SIEMENS 1 SYSTEM DESCRIPTION MBT GAS GENERATOR SYSTEM Pagenon deef GRPD Date 2004-02-10 M DB 101 GAS GENERATOR SYSTEM B. Wassberg YAMAMA CE TABLE OF CONTENTS PURPOSE OF THE SYSTEM GENERAL DESCRIPTION OF THE SYSTEM MAIN COMPONENTS FUNCTION Survige DEDIFICATION <td< th=""><th>et</th></td<>	et
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SYSTEM DESCRIPTION MBT	Respons. dept	Date 2004-02-10	Reg. M DB 101	
GAS GENERATOR SYSTEM	Prepared B. Wassbe	erg	YAMAMA	CEMENT

Purpose of the system

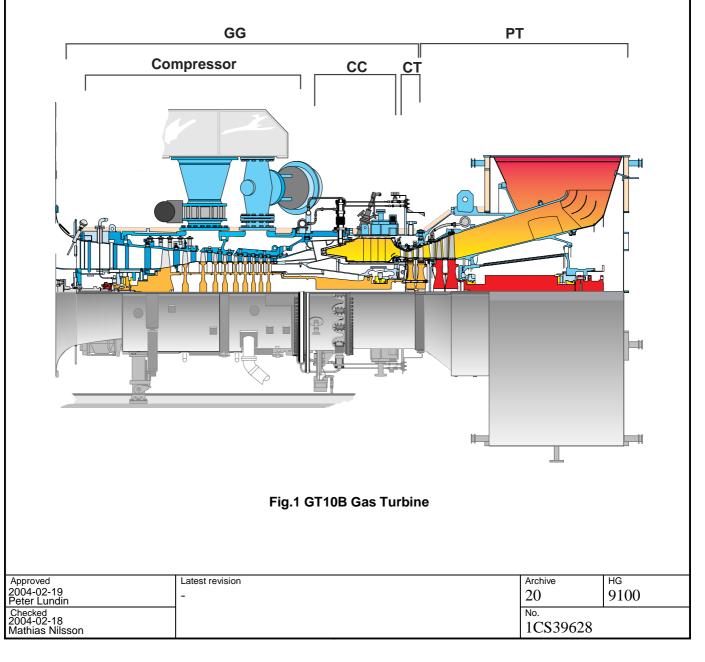
The gas generator generates a flow of pressurized hot gas, driving the power turbine.

General description of the system

Refer to P&ID 2046 019

The GT 10B gas turbine operates in a simple open cycle with straight air and gas flow through the turbine. It can be divided into two main sections, the gas generator and the power turbine. The two main sections are not mechanically interconnected, so the gas generator speed is determined by the output of the unit as well as ambient conditions, which allows a wider control range at sustained efficiency.

The gas generator comprises the compressor, the combustion chamber and the compressor turbine.



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Compressor

The inlet casing consists of an outer and an inner casing, which directs the incoming air to the compressor first stage. The inner casing contains bearing housing no.1 and the SSS-clutch, connecting/disconnecting the starting motor to the gas generator rotor. The SSS-clutch is described in the starting system, MBJ.

The inner casing is connected to the outer casing via four hollowed profile rods. The rods contain lube oil and seal air pipes as well as instrumentation cables (speed, vibration, axial position, bearing temperature, phase angle).

The inlet casing is bolted to the compressor casing.

The compressor casing, covering the whole compressor section, is horizontally split to facilitate maintenance. The casing contains the three stator subassemblies - front, central and rear stator casings. These casings carry the guide vanes and the stator rings.

The stator casings form slots for bleeding air downstream the second (low pressure bleed) and the fifth stage (high pressure bleed).

Two bleed valve are located on the upper compressor casing half, one for the low-pressure cavity (BV1) and one for the high pressure cavity (BV2). The bleed valves open at low load to prevent the compressor from surging. Bleed air is directed into the air intake. The BV2 is also used for emission control when required. BV2 is then used over a wider load range.

