^2$. The vessel which was made of steel has a maximum diameter of 1.5m, a height of 1.8m and a wall thickness of 6mm. On the outside of the pressure vessel, the high voltage feedthrough of a 25m high voltage coaxial cable, a valve arrester and 400V 3-phase input feedthrough of primary leads are mounted on the top flange of the vessel. The vessel has a manway, a gas manifold, a gas relief valve, a rupture disc and an interlock system utilizing a Bourdon tube pressure gauge. The gas manifold is provided to enable the vessel to be purged before filling with SF_6 gas. The relief valve and the rupture disc is fitted and set to open at $+2.5Kg/cm^2$. The pressure gauge has two electrical contacts for switching off a 330KV high voltage power supply of the injector.

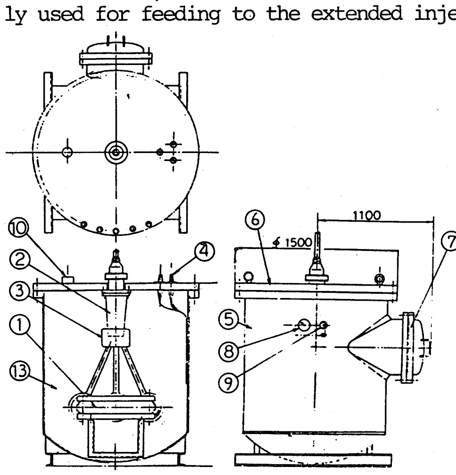


Figure 2. Outlines and a cross-section of the SF_6 gas insulated high voltage isolation transformer. (1) Isolation transformer, (2) Insulating epoxy resin tube, (3) Shield ring, (4) Primary leads, (5) Pressure vessel, (6) Top flange of the vessel, (7)Manway, (8) Bourdon tube pressure gauge, (9) Gas manifold, and (10) Gas relief valve and rupture disc.

Cross-sectional drawings of the cable, a cable terminal and a cable head are illustrated in figs.3, 4 and 5, respectively. Four conductors of the cable are centered inside and insulated by polyethylene tube from outer metal tapes and layers. The cable was originally designed to be usable at 500KV and below. During the cable test, a flash-over around 750KV was observed and no permanent damage was found on the cable.

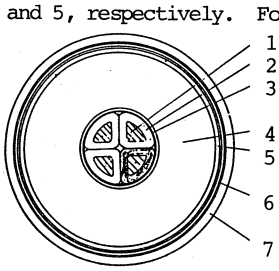


Figure 3. A cross-section of the high voltage cable. (1) Four conductors of copper wire having a 90° sector and $25mm^2$ cross-section, (2) Polyethylene insulator, (3) Semiconductive tape and layer, (4) Polyethylene insulator, (5) Semiconductive tape and layer, (6) Copper tape and compressing tape, and (7) Polyvinyl chloride jacket.

The terminal in SF_6 gas has a tube made from epoxy resin with silica filler and the shield ring in order to be discharge-free up to

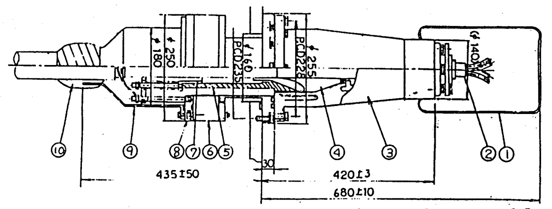


Figure 4. A cross-section of the high voltage cable terminal in gas. (1) Shield ring, (2) Metal conductor, (3) Insulating epoxy resin tube, (4) Rubber insulator, (5) FRP pipe, (6) Insulating ring, (7) Compressing spring of the rubber insulator, (8) Flange, (9) Metal cap for protecting the cable, and (10) Water proofed tape layer.

400KV and above. The epoxy resin serves as a main insulating medium whereas the gas serves only as a secondary one. The gas is filled mainly to prevent surface discharges on the resin. The head in air consists of the cable, rubber bushings and supporting brackets. The cable head has a length of 1.5m and a maximum diameter of 23cm.

