# HIGH POWER INPUT COUPLER DEVELOPMENTS AT DESY

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ABSTRACT
A high power test set up for input coupler conditioning and operation was installed. Diagnostic tools like spark detector, charged particle pick up, infrared thermometer, mass spectrometer, photomultiplier e.t.c. are used to investigate processing behaviour. The existing input coupler of the superconducting HERA cavities was operated up to 300 kW CW. An improved version of the coupler is currently investigated.

## INTRODUCTION

During summer we plan to install 8 cryostats containing 16 superconducting 4-cell 500 MHz cavities in HERA. First system tests of a prototype module have been carried out in 1987. A first beam test of the system in PETRA followed in november 1987.

A high power RF system has to be conditioned prior to operation at high power levels. In our case the input coupler as well as the cavity itself have to be processed. At the beginning we tried to process the input couplers together with the superconducting cavity. The coupler was monitored with a diagnostic system [1] to avoid sparking. In a similar way the klystron was interlocked by a cavity monitoring system (quench detector, LHe-pressure, vacuum pressure e.t.c.). In practice, however, the simultaneous processing turned out to be disadvantageous because:

- a possible break of the window during the processing stage would deteriorate the cavity
- even without a break of the window the desorbed gases from the coupler region would be cryopumped very effectively by the cold cavity surface.

