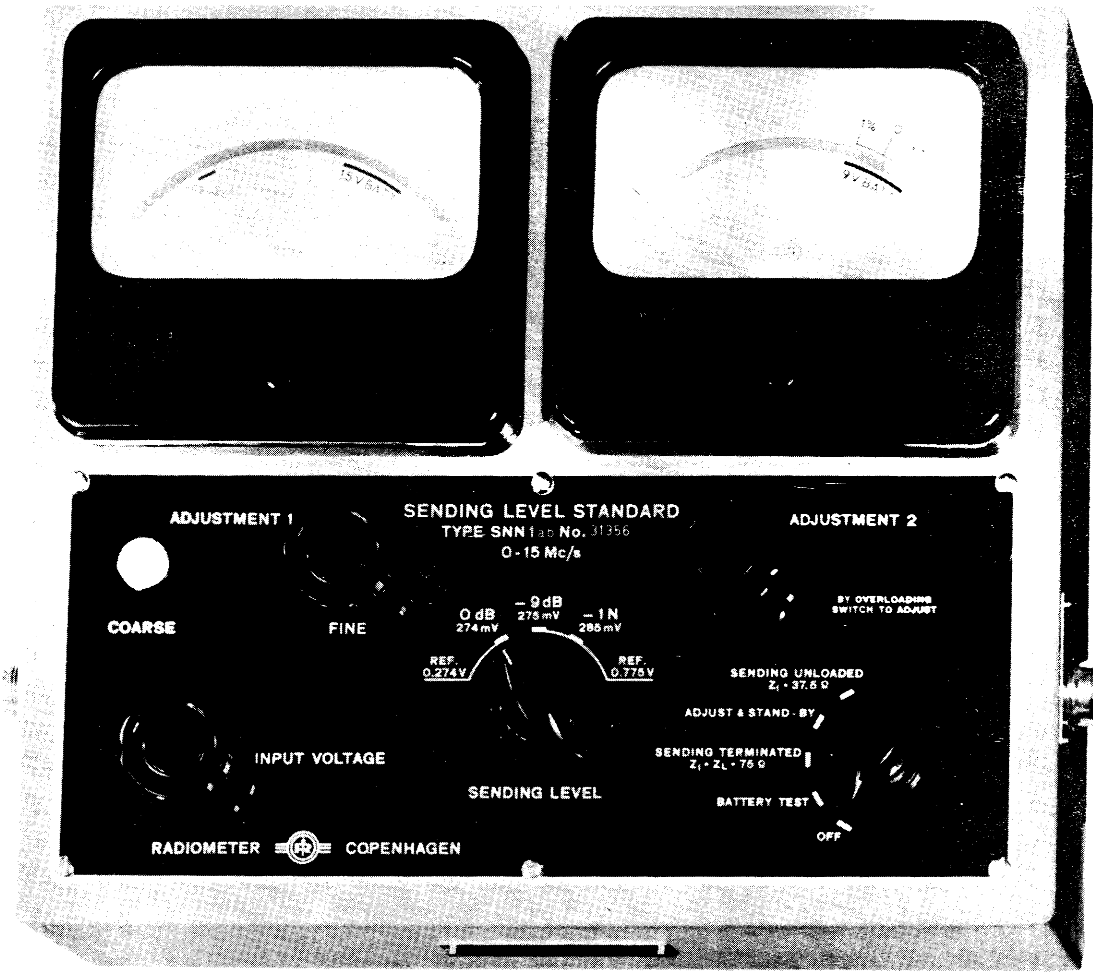
INSTRUCTION AND OPERATING MANUAL
FOR

Type SNN1c

SENDING LEVEL-STANDARD


ADJUSTMENT 1
SENDING LEVEL STANDARD
TYPE SNN 1ab No. 31356
0-15 Mc/s
ADJUSTMENT 2
COARSE
FINE
0 dB
274 mV
-9 dB
275 mV
-1 N
285 mV
REF.
0.274 V
REF.
0.775 V
BY OVERLOADING
SWITCH TO ADJUST
SENDING UNLOADED
ADJUST & STAND-BY
SENDING TERMINATED
BATTERY TEST
OFF
INPUT VOLTAGE
SENDING LEVEL
RADIOMETER
COPENHAGEN

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INTRODUCTION

The type SNN1 Sending Level-Standard is a high-precision instrument for the accurate calibration of level measuring instruments, and the exact measurement of their frequency responses.

When fed from a suitable signal generator, the Sending Level-Standard can be set to supply three voltage levels with an accuracy better than 1% over the entire frequency range from d-c to 15 Mc, and with a well-defined source impedance.

The output levels are referred to 1 mW into 75 ohms and 600 ohms, respectively, and they are expressed in dB and nepers, which provides for convenient calibration of instruments with different readings.