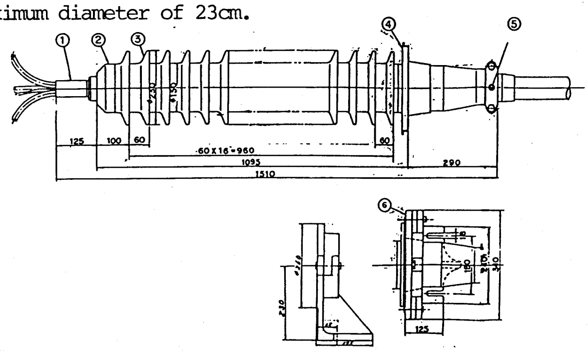
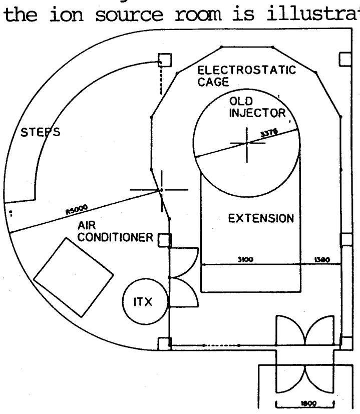


Figure 5. Outlines of the high voltage cable head in air. (1) Brass terminal tube, (2) Rubber cap, (3) Rubber shell, (4) Aluminum cover, (5) Screw hole for an earthing terminal, and (6) Supporting bracket.

Arrangement of the ITX and the extended injector in the ion source room is illustrated in fig.6.



The ITX was installed at the room in the JAERI tandem accelerator facility in May 1983. Since then, the ITX has been used and usually applied the negative voltages ranging from 200KV to 300KV. No deterioration of the SF_6 gas and the insulating epoxy resin media has been found by monitoring the lost and corona currents of the injector.

Figure 6. Arrangement of the ITX and the extended injector in the ion source room of the JAERI tandem accelerator facility.

VACUUM SYSTEM

As shown in fig.7, new vacuum system of the extended injector consists of four mini-beam lines, which has an ion source, an einzel lens and extractor unit, a lucite-rod-controlled metering valve, a 520 l/s TMP (model no. OV-TH 522CA manufactured by Osaka Vacuum Co.Ltd.), a switching magnet chamber, a 300KV accelerating tube, a sputter ion pump, 8 Pirani gauges and 4 Pirani gauge controllers, 5 sets of BA gauge and guge controller, purge valves, automatic and manual leak valves, right-angle valves, straight-through valves and gate valves and so on.

A diagrammatic display of the S1 mini-beam line illustrated in fig.8 has 11 toggle switches of the

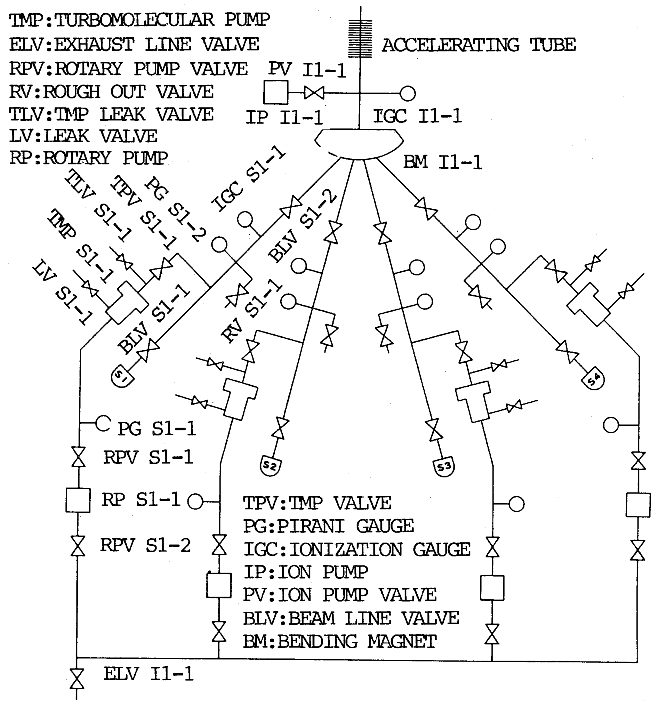


Figure 7. New vacuum system of the extended injector.

valves, the TMP and a rotary pump(RP as an abbreviation), 11 sets of LED indicators of them and a meter of the TMP rotation. This line is attached to a Heinicke Penning ion source and the eizel lens and extractor unit.