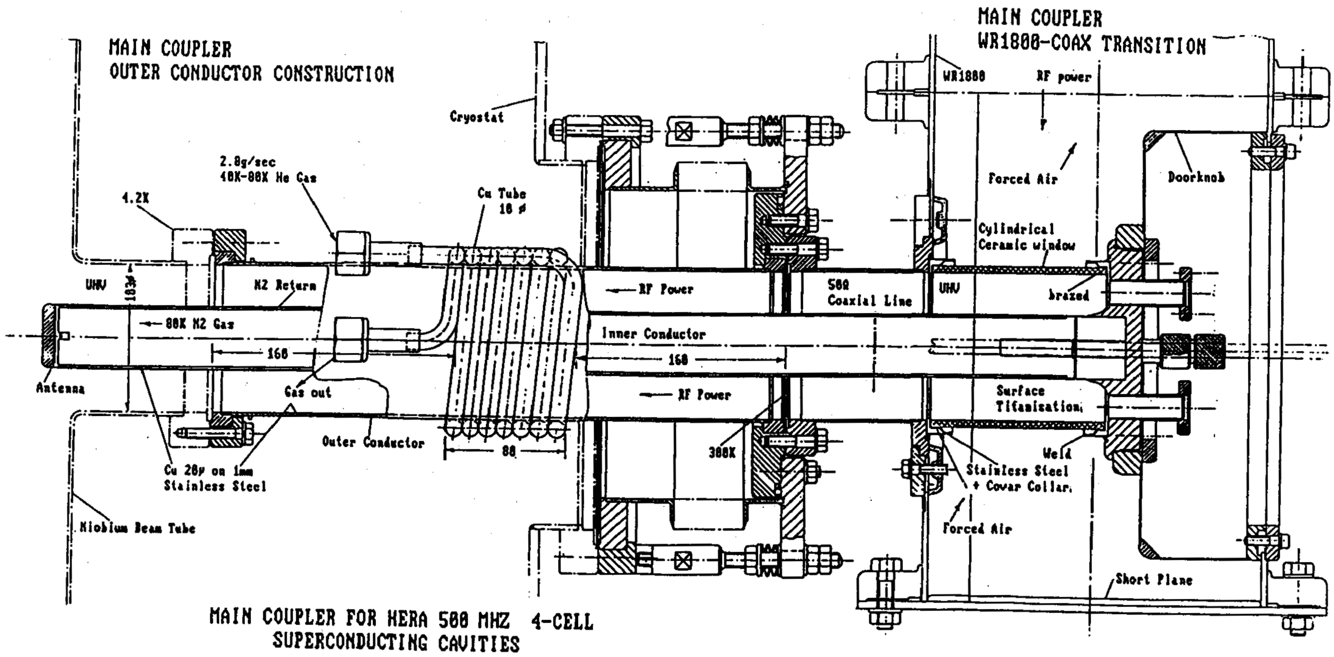
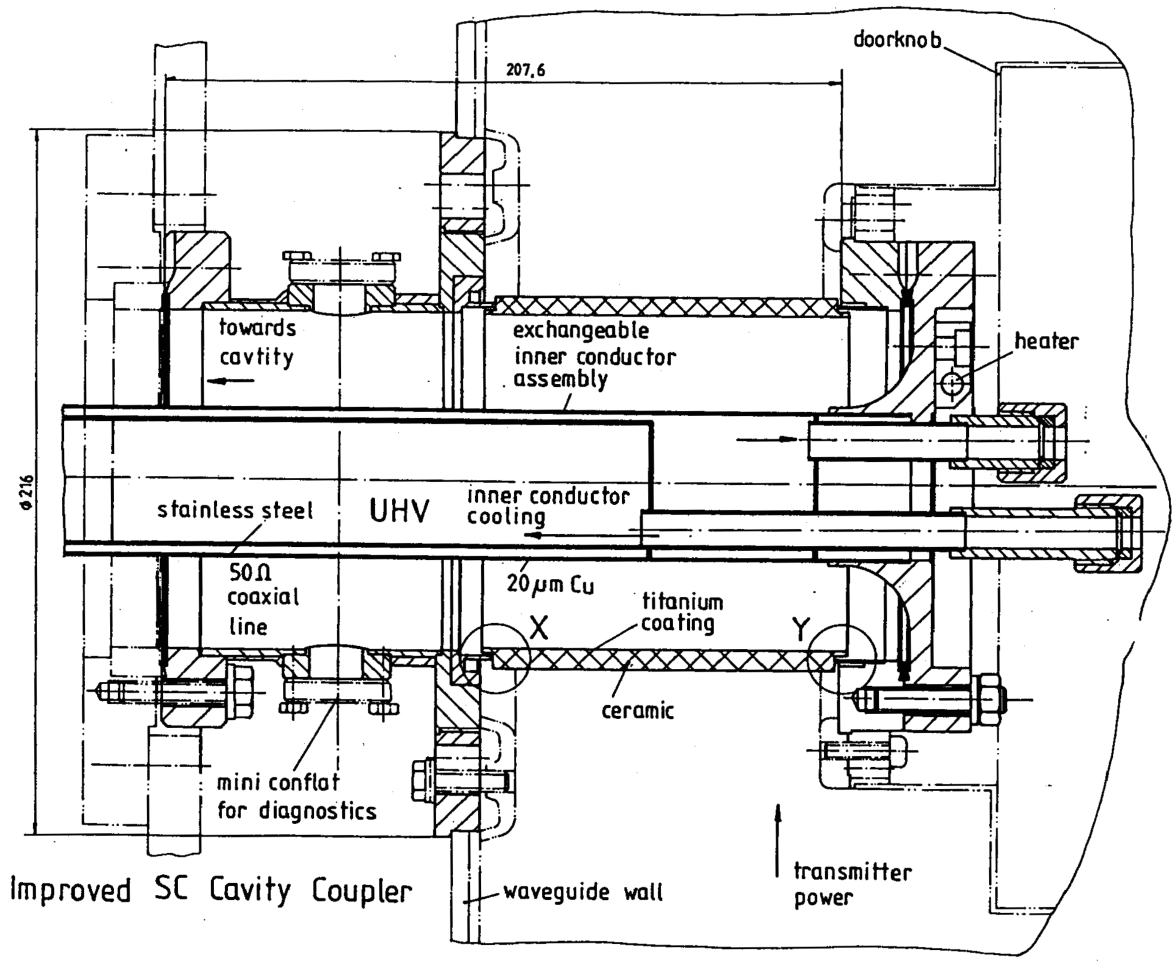