The axial flow compressor has ten stages. The guide vanes of the first two stages are of the variable geometry type, actuated by a spindle control mechanism and an AC-servo.

The compressor rotor is solid, built up from a number of fully electron beam welded discs and an intermediate shaft. The compressor blades are fitted in the discs by dove tail attachment. The blades and vanes are coated for corrosion protection.

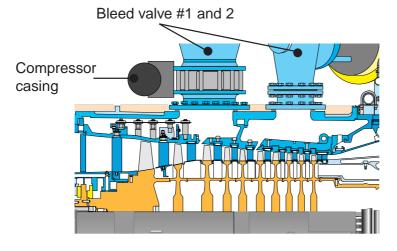


Fig.2 Compressor section

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Central casing

The central casing consists of an inner and an outer casing. The fuel rods are mounted on the outer casing. A diffusor section, located between the outer and the inner casing, slows down the air speed and directs the air flow into the combustion chamber. The inner casing contains bearing no.2. The inner casing has nine profile rods. Some of these rods contain oil and sealing air pipes as well as instrumentation cables (vibration and temperature).

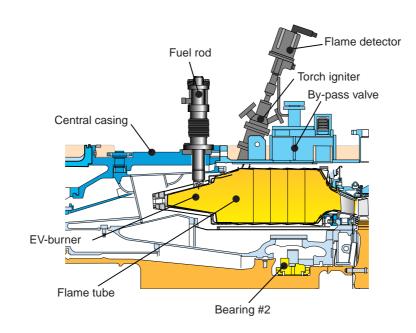


Fig.3 Combustor chamber section

Combustion chamber

The GT10 low emission combustion system is using the ABB EV-burners, which are working according to the lean premixed combustion principle when operating on gaseous fuels.

The EV-burner has the form of a cone with two slots where the compressor air is flowing in. Main gas is introduced into the air along the slots through a number of small holes. Each burner is equipped with a fuel injector, for primary gas and oil, in the tip of the cone. Primary gas fuel is used during start up and is supporting the main gas up to approximately 95% load.

In the annular combustion chamber fuel is injected by the 18 EV-burners. Ignition takes place by means of a torch ignitor. The torch ignitor is supplied with instrument air and ignition fuel from a separate ignition fuel system. The torch igniter is ignited by a spark plug.

There are two flame detectors in the combustion chamber, one indicating the ignition torch, the other the main flame.

The fuel rods, each consisting of three concentric pipes, connects the burners to external fuel manifolds.

When operating on liquid fuel, the burners form a conventional diffusion flame.

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SYSTEM DESCRIPTION	Respons. dept Date GRPD 2004-	-02-10 Reg. M DB	101
MBT GAS GENERATOR SYSTEM	Prepared B. Wassberg YAMAMA CEN		
Gas fuel stage 2 Gas fuel staage 1 Liquid fuel Gas fuel stage 2 Atomization nozzle	ombustion air	Flame	
Fig.4 ABB E	V-burner		
Turbine casing			
The combustor and the turbines are covered by detectors are mounted on the turbine casing.	the turbine casing. Th	e ignition burner	and the flame
Compressor turbine			
The 2-stage compressor turbine comprises the s to the compressor rotor.	stator and the turbine c	liscs. The turbine	discs are bolted
The stator surfaces are provided with honeycor withstand a blade tip rubbing. The turbine blad minimize the interstage gas leakage.	•		
	precision cast and inte	ernally cooled. A	ll surfaces

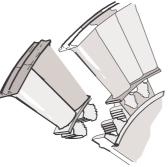


Fig.5 Fir-tree roots

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SYSTEM DESCRIPTION MBT	Respons. dept	Date 2004-02-10	Reg. M DB 101		
GAS GENERATOR SYSTEM	Prepared B. Wassbe	erg	YAMAMA	CEMENT	