The highly expanded meter scale carries marks for ±1% deviations from the standard levels, and with 1% corresponding to 7 mm scale length, the relative reading accuracy reaches the extraordinary value of 0.1%. This facilitates the operation of the instrument, because it is possible even at a distance to establish whether or not the level is correctly set. Furthermore the 1%-scale can be utilized at specific measurements, such as measurement of small filter transmission losses within the pass-band or measurement of small variations in signal generator outputs caused by line voltage variations.

SECTION 1
GENERAL DESCRIPTION

The principle of the instrument appears from fig. 1/1 of the schematic diagram. From a suitable a-c or d-c generator connected to the Level-Standard a current is passed through the filament of a small battery-type diode to the resistors of the output network.

The current in the filament gives rise to a certain plate current, and as the plate voltage has been chosen so high that the diode is saturated, the plate current which is measured with J2 can be used as a measure of the filament current.

If the plate current is kept constant, the diode operates as a constant-current generator, and the output network can therefore be transformed into the equivalent diagram shown in fig. 1/2. From this it appears that the output circuit is equivalent to a constant emf in series with 75 ohms.

The instrument is adjusted at d-c and as a reference is used an especially sturdy temperature compensated moving-coil meter with a scale length of 100 mm. During the adjustment the output is generally short-circuited, but by opening an internal connection the adjusting voltage can be drawn from the output connector.

The operating point of the diode has been so selected that the plate current increases by about the 10th power of the filament current. This provides for the expanded meter scale which carries marks for ±1% deviation from the standard levels.

In the schematic diagram shown in fig. 1/1 the plate current of the tube is added to the measuring current and this would give rise to a reversal error at d-c. This source of error has been eliminated by using the coupling shown in fig. 1/3. With good approximation the plate current acts on the filament symmetrically around the center, and with the two identical resistors of 39 kilohms a bridge coupling has been formed in which the plate current does not influence the measuring circuit.

The instrument can be set to three output levels:

0 dB/0.274 V	= 274 mV	(273.9 mV)
−9 dB/0.775 V	= 275 mV	(274.8 mV)
−1 N/0.775 V	= 285 mV	(285.0 mV)

The output impedance is kept unchanged at 75 ohms.

In one of the two measuring positions of the instrument, SENDING TERMINATED, the output level is correct at external termination with 75 ohms. In the other measuring position, SENDING UNLOADED, the level standard is internally loaded with 75 ohms so that instrument with a high input impedance can also be calibrated at the said levels.

The advantage of using a directly heated diode instead of e.g. a thermocouple is that the thin filament reacts very quickly to changes in level. Thus, when switching from ADJUST & STAND-BY to one of the sending positions, the meter reading has reached its final value after only 1.5 seconds.

This advantage has furthermore been utilized to protect the diode against overload. A fast relay has been inserted in the plate circuit, and when the plate current exceeds a permissible value, the input is short circuited by the contacts of the relay. In this way the diode is secured against overload of up to 8 times. An overload is indicated by the left-hand meter, and the relay is reset by switching to ADJUST & STAND-BY.

As it is often difficult to set the output from a signal generator within the close limits desired for the level adjustment, the instrument is provided with a fine adjustment knob, INPUT VOLTAGE, which covers a $\pm 2.5\%$ range.

The useful life of the built-in batteries amounts to at least 300 hours. The battery voltages are checked by means of the two meters when the switch is set to position BATTERY TEST. The batteries consist of 7 identical cells of 25^{ϕ} x 50 mm and are readily replaceable.

SECTION 2
OPERATING INSTRUCTIONS

2.1 CONNECTING THE GENERATOR

The input impedance of the instrument is about 75 ohms in all positions of the operating switch, and the voltage fed to the instrument should normally not exceed about 1 volt rms.

To avoid unnecessary overload the voltage fed to the instrument should be checked before switching to the measuring positions.

Accurate measurements require a rather stable generator voltage, so in many cases it will be necessary to stabilize the supply voltage of the generator.

2.2 BATTERY TEST

The deflection of both meters, which are independent of the setting of the other knobs, must be within the black field.

If only the adjusting battery is too much discharged, you may sometimes interchange it with one of the cells in the anode battery. Replacing the batteries is described in section 4.4.

2.3 ADJUSTMENT

(1) Unfold the support bracket to put the instrument in a sloping position which provides for increased convenience and accuracy of the meters.

(2) Set the operating switch to OFF and check the zero of the meter.

(3) Choose the desired output level with the switch SENDING LEVEL.

(4) Set the operating switch to ADJUST & STAND-BY

(5) Rotate the knob ADJUSTMENT 1 until the needle of the left-hand meter points at the calibration mark.

(6) Rotate the knob ADJUSTMENT 2 until the output meter reads 0%.

The output is normally short circuited in the position ADJUST & STAND-BY, but by opening an internal short circuit placed on top of the operating switch the adjusting voltage can be drawn from the output connector.

2.4 SENDING TERMINATED

At an external load with 75 ohms an rms level is had which at correct adjustment is equal to that set to with the switch SENDING LEVEL.

(1) Make the adjustment as described in the preceding section. Switch to SENDING TERMINATED.