MAIN COUPLER
OUTER CONDUCTOR CONSTRUCTION
Cryostat
2.8g/sec
40K-80K He Gas
4.2K
Cu Tube
10 ø
UHV
183ø
N2 Return
80K N2 Gas
160
Antenna
Gas out
Outer Conductor
80
Cu 20μ on 1mm
Stainless Steel
Niobium Beam Tube
RF Power
50Ω
Coaxial Line
Inner Conductor
160
RF Power
300K
MAIN COUPLER
WR1800-COAX TRANSITION
WR1800
RF power
Forced Air
Doorknob
Cylindrical
Ceramic window
UHV
brazed
Surface
Titanization
Weld
Stainless Steel
+ Covar Collar
Forced Air
Short Plane
MAIN COUPLER FOR HERA 500 MHZ 4-CELL
SUPERCONDUCTING CAVITIES

Fig.1


doorknob
207,6
towards
cavtity
exchangeable
inner conductor
assembly
heater
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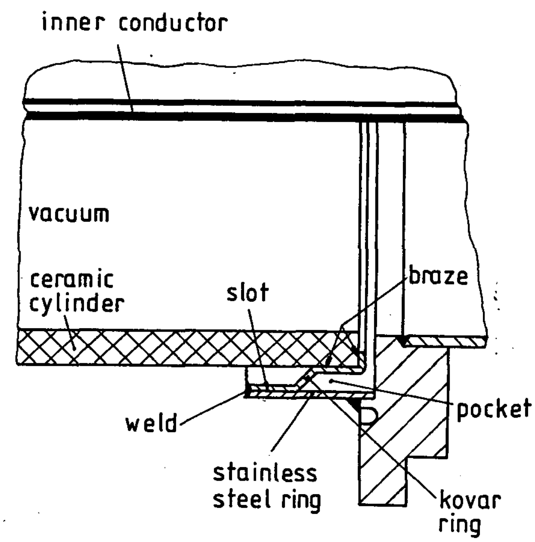
stainless steel
UHV
inner conductor
cooling
50Ω
coaxial
line
20μm Cu
titanium
coating
X
Y
ceramic
mini conflat
for diagnostics
Improved SC Cavity Coupler
waveguide wall
transmitter
power

Fig.2

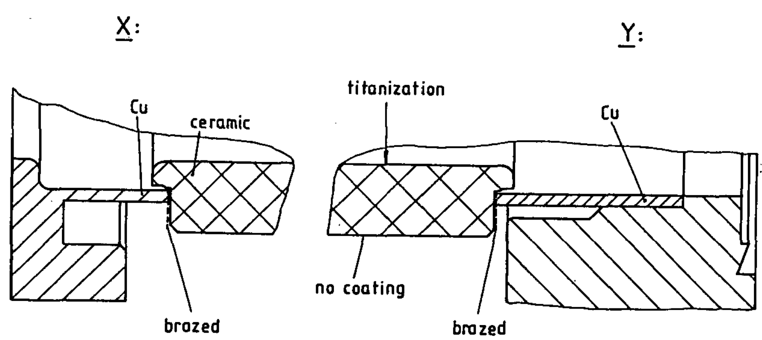
3. Point 2 is intensified by the fact that the main coupler shown in Fig.1 prevents thorough cleaning of its vacuum side because of special parts of its construction [1]. These are the double collars supporting the ends of the ceramic like shown in Fig.3. They form an enclosed pocket like volume ending in a narrow slot which itself is closed by a connecting circular weld on the normal pressure side. This slot and the pocket have to carry the total coaxial RF current thus leading to a temperature increase with gas desorption.