Bearings

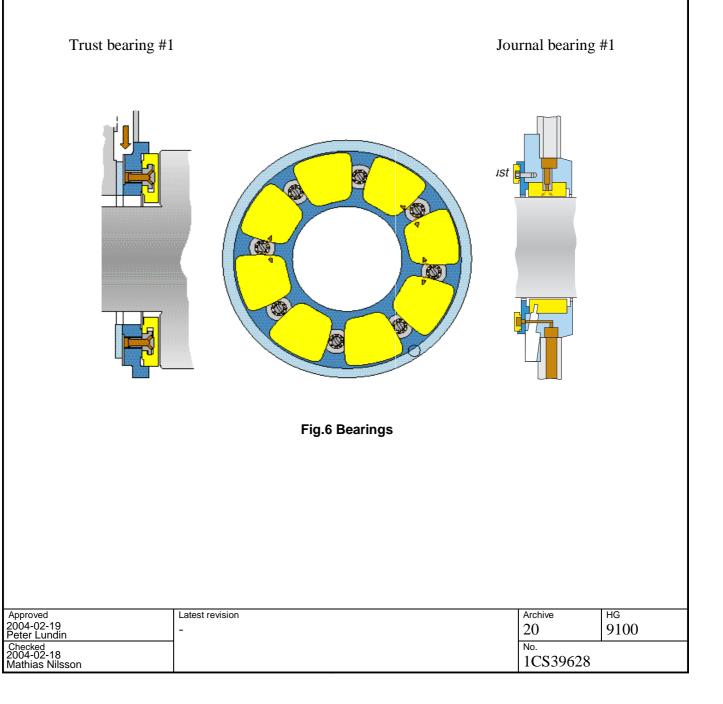
The bearings are of tilting pad design with a directed lubrication system.

The bearings are equipped with temperature sensors and vibration transducers.

Two journal bearings, no. 1 and 2, numbered from the inlet to the exhaust and one thrust bearing located next to journal bearing no.1 carry the gas generator rotor.

While the bearing housing of the bearing no 1 is kept subatmospheric, the housing of bearing no 2 is pressurized as it is located next to the compressor discharge. This permits size reduction and reduces the use of intricate labyrinth seals.

During operation, oil is continuously supplied to the bearings. Return oil from the bearing casings is led back to the lube oil tank by gravity. See also the lubrication oil system, MBV.



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GAS GENERATOR SYSTEM	Prepared B. Wassbe	org	YAMAMA	CEMENT

Cooling and sealing air

The cooling and sealing air are taken from the different bleed cavities and from the compressor discharge.

Cooling air is used for cooling the compressor turbine vanes, blades and discs. Sealing air is used to prevent hot gases from entering the bearing housing or oil leakage.

See also cooling and sealing air system, MBH.

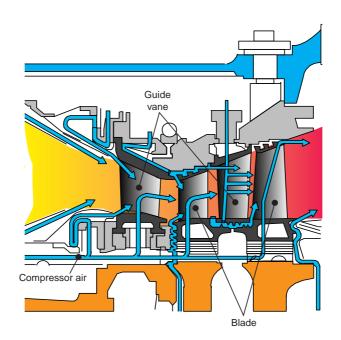


Fig.7 Cooling air - compressor turbine

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	YSTEM DESCRIPTION	Respons. dept	Date 2004-02-10	Reg. M DB 101
	IBT AS GENERATOR SYSTEM	Prepared B. Wassbe		YAMAMA CEMENT
N	Jain components			
•	MBT10CP005			
	The transmitter is continuously monitoring the	absolute pre	essure before th	e inlet plenum.
•	Pressure transmitter, compressor inlet flow MBT10CP010			
	The transmitter is continuously monitoring the and before the compressor inlet.	differential	pressure betwee	en before the inlet plenu
•	Pressure transmitter, compressor discharge pres MBT10CP015	ssure		
	The transmitter is continuously monitoring the	absolute pre	essure after the	compressor.
•	Pressure transmitter, compressor discharge pres MBT10CP020	ssure		
	The transmitter is continuously monitoring the	absolute pre	essure after the	compressor.
•	Pressure transmitter, compressor discharge pres MBT10CP025	ssure		
	The transmitter is continuously monitoring the	absolute pre	essure after the	compressor.
•	Speed transducer, GG speed MBT10CS005			
	The transducer is continuously monitoring the s from overspeed. It is also used for governing.	speed of the	GG rotor. It is	used to protect the rotor
	High speed (H1) initiates a turbine trip.			
•	Speed transducer, GG speed MBT10CS010			
	The transducer is continuously monitoring the	speed of the	GG rotor. It is	used to protect the rotor
	from overspeed. It is also used for governing. High speed (H1) initiates a turbine trip.			
~		CC rotor		
•	Axial position transducer, Axial displacement (MBT10CG005	oo rotor		
	The transducer is continuously monitoring the a Axial displacement (L1) initiates an alarm.	axial positio	n of the GG rot	or.