(2) Adjust the generator voltage so that the right-hand meter reads 0%. Make the fine adjustment with the knob INPUT VOLTAGE.

(3) Check the adjustment in position ADJUST & STAND-BY once more before the final measurement.

The highest accuracy of measurement is obtained when switching over rapidly so that the cooling of the filament of the tube is only negligible.

2.5 SENDING UNLOADED

In this position the Sending Level-Standard is internally loaded with 75 ohms, and the output impedance is 37.5 ohms. Thus instruments with a high-impedance input will be calibrated at the voltage level indicated by the switch SENDING LEVEL. Moreover the measurement is made as stated in item 2.4.

Make sure that the input impedance + the lead capacity does not load the instrument so much that errors are introduced. If the load cannot be avoided, it is an easy matter to compensate for voltage drops of up to 1% by means of the scale of the right-hand meter.

At a purely ohmic load of R_L ohms the voltage drop in per cent ΔA is

$$\Delta A = \frac{R_i}{R_i + R_L} \cdot 100 = \frac{37.5}{37.5 + R_L} \cdot 100\% \quad (R_L \text{ in ohms})$$

At a purely reactive load of X_L ohms you will get for

$X_L >$ about 150Ω $(X_L^2 \gg R_i^2)$

$$\Delta A \approx \frac{1}{2} \left(\frac{R_i}{X_L}\right)^2 \cdot 100 = \frac{1}{2} \left(\frac{37.5}{X_L}\right)^2 \cdot 100\% \quad (X_L \text{ in ohms})$$

As will be seen an error of 0.1% occurs at an ohmic load of 37.5 kΩ and at a capacitive load of 840 Ω ∿ about 20 pF at 10 megacycles.

2.6 STAND-BY

When switching to another measuring range on the connected generator, or when changing the source under measurement, the operating switch of the Sending Level-Standard is set to STAND-BY thus ensuring optimal stability of the operating point of the tube.

2.7 OVERLOAD PROTECTION

When the input voltage exceeds its normal value by about 5% (SENDING LEVEL in position −1N/0.775 V), a fast relay will operate and shortcircuit the input in series with a resistor of 15 ohms. The overload is indicated by the meter deflecting to OVERLOADED. The relay is reset with the operating switch in position ADJUST & STAND-BY. A readjustment should be made, if necessary.

The diode is secured against up to 8 times overload, but even a smaller overload may give rise to permanent displacement of the operating point of the tube and should therefore be avoided.

2.8 MEASURING WITH A SUBSEQUENT ATTENUATOR

In many cases the Sending Level-Standard will be used with a subsequent attenuator for the accurate setting of very low levels. To obtain the maximum accuracy the connecting cables should be short so that the resistance in the ground wire from the generator via the SNN1 and the attenuator to the receiver is reduced as much as possible. Generally it is most expedient to establish a ground connection at the generator. Furthermore the generator and the receiver should be well shielded to avoid coupling around the attenuator.

2.9 MEASURING WITH AN ARBITRARY TERMINATION

The Sending Level-Standard keeps the emf constant, so the instrument can be used as a generator for accurate loss measurements.

If you want to compute the output voltage at an arbitrary load impedance, make use of the values stated for the output impedance of the level-standard. In the position SENDING TERMINATED the output impedance is 75 Ω in series with 0.06 pH. This corresponds to only 3^{o} phaseshift at 10 Mc, so the phaseshift can be neglected in most cases. The emf is twice the value indicated by the switch SENDING LEVEL.

SECTION 3
DESCRIPTION OF INSTRUMENT

3.1 INTRODUCTION

In the subsequent text reference is made to the diagram No. 1554-A4 in which the main circuit between the input connector and the output connector appears as a heavy line. The parts in which the generator current does not flow have been drawn in the lower part of the diagram.

3.2 INPUT CIRCUIT

Via the input connector the signal is fed to a variable voltage divider (INPUT VOLTAGE) by means of which the output voltage can be varied by about ±2.5%, provided that the impedance of the generator is about 75 ohms. If the impedance is 0 Ω, the range of variation drops to about 1.5%.

When the operating switch is not in one of the two measuring positions, the input impedance is kept unchanged = about 75 ohms with the resistor R4 (pos. B3) coupled to section No. 1 of the switch.

3.3 TUBE CIRCUIT

The type DF67 battery tube is coupled as a diode and forms the current measuring element. The tube is aged and selected, and the final adjustment of the operating point has been made with R6 which is placed in parallel with the filament. (The adjustment of R6 is described in section 4.2). By means of the two resistors R7 and R8 connected to the filament, a bridge coupling has been established which (as mentioned in section 1) separates the plate current from the sending circuit.

Changes in room temperature will bring about a change in the working temperature of the filament and this will cause a change in the plate current of about 1% per degree centigrade. However, it is always possible to set the meter needle to 0% in the temperature range 0-40° C by means of the knob ADJUSTMENT 2 (R13) which controls the sensitivity of the meter.