Original Metal To Ceramic Transition

Fig.3

4. Conditioning of the system without beam is uncomplete. The reason is that the cavity is nearly an ideal mismatch in case of missing beam. Hence without beam the coupler can be driven only under full reflection standing wave conditions. The prototype cavities have been processed together with the input coupler. For the next 16 cavities, however, a high power coupler test set up has been established. In addition an improved window design is under construction.




Metal Ceramic Transition Of Improved Coupler Design

Fig.4

## IMPROVEMENTS OF COUPLER DESIGN

Fig.2 shows the new high power coupler design. Main purpose of the new design is to avoid several limitations of the coupler of Fig.1. Compared to this coupler the new coupler has 3 essential differences.

The first one is replacement of the stainless steel/kovar double ring by the construction of Fig.4. This construction eliminates the above described pockets by a smooth metal to ceramic transition. A special feature of this transition is the plane to plane braze connection between the end planes of thin walled copper cylinders and the ends of the ceramic cylinder. There are already industrial experiences which prove that this connection is very reliable and mechanically resistant. An additional characteristics is a much improved heat transition between ceramic and waveguide. Less than 10 K temperature difference between both are expected for 100 kW of transferred RF power. Dissipation of the ceramic in this case is expected to be about 60 W. The cooling situation is relaxed by less surface current losses of the metal ceramic transition area. The supporting copper rings are much better electrical conductors than the stainless steel/covar construction.

A second improvement is the special form of the ceramic cylinder ends at its transition to the supporting copper rings.

This shape as shown in Fig.4 inhibits direct exposure of the triple point of ceramic, metal and vacuum to high electric fields. This point normally is in danger to form metallic edges of braze or metalization on the ceramic. Together with flux concentration due to the high ceramic dielectricity constant and due to the actual field distribution this leads to locally high peak fields, charge accumulation, glow discharge and multipacting under direct exposure to electrical fields. Direct exposure is prevented by a protecting ceramic nose which redistributes the electrical fields around the connection point.

At third the coupler no longer combines the metal ceramic assembly and the inner conductor to one undemountable unit after final welding. As shown in Fig.2 the inner conductor has a flange connection to the ceramic assembly. The possibility of inner conductor exchange even without unmounting the waveguide allows to correct simply the external Q-value of a coupler or to decide for a different inner conductor construction.

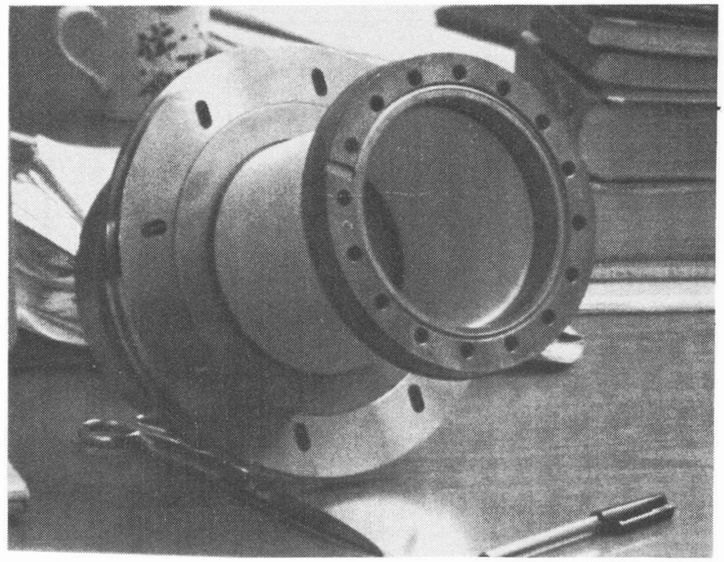


Fig.5

An impression of the real coupler metal ceramic assembly may be taken from Fig.5.