Axial displacement (L1) initiates an alarm. Axial displacement (H1) initiates an alarm. Big axial displacement (L2) initiates a turbine trip.

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S	YSTEM DESCRIPTION	Respons. dept	Date	9 (16) Reg.
М	IBT	GRPD Prepared	2004-02-10	M DB 101
G	AS GENERATOR SYSTEM	B. Wassbe	rg	YAMAMA CEMEN
•	Key phasor, GG rotor angle			
	MBT10CG010 The key phasor detects rotor angle at balance	ing of the GG r	otor	
		-	0101.	
•	Temperature transmitter, compressor inlet to MBT10CT005	emperature		
	The PT100 is continuously monitoring the a	ir temperature b	before the comp	pressor inlet.
•	Temperature transmitter, thrust bearing (no.	1) temperature		
	MBT10CT010 The PT100 is continuously monitoring the b	acring tomporat	ture The transp	nittor is massuring the
	temperature of the escaping oil from the page			initier is measuring the
	High temperature (H1) initiates an alarm.			
	High temperature (H2) initiates an alarm.			
•	Temperature transmitter, thrust bearing (no.	1) temperature		
	MBT10CT015 The PT100 is spare for MBT10CT010.			
•	Temperature transmitter, journal bearing (no	a 1) temperature	x	
•	MBT10CT020	<i>J.1)</i> temperature	,	
	The PT100 is continuously monitoring the better temperature in one of the bearing pads.	bearing temperat	ture. The transm	nitter is measuring the
	High temperature (H1) initiates an alarm.			
	High temperature (H2) initiates an alarm.			
•	Temperature transmitter, journal bearing (ne	o.1) temperature	e	
	MBT10CT025 The PT100 is spare for MBT10CT020.			
	-			
•	Temperature transmitter, compressor discha MBT10CT030	rge temperature	;	
	The TC is used for performance evaluation.			
•	Temperature transmitter, compressor discha	rge temperature	,	
	MBT10CT035	J		
	The TC is used for performance evaluation.			
•	Temperature transmitter, compressor discha	rge temperature)	
	MBT10CT040 The TC is used for performance evaluation.			
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	YSTEM DESCRIPTIC	DN	Respons. dept	Date	Reg.	10 (16)
	BT AS GENERATOR SY	STEM	GRPD Prepared B. Wassbe	2004-02-10	M DB 101	A CEMENT
				<u> </u>	TAMAM	ACEMENT
•	Temperature transmit MBT10CT045 The PT100 is continu temperature of the eso High temperature (H1 High temperature (H2	ously monitoring the caping oil from the 1) initiates an alarm 2) initiates an alarm	ne bearing temperat pads.	ture. The transi	nitter is mea	usuring the
•	Temperature transmit MBT10CT050 The PT100 is spare for		(no.2) temperature	; ;		
•	Temperature transmit MBT10CT055 The PT100 is continu	-	-	ofore the com	rassor inlat	
•	The PT100 is continu Temperature transmit		-		pressor linet	•
	MBT10CT060 The PT100 is continu	-	-	before the com	pressor inlet	
•	Vibration transducer, MBT10CY005	bearing (no.1) vibr	ation			
	The accelerometer is High vibrations (H1) High vibrations (H2)	initiates an alarm.	-	s.		
•	Vibration transducer, MBT10CY010	bearing (no.2) vibr	ation			
	The accelerometer is High vibrations (H1) High vibrations (H2)	initiates an alarm.	-	8.		
•	Flame detector, main MBT10CQ005				•	
	The flame detector in Flame out will trip the		g start up and detec	cts flame out di	iring operati	ion.
•	Flame detector, torch MBT10CQ010 The flame detector in			ets flame out du	uring operation	ion.
	Flame out will trip the				0 · r · · ·	
•	Guide vane control MBT10AE005 The rotary actuator is feed-back.	driven by an AC-se	ervo motor. A posi	tion transducer	(RVDT) gi	ves position
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SYSTEM DESCRIPTION MBT	Respons. dept	Date 2004-02-10	Reg. M DB 101
GAS GENERATOR SYSTEM	Prepared B. Wassber	rg	YAMAMA CEMENT
 during start and low load. The limit positions are mechanical lim Turbine trip is activated if not open du Bleed valve 2 (spring opening type) MBT10AA010 The bleed valve no.2 is a regulating, pr during start and regulating at part load A position transducer (analogous) give 	0AA005 eed valve no.1 is an on/off valve of butterfly type, pneumatically actuated. The valve is ope start and low load. mit positions are mechanical limit switches. he trip is activated if not open during start-up. valve 2 (spring opening type) 0AA010 eed valve no.2 is a regulating, pneumatically actuated, butterfly valve. The valve is open		
• Ignition system MBT10AV005 The spark plug (E01) is powered by th	e ignition exciter (T0	1).	