When the switch SENDING LEVEL is operated, the working point of the tube is changed, and the plate current will change accordingly. To avoid too great changes in the deflection of the output meter the meter sensitivity is changed by means of the resistors R14, R15, and R16 when the SENDING LEVEL switch is operated.

3.4 OVERLOAD PROTECTION

The magnitude of the plate current is generally between about 90 and 150 μA. When it exceeds about 200 μA, the relay operates and short-circuits the input voltage in series with 15 ohms (R1).

When measuring, the calibrating meter is shortcircuited to the chassis via the T-contact of the relay, and a current of about 3 mA flowsin this circuit. When the relay is operated, however, the short circuit is released and the current will flow through the meter, thus indicating the overload.

By setting the operating switch to ADJUST & STAND-BY a free relay winding is inserted in the adjusting circuit so that the relay is reset. At the same time you are automatically reminded of making sure whether or not the operating point has been displaced due to the overdrive. Without this arrangement an overload of 4 times would burn out the filament with certainty, while you will now with the same overload have only a small displacement of the operating point.

The relay is of the polarized type provided with gold contacts to ensure optimal connection.

3.5 ADJUSTING CIRCUIT

As the accuracy of the instrument is mainly based on the calibrating meter I_1, this has been made especially rugged and is carefully temperature stabilized. The final calibration of the meter is made with the resistor R20.

The meter shunt is a universal shunt so it is possible to choose three different output levels for the same meter deflection by means of the switch SENDING LEVEL. The resistors R24 and R25 are so inserted that the impedance in the circuit is constant, thus ensuring a practically constant deflection when switching.

3.6 OUTPUT CIRCUIT

The output-network consists of 0,25 watt precision resistors of the metal film type. They may be expected to keep within ±0.3% of the nominal value.

The temperature coefficient of the resistors is below 0.005%/°C, and as the calibration meter is temperature-compensated, the output voltage of the instrument is practically independent of the temperature (below +0.015% per degree centigrade).

At frequencies above some 100 cycles capacities to ground in the plate circuit will have the effect that one of the bridge resistors of 39 kilohms (see fig. 3/1) and the double value of the internal resistance of the tube (about 100 kilohms) are added in parallel with the resistor R10 (=48Ω) in the output network. Accordingly the output impedance is decreased by about 0.1%, and the output level is decreased by about 0.12% in proportion to the value at d-c (at nominal load). This has been taken in account at the calibration of the instrument so that the output level in the frequency range 1 kilocycle to 1 megacycle is accurate within +0.5%. The magnitude of the corrections mentioned may vary a little, one of the reasons being that the internal resistance of the tube also changes when the operating point is changed. Generally, however, the said conditions are only of importance when making very accurate examinations of frequency response with respect to d-c.

SECTION 4
MAINTENANCE

4.1 CHECKING THE OUTPUT LEVEL

The output level can be checked either at a-c or d-c with a measuring equipment having an accuracy of about 0.1%.

The following procedure is recommended:

(1) Measure the output impedance at d-c from the output connector with the operating switch at OFF. The value should be 75 Ω ±0.3% at 20 °C. (Note: deduct the lead resistance).

(2) Check the output voltage in the position ADJUST & STAND-BY at no load, i.e. R_L>>75 Ω. As the output is normally short-circuited in this position, the internal short-circuit connection on the operating switch must be opened. The output is now analogous with that in position SENDING TERMINATED but offers the advantage that the output level can be set directly by means of the built-in adjusting meter.

Calibrate the instrument carefully (see section 2.3) and make sure that the no-load voltage is twice the voltage indicated by the switch SENDING LEVEL. The voltage is readily measured with Radiometer's pH Meter 4 which uses a standard cell as reference and which measures with an accuracy of ±0.05%.

The no-load voltage measured should be within +0.75% and −0.35% of the nominal value. If that is the case, the tolerance at a-c will be ±0.5% in the medium frequency range, as the output level in this range is about 0.15% lower than at d-c (see section 3.6).

(3) Check the output voltage in a similar way in position SENDING UNLOADED, however, with an external voltage source connected to the input connector. In this position of the operating switch the output is internally loaded with 75 Ω, so the no-load voltage should be equal to the voltage indicated by the switch SENDING LEVEL +0.65, −0.35%. If item 1 and 2 are o.k., this provides a check of the internal load resistor R12 = 75 Ω.

(4) At a-c the level and the frequency response can be checked by loading with a sensitive thermocouple, such as Philips thermocouple

Thl, the hot-wire resistance of which is about 75 ohms. When unsoldering it from its socket and connecting it to the output of the SNN1 without extra leads, it is possible with a sufficient accuracy to check the frequency response of the instrument up to 15 megacycles.

Proceed as follows:

Keep the deflection on the mV-meter of the thermocouple circuit constant, and switch between an external d-c or a-c source and the known frequency. The frequency response is then read on the 1% scale of the output meter with opposite sign.