HIGH POWER TEST SET UP

Fig.6 shows the technical structure of a test set up for high RF power couplers. This set up combines two couplers of the type of Fig.1 to form one common evacuated coaxial line. The high power (vacuum) transition between the antenna ends of the inner conductors is realized by means of a connecting coaxial center part which uses spring contact clamps out of beryllium bronze (Fig.7). Additionally the inner conductor clamp is supported by a lamda/4 stub shown in Fig.7 which allows cooling of the contacting parts in addition to the inner conductor cooling circuit. Connection of the outer conductors between ceramic assembly flange and center part of the test set up (Fig.6) is readily realized by watercooled stainless steel tubes which are copper coated. Two carefully matched coaxial line to waveguide transitions are mounted to the ends of the assembly. Thus it is possible to feed transmitter power to one coupler over a waveguide system. The other coupler transmits this power to a high power absorber. A

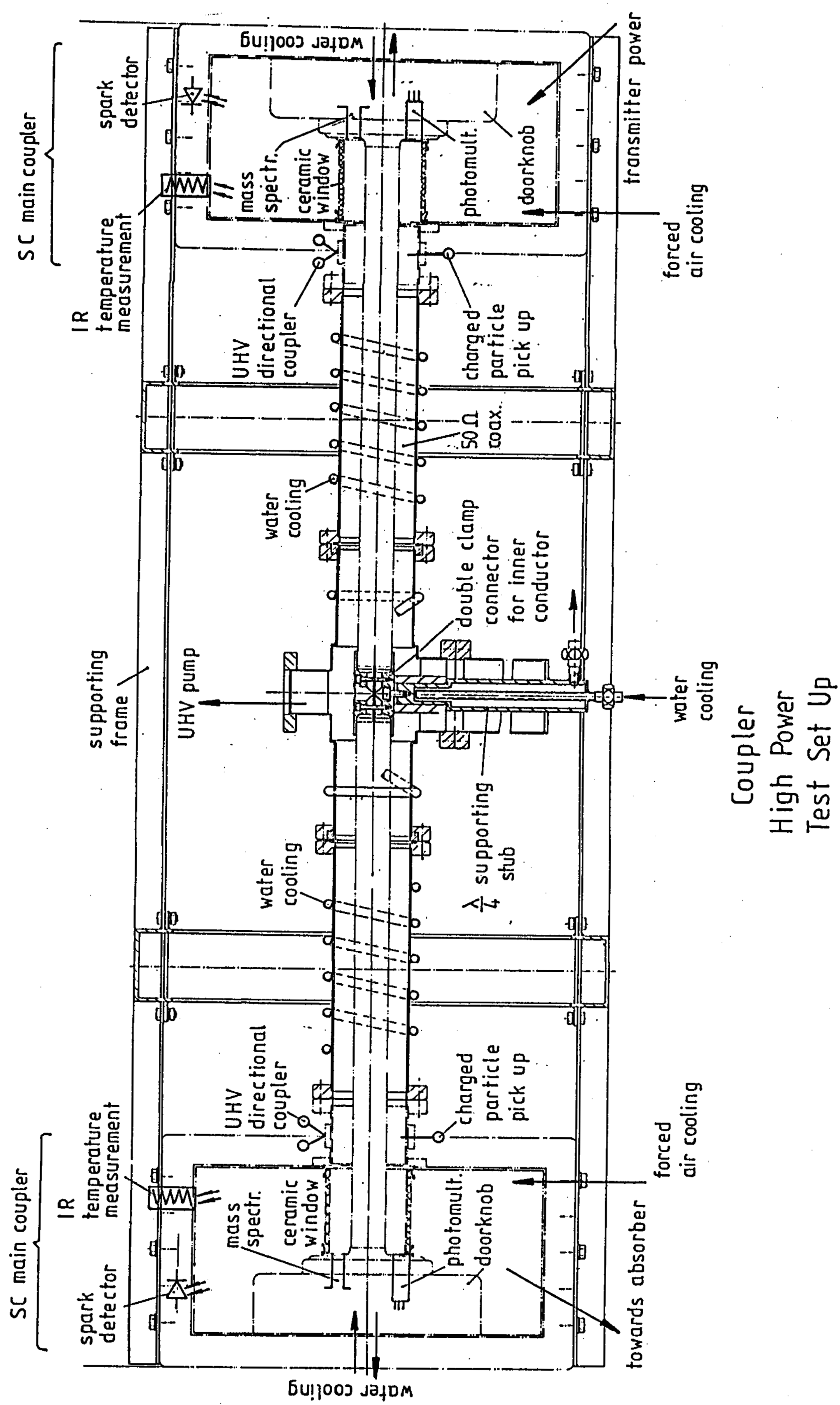

SC main coupler
spark detector
IR temperature measurement
water cooling
transmitter power
mass spectr.
ceramic window
photomult.
doorknob
forced air cooling
UHV directional coupler
charged particle pick up
50 Ω coax.
water cooling
double clamp connector for inner conductor
supporting frame
UHV pump
water cooling
supporting stub
λ/4 supporting stub
water cooling
UHV directional coupler
charged particle pick up
SC main coupler
IR temperature measurement
spark detector
mass spectr.
ceramic window
photomult.
doorknob
forced air cooling
towards absorber
water cooling