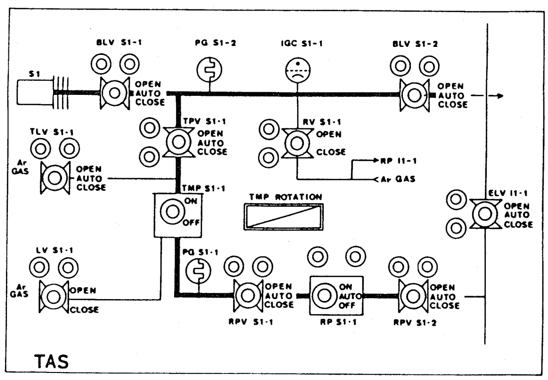


Figure 8. A diagrammatic display of the S1 mini-beam line.

The LV S1-1 manual leak valve prevents intruding of the corrosive gases into the bearing groove of the TMP by constant leaking of inert gas. The TLV S1-1 automatic leak valve leaks a constant volume of N_2 gas and pressurizes a housing of the TMP up to about 3 torr, whenever the TMP is turned off and the toggle is located at the auto position. The TPV S1-1, BLV S1-1 and BLV S1-2 valves are designed to close whenever their toggles are at the auto position and the BA gauge of IGC S1-1 is tripped off by sensing the increased pressure. The roughing out valve RV S1-1 can not be opened whenever the TPV S1-1 is open. Whenever the TLV S1-1 is at auto or close, the RPV S1-1, RPV S1-2 and ELV I1-1 at auto or open, and the RP S1-1 at auto or on, we can turn on the turbomolecular vacuum pump of TMP S1-1. If all of them are at auto position, we can run all of them by turning on the toggle of the TMP S1-1 only.

ION SOURCE GAS HANDLING SYSTEM

Flammable or poisonous ion source gases(H_2, D_2, CH_4, NH_3, PH_3, AsH_3, H_2S, H_2Se, F_2, Cl_2 and HCl) are stored and used in the gas cabinets. Unflammable and unpoisonous ones(He, O_2, CF_4, CCl_2F_2, $CBrF_3$, ClF_3 and SF_6) are arranged and used in the second floor of the ion source room. Air of the room via opennings of the cabinets are always evacuated with a gas blower installed at the outside of the accelerator building. Each of the three harmful gas panels for fluorine, ammonia and hydrogen gases in the cabinets has an emergency stop valve which is interlocked with a gas sensing and warning system. The gas cabinets, a poisonous gas absorber and the blower, and the panel are illustrated in figs. 9 and 10, respectively.

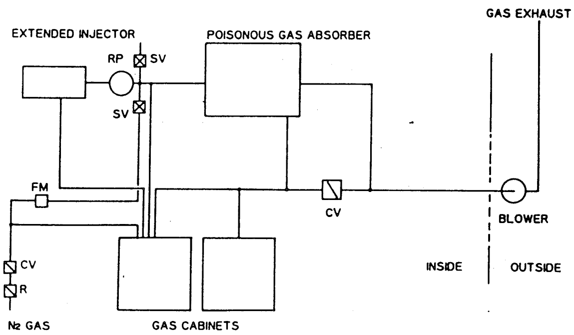


Figure 9. Gas cabinets, a poisonous gas absorber and a gas blower. RP; Rotary pump, SV; Stop valve, FM; Flow meter, CV; Check valve, and R; Regulator.

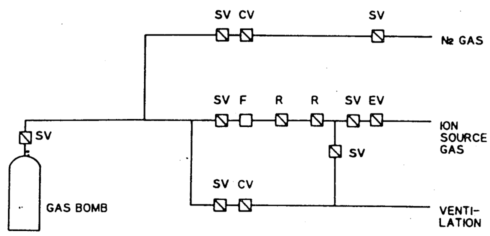


Figure 10. A gas panel for handling harmful gases. SV; Stop valve, CV; Check valve, F; Filter, R; Regulator, and EV; Emergency stop valve.