It should be noted, however, that to measure the frequency response with an accuracy of 0.1% the outputs of the generators have to be very stable, and a device for rapid switching between the measuring frequency and the reference signal is required. As reference signal, a 100-kc generator is recommended. Above 10 Mc a special UHF-thermocouple is also generally required to reach this high measuring accuracy.

4.2 ADJUSTING THE OPERATING POINT OF THE TUBE

After a long time of operation or after a heavy overload the emission of the filament may drop so much that the needle of the right-hand meter cannot be set to 0 with the ADJUSTMENT 2 even at correct setting of the calibrating meter.

In many cases the operating point of the tube can be readjusted by adjusting the resistor R6 mounted in parallel across the filament. Proceed as follows:

Set the switch SENDING LEVEL to position 0 dB/0.274 V. Set the operating switch to ADJUST & STAND-BY, and the needle of the left-hand meter to the calibrating mark. Then set the knob ADJUSTMENT 2 to the extreme right-hand position so that the plate current meter gives maximum deflection.

Now adjust the R6 so that the meter gives about full deflection. If the adjustment is not made between 20 and 30° C, allow for the temperature coefficient of the plate current of +1% per ° C.

Correct setting of the operating point is of importance to the accuracy of the ±1% scale and it always provides for setting the needle of the right-hand meter to 0% in the entire temperature range from 0 to 40^{o} C with the ADJUSTMENT 2.

4.3 REPLACING THE TYPE DF67 TUBE

The instrument is provided with a spare tube which has been burnt in and selected. It can replace the tube supplied with the instrument. Extra spare tubes can be supplied by Radiometer.

The setting of the operating point is described in section 4.2.

As the accuracy of the instrument depends on the adjusting meter and the precision resistors in the output circuit, a tube replacement requires no regular calibration.

4.4 MECHANICAL CONSTRUCTION

The built-in batteries can be replaced when the back panel has been removed. The adjusting battery, the voltage of which can be checked with the left-hand meter, is placed nearest to the spare tube.

A potentiometer or a switch is replaced by removing the front panel and loosening the parts concerned from the front.

Reference is made to the attached assembly drawing No. 1505-A4.

SECTION 5

SPECIFICATIONS

Frequency range:	0-15 Mc
The instrument can readily be used at higher frequencies but with a somewhat reduced accuracy. See below.	
Output levels at nominal termination:	0 dB/0.274 V = 274 mV −9 dB/0.775 V = 275 mV −1 N/0.775 V = 285 mV
The reference levels of 0.274 V and 0.775 V correspond to 1 mW into 75 ohms and 600 ohms, respectively.	
Indication:	root mean square (rms)
Accuracy of output levels (20°C):	
1 kc to 1 Mc	±0.5%
Frequency response (referred to 100 kc):	
1 kc to 1 Mc	~0%
10 cps to 10 Mc	±0.2%
to 15 Mc	±0.5% +)
Change in output level when switching from a-c (1 kc - 1 Mc) to d-c:	about +0.15%
The accuracies stated are valid not only when the instrument is operated with the nominal load, but at any load, provided that the output levels are calculated by using the values stated for the output impedance.	
Reversal effect at d-c	< 0.1%
Accuracy of the ±1%	±0.2%
Output impedance:	
SENDING TERMINATED	75 ohms in series with approximately 0.06 μH
SENDING UNLOADED	37.5 ohms in series with approximately 0.06 μH

+) up to 25 Mc when loaded with 75 Ω in SENDING TERMINATED

Accuracy of output impedance at d-c	±0.3% (20°C)
Setting time when switching from ADJUST and STAND-BY:	about 1.5 seconds
Input impedance:	about 75 ohms
Input voltage: Adjustable over a range of about ±2.5% when the output impedance of the connected generator is 75Ω.	about 1 volt
Temperature range:	0-40°C
Temperature coefficient of output impedance:	below ± 0.005% per °C
Temperature coefficient of output voltage:	<±0.015% per °C
Tube complement:	1 DF67 + 1 spare tube (The spare tube is mounted in the instrument)
Make of tubes:	Philips. The tubes are burnt-in and selected.
Overdrive relay:	Polarized relay, Siemens make, type T. rls. 64ab, T. Bv. 3402/1
Security against burning out of filament:	8 times nominal input voltage
Resetting after overload:	In position ADJUST and STAND-BY
Batteries:	7 1.5 volt or 25Ø x 50 mm (Pertrix type 235, Hellesen types VII-26, VII-27 or the like)
Battery life:	at least 300 hours, however not more than the shelf-life guaranteed by the factory.
Dimensions:	295 x 240 x 115 mm
Weight:	4.7 kilos (10 1/2 lbs.)