Coupler
High Power
Test Set Up

Fig.6

supporting frame stabilizes the whole set up. For investigation of coupler behaviour under high RF power as well as for interlock purposes the set up is equipped with the diagnostic coupler control system mentioned already above.

The tasks of the high RF power test set up are :

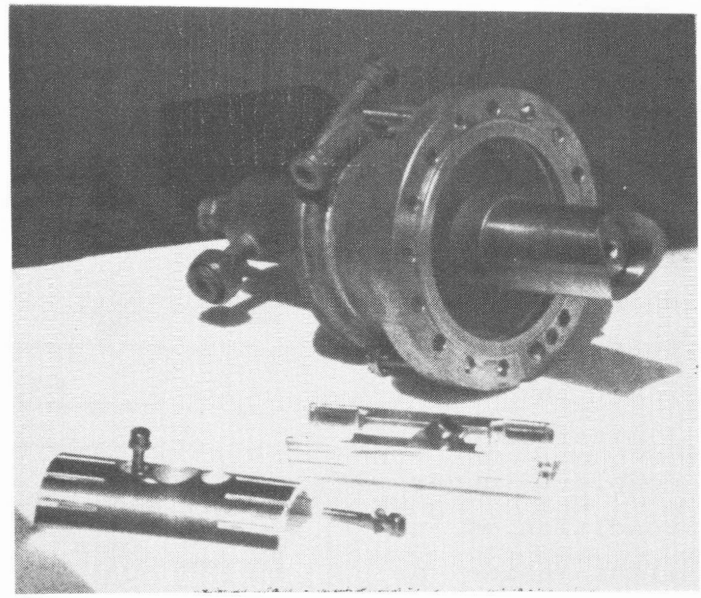


Fig.7

1.Investigation of pure coupler behaviour under travelling wave and full reflection conditions.

2.High power conditioning of a series of couplers independent of a cavity system and finding out if this is realistic.

3.Development of adequate coupler cleaning methods with respect to its application at superconducting cavities.

4.Improvement and development of couplers.

HIGH POWER TESTS

Since installation of the test set up for high power couplers three high power tests were performed. The main tool for measurement and control of the couplers was the diagnostic system of Fig.8 installed to each coupler. Besides those informations vacuum and forward and backward power were measured.

The devices of the diagnostic system include a light detector which registers sparking outside the ceramic, an infrared detector measuring the outside surface temperature of the ceramic, a directional coupler on the UHV side to check the electrical length of the window (which could be changed by material deposition) , an UHV feedthrough to monitor charged particles in the coupler area, a mass spectrometer to survey the atomic species if the pressure were to increase and a photomultiplier registering light inside the vacuum logarithmically over 6 decades of intensity.