The gas panel of unharmful gases has 8 gas manifolds and a rotary pump for evacuating both the harmful and unharmful gas lines filled with unharmful gases. The panel is arranged in the 2nd floor.

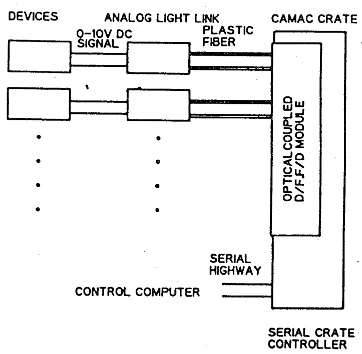
HIGH AND LOW VOLTAGE POWER SUPPLIES, AND HIGH VOLTAGE AND GROUND RACKS

In order to operate 3 ion sources(Heinickie Penning ion source, Direct extraction duoplasmatron ion source and Negative ion sputter source) simultaneously, 3 sets of the high and low voltage power supplies, and analog light links for them were installed in the high voltage and ground racks. Two set of the power supplies for a lithium charge exchange ion source and the 2nd negative ion sputter source, and the racks for them are removed from the platform now. The devices of the vacuum system, the control system and so on in the ground racks are also arranged in the ground racks.

CONTROL SYSTEM

The accelerator including the injector is controlled by a computer-based CAMAC system with serial highways[1]. Most of the devices around the injector are connected to CAMAC modules in 3 crates which are located near the devices. The crate inside the platform is connected to other crates via a digital light link of the high way.

The devices located at the high voltage racks are controlled via the crate by sending and receiving command and reading signals, respectively. The digital command signals from the computer are directly converted to light frequency ones, and the light frequency reading signals to the digital ones by a CAMAC module, which is an optically couplied frequency to digital and digital to frequency converter module (D/F.F/D module as an abbreviation) newly-developed in our institute[2]. The analog light link at the device receives the light command signals transfered through a plastic fiber and



converts them to 0-10V DC voltage signals. The link also receives 0-10V DC voltage reading signals from it and converts them to the light signals. The light signals are transfered through another plastic fiber between the module and the link. This is illustrated in fig.11.

Figure 11. An illustration of an optical coupled D/F.F/D module, plastic fibers and analog light links used for controlling the devices in the high voltage racks.

EXPERIENCE OF THE FIRST RUNNING

As already mentioned above, the ITX has been working without no trouble except for the rupture disc since the date of the installation. The vacuum system has been working continuously without no trouble for about a year. Before we changed the system we had a malfunctioning TMP every 3 or 4 months, and we had to get a new TMP every year. Before the replacement of the new light link system, we could not read 1/3 of the parameters and control 1/3 of the devices properly. Now we can read and control precisely all parameters of the devices.

Except for the ion sources themselves, all of the devices, the racks and the cables being applied with some high voltages are completely covered with grounded metal sheets or ducts, or plastic sheets. Therefore, we can greatly reduce the possibilities that operation crews working on the platform could be seriously damaged to receive electric shocks.

During this machine time period from July 9th to October 12th, we have run a certain ion source among the three negative ion sources and have tuned another of them or all of them simultaneously. Before this machine time, it took three or four hours to prepare the ion source and generate some negative ion beams having an enough ion current from it. Because the ion source which would be used next has been already well-prepared and -tuned during this machine time, it has taken a few minutes to preaccelerate any negative ion beams with an enough and stable current excluding a few exceptional ion beams. An average maintenance interval of the Heinicke Penning ion sources became several times longer than before. The intervals of the other ion sources seem to become longer to some extents. As it has not been necessary to prepare and tune them up rapidly, their runnings have been usually experienced to be very stable. Currents of the most ion beams have been recently found to become several tens to a few hundred % higher than before. After the extended injector has been used, we have been able to run the whole injector system very steadily, and have had few trouble concerning about every item of the extension other than the ion sources themselves.

ACKNOWLEDGEMENTS

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