SECTION 6
LIST OF COMPONENTS

Condensers:

C1	0.1 μF		
C4	20 pF	ceramic	20%

Resistors:

R1	15 Ω	carbon film	0.3 W	5%	
R2	390 Ω	- -	0.5 W	5%	
R3	1 kΩ	carbon potentiometer, lin.	0.4 W		INPUT VOLTAGE
R4	68 Ω	carbon film	0.3 W	5%	
R6	5 kΩ	carbon potentiometer, log.	0.1 W		
R7	39 kΩ	carbon film	0.2 W	5%	
R8	39 kΩ	- -	0.2 W	5%	
R10	48 Ω	prec. metal film	0.25 W	0.2%	TC $\leq 25 \cdot 10^{-6}/^{o}C$
R11	27 Ω	- - -	0.25 W	0.2%	" " "
R12	75 Ω	- - -	0.25 W	0.2%	" " "
R13	10 kΩ	wirewound potentiometer	4 W		ADJUSTMENT 2
R14	2.7 kΩ	carbon film	0.5 W	5%	
R15	2.7 kΩ	- -	0.5 W	5%	
R16	2.2 kΩ	- -	0.5 W	5%	
R17	136 kΩ	- -	0.5 W		matched
R20	about 2 Ω	wirewound, manganin			matched
R21	115.33 Ω	- -		0.05%	
R22	4.280 Ω	- -		0.5%	
R23	0.392 Ω	- -		1%	
R24	10.4 Ω	- -		0.5%	
R25	9.5 Ω	- -		0.5%	
R26	50 Ω	wirewound potentiometer	2 W		ADJ. 1 COARSE
R27	30 Ω	- -	4 W		ADJ. 1 FINE
R28	27 Ω	carbon film	0.5 W	5%	
R29	139 Ω	wirewound manganin		0.5%	
R30	560 Ω	carbon film	0.5 W	5%	

Tubes:

Tube No. 1: DF67 burnt-in and selected

Spare tube: as tube No. 1

Meters:

11	DS120	10.5 mA (calibrating mark)	8.0 Ω	IBS 209/73
12	DS120	54 microamps ("0%")	2.3 kΩ	IBS 208/72

Relay:

Polarized relay, Siemens, type T. rls. 64ab, T. Bv. 3402/1

Switches:

Operating switch	MEC 739
SENDING LEVEL	MEC 740

Batteries:

E1	1.5 V	1 cell battery 1.5 V	25ᶲ x 50 mm
E2	9 V	6 batteries - -	- - - -

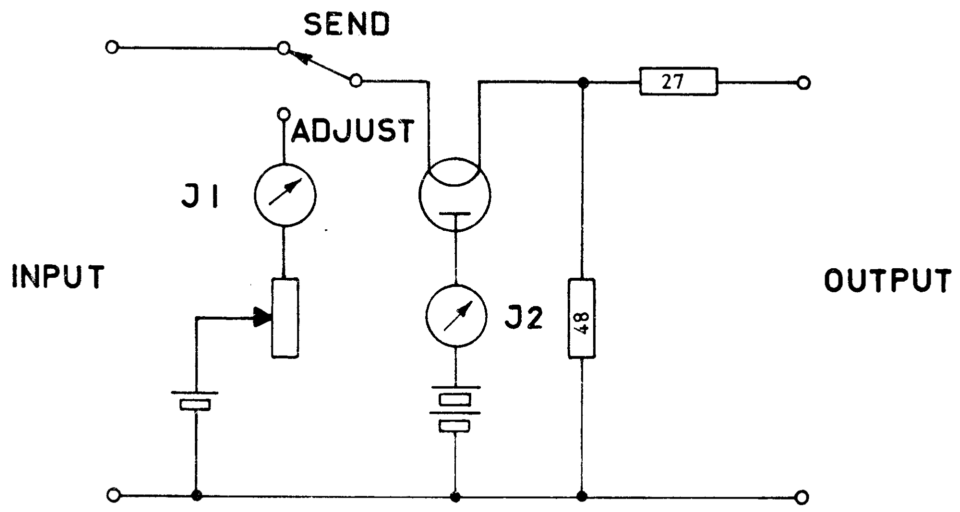


Fig. 1/1 SIMPLIFIED DIAGRAM

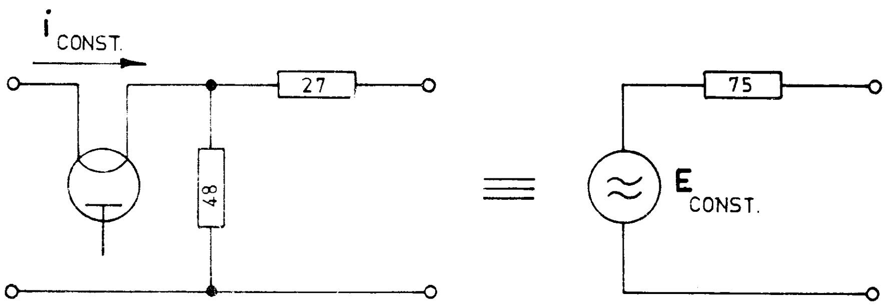