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Function

Start up

The starting procedure is generally described in the Starting system description, MBJ.

The electrical starting motor accelerates the gas generator rotor to purging speed. The purging continuous for a time sufficient to ventilate the gas turbine and the complete exhaust system. When the purging time has elapsed fuel is injected and the gas turbine is ignited. The GG rotor accelerates, with help from the starting motor, until self-sustaining speed.

Continuous operation

The gas generator speed varies dependant of load and ambient air conditions. The gas generator output is limited by the maximum rotor speed or the exhaust gas temperature.

Shut down

When shutting down the combustor, the gas generator speed slowly decreases until reaching the barring speed of the electrical starting motor. Barring is then continued until the gas generator is cooled down. After this, the starting motor is stopped and the gas generator brought to stand still.

Stand still

The gas generator is kept at stand still.

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Disturbances

Gas turbine trip and Generator breaker trip

A gas turbine trip interrupts the fuel flow to the gas generator. The gas generator speed decreases until the barring speed is reached. The barring continues until the cooling down period is finalized. After this, the gas generator is brought to a stand still.

A generator breaker trip decreases the fuel flow to the gas generator to prevent over-speeding of the power turbine. The gas generator is brought down to nominal speed, no load until the generator breaker is synchronized again.

Loss of power supply

Loss of main AC power supply trips the gas turbine.

System faults

If there are any damages on turbine, compressor, bearings or combustion chamber the system may not be started or has to be shut down.

If bleed valve MBT10AA005 or MBT10AA010 not is opened during start, the gas turbine will be tripped out.

Other faults

The gas generator is dependent of its auxiliary systems for proper function. Faults in any of these systems may restrict or interrupt continued start up or operation.

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SYSTEM DESCRIPTION MBT	Respons. deptDateReg.GRPD2004-02-10M DB 101	
GAS GENERATOR SYSTEM	Prepared B. Wassberg YAMAMA CEMENT	
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Technical specification

Design criteria and standards

Direction of shaft rotation Anti-clockwise looking in the reverse direction of flow.

Dimensioning data

•	Pressure ratio	14:1 at ISO-conditions
•	Nominal speed	9770 rpm at ISO-conditions

Engineering data

Figures given below might differ somewhat from project to project Nominal flow 80 kg/s

Installation

The gas generator is bolted by a flange connection to the power turbine. The complete unit, gas generator and power turbine, is mounted on the main base frame by a fix point and pendulum supports at the power turbine end and a flexible support in the front of the gas generator. As the different sections of the gas generator is built up as removable modules, this also permits easy access and fast maintenance.