All of the sensors were connected to an interlock system.
The first test was done with two couplers of the type to be installed to HERA. These couplers were installed to the test set up without any prior cleaning just as they came from manufacturing. One of the main purposes of this test was to find the power limitation of the coupler under condition of no light inside or outside the coupler, no charged particles in the vacuum, no vacuum perturbances, no increase of RF reflection, window temperatures less or equal 90 degree celsius for several hours. This limitation was found to be at about 255 kW of transfer CW power. 360 kW were achieved at pulsed operation with 19 msec compared to 8 msec on off ratio. After this test which needed several days of conditioning an inspection of the coupler inside surfaces showed no obvious change.

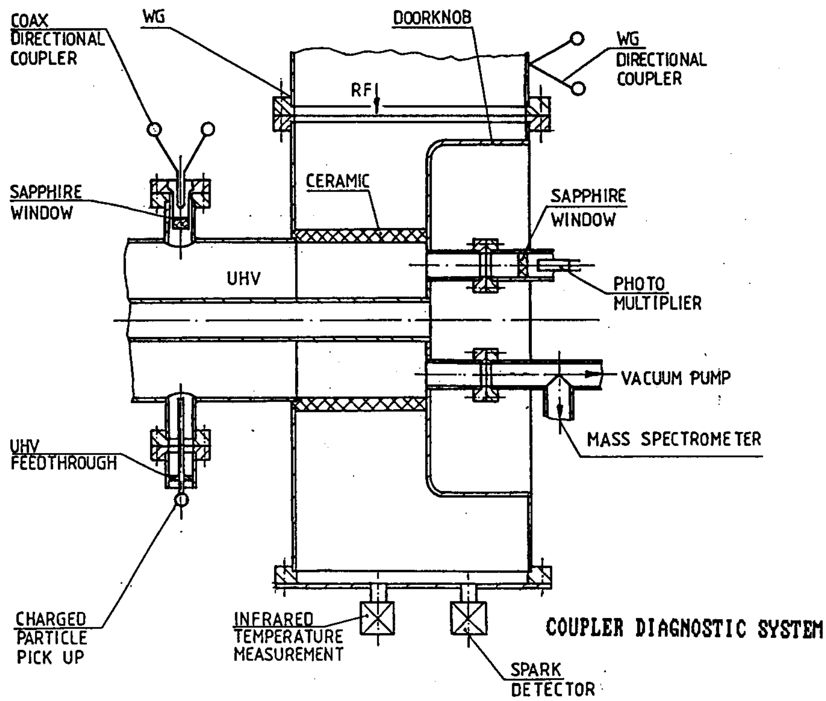



Fig.8

A second test with the same two couplers should answer the question of whether a conditioned coupler is allowed to undergo an additional surface treatment (for example to remove dust after contamination due to transportation. The inside surfaces of one coupler were rinsed with dustfree water and after that with alcohol. This procedure made a new conditioning necessary which means that surface treatments after high power conditioning should be avoided. After repetition of conditioning 300 kW CW were achieved but the air cooling was not enough to keep the ceramic temperature at less than 90 degrees Celsius. 270 kW of CW power were achieved over many hours without problems.

The third test was performed with the new improved coupler type. Four of these couplers have been manufactured. Two of these will be titanized on their ceramic surfaces. The untitanized ones were tested in July this year.

Purpose of this test was to find out if titanization is necessary. From CERN experiences it is known that the coupler of Fig.1 which is a modified LEP cavity coupler will not work without titanization.