Fig. 1/2 EQUIVALENT DIAGRAMS

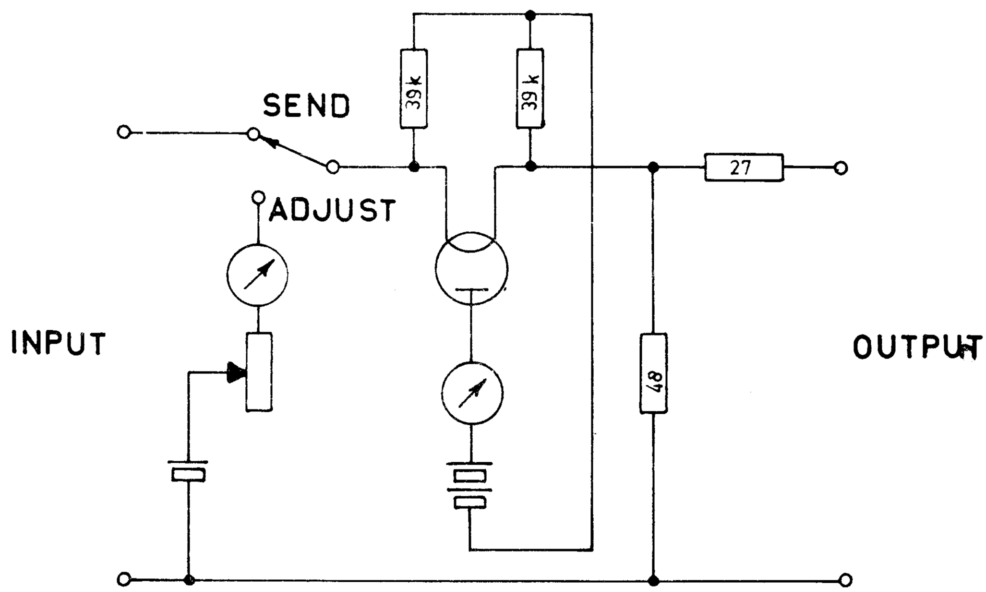


Fig. 1/3 COUPLING FOR COMPENSATING THE REVERSAL ERROR

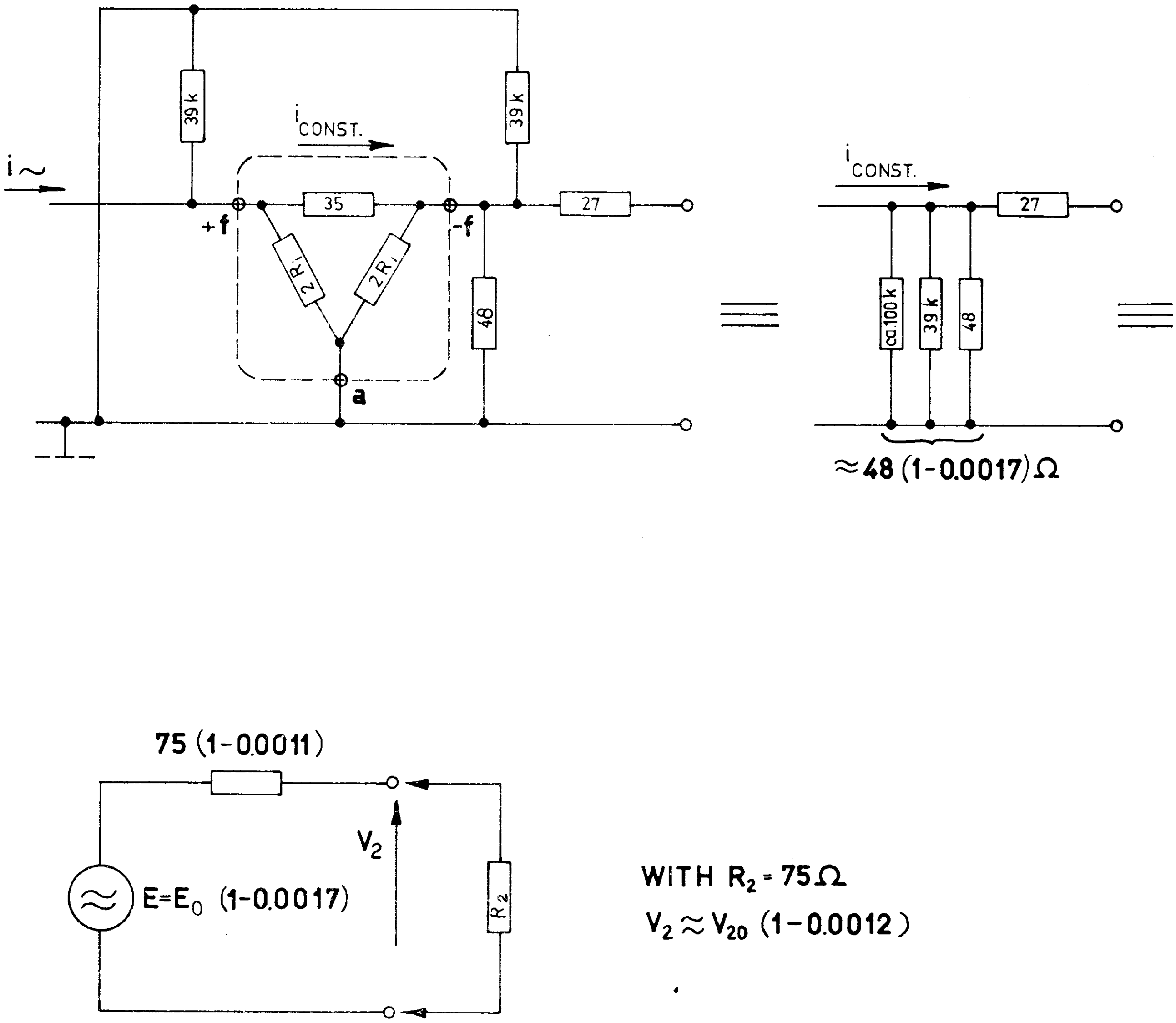
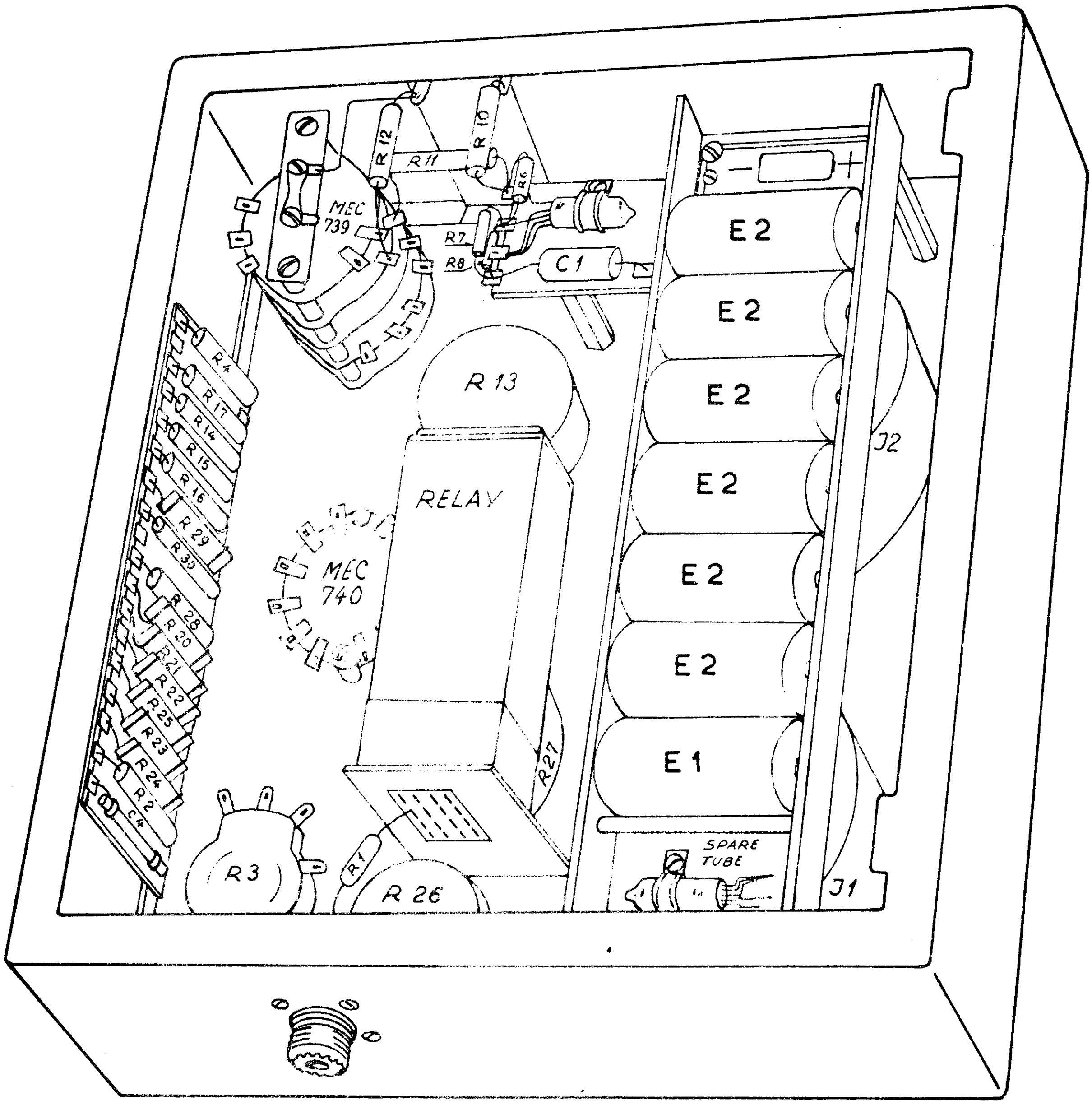