Materials

Compressor

Discs	
Stages $1-5$	ASTM SA 508 CL4
Stages 6 – 10	NIM 901-AMS 5661
Blades	
Stage 1	Titanium alloy (Ti 6 Al 4V)
Stages 2 – 10	X12 Cr Ni Mo 12 (ASTM A 565)
Surface coating	SSA12
Vanes	
Stage $0 - 1$	X20Cr13 (AISI 420)
Stage 2 – 10	X20 CR MO V12.1 (ASTM A437 B4B)
	Stages 6 – 10 Blades Stage 1 Stages 2 – 10 Surface coating Vanes Stage 0 – 1

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MBT GAS GENERATOR SYSTEM		Prepared B. Wassbe		YAMAMA	CEMENT
			-		
Combustion chamber					
Combustion chamber Surface coating	Hastelloy X Thermal barr	rier coating			
Compressor turbine					
• Discs	NIM 901-AN	AS 5661			
• Blades					
Stages $1-2$	IN 792 Vapor depos	ited Al coating with	n Distinum		
Surface coating Vanes 	v apor depos	ited Al-coating with	i é latiliulíl		
Stage 1	IN 792				
Stage 2	IN 939				
Surface coating	Vapor depos	ited Al-coating with	n Platinum		
Component data					
 Number of compress 	or stages	10			
 Number of turbine st. 		2			
• Thrust bearing type	Tilting pad				
 Journal bearing type Tilti Rotor design Elect Rotor weight (incl. blades) 1620 		Tilting pad			
		Electron-beam w	elded		
		1620 kg			
		Single, annular			
Burner type		DLE, Dual fuel			
Number of burnersIgnition system		18 1 pilot (torch) bu	rner		
		i phot (toren) ou	inci		
See the system lists.					
Weight					
Total weight of the gas gen	erator is 9500 k	.g.			
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hecked 004-02-18				No.	1 -
athias Nilsson				1CS39628	

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IEMENS					Sheet
					16 (16)
SYSTEM DESCRIPTION		Respons. dept		Reg.	
MBT		GRPD Prepared	2004-02-10	M DB 101	
GAS GENERATOR SYSTEM		B. Wassb	erg	YAMAMA (CEMENT
Testing and service					
Testing during normal operation					
N/A					
Accessibility during normal opera	tion				
N/A					
Index of components					
MBT10AA005		Spe	ed transducer, C	GG speed	
Bleed valve 1	11	MBT	10CT005	-	
MBT10AA010			mpressor inlet te	emperature	
Bleed valve 2	11		10CT010		
MBT10AE005			ust bearing (no.	1) temperature	
Guide vane control	10		I0CT015		
MBT10AV005	1.1		rust bearing (no.	1) temperature	
Ignition system	11		10CT020	1	
MBT10CG005	o		rnal bearing (no 10CT025	(1) temperature	
Axial displacement GG rotor MBT10CG010	8			1) tomporature	
Key phasor, GG rotor angle	9		rnal bearing (no 10CT030	(1) temperature	5
MBT10CP005)		npressor discha	rge temperature	x
Compressor inlet pressure	8		10CT035	ige competatore	
MBT10CP010		Cor	npressor dischar	rge temperature	e
Pressure transmitter, compressor inlet	flow 8		10CT040	C	
MBT10CP015		Cor	npressor dischar	rge temperature	e
Compressor discharge pressure	8		10CT045		
MBT10CP020			rnal bearing (no	.2) temperature	
Compressor discharge pressure	8		IOCT050		
MBT10CP025	0		rnal bearing (no	.2) temperature	
Compressor discharge pressure	8		IOCT055		
MBT10CQ005 Flame detector, main flame detection	10		npressor inlet te 10CT060	mperature	-
MBT10CQ010	10			mparatura	
Flame detector, torch and main flame			npressor inlet te 10CY005	mperature	-
detection	10		ring (no.1) vibr	ation	
MBT10CS005	10		10CY010		-
			ring (no.2) vibr]

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