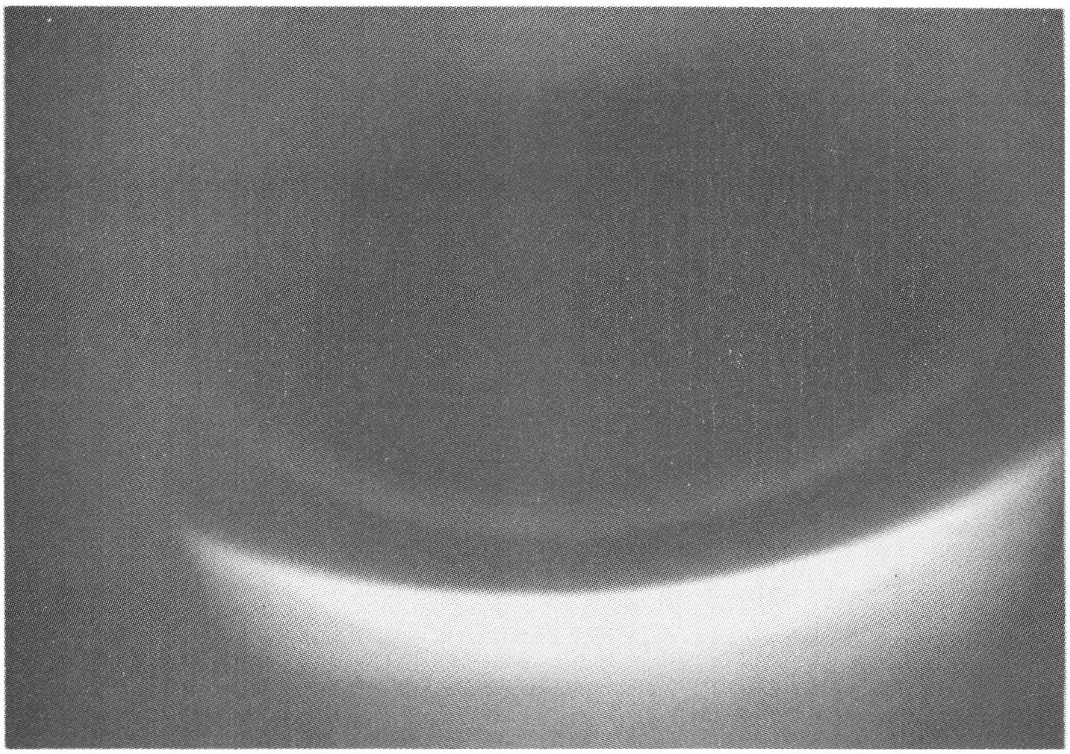


Fig.9

The high power test result of the untitanized couplers was not clear. Up to 60 kW of CW conditioning was without problems. Beginning at this power level the transmitter side coupler showed more and more light at its vacuum side. Hence the interlock switch off level was stepwise increased. At 70 kW CW it was observed that besides a continuous light effect the ceramic temperature increase was 10 K within 5 minutes whereas the other coupler showed no light and stabilized at a temperature increase of only 1K. The light was forming a thin fillet very close to the ceramic surface . Its brightness was comparable to a candle. Its color was between violet and purple. Fig.9 shows the effect from the photomultiplier point of view.

In order to eliminate the suggestion that the one side characteristics of the light was due to direction of power flow, the test was repeated with inverse RF power flow. The result was unchanged. Hence the coupler under discussion has to be unmounted in order to find out the source of the effects.

## CONCLUSIONS

The main coupler situation of the HERA superconducting cavities was delineated. Related activities are design of an improved coupler version and installation of a coupler test set up. The basic design ideas of the new coupler and the technique of the test set up are described. First tests and results achieved with the set up are described also. It was found that the couplers for the HERA superconducting cavities will withstand much more travelling wave power than specified for HERA. A remarkable additional result is that the inner conductor clamp connection as shown on Fig.7 was capable to transfer the currents of more than 300 kW RF power under vacuum conditions even after several mounting and unmounting cycles. The improved coupler design has to undergo further tests in order to prove the expected features and to find out the RF power level from where on an antimultipactor coating like titanium is necessary on the ceramic surface or its neighbouring metal surfaces.

## REFERENCES

[1] B.Dwersteg, Main coupler for HERA superconducting cavities, DESY-M-87-15, September 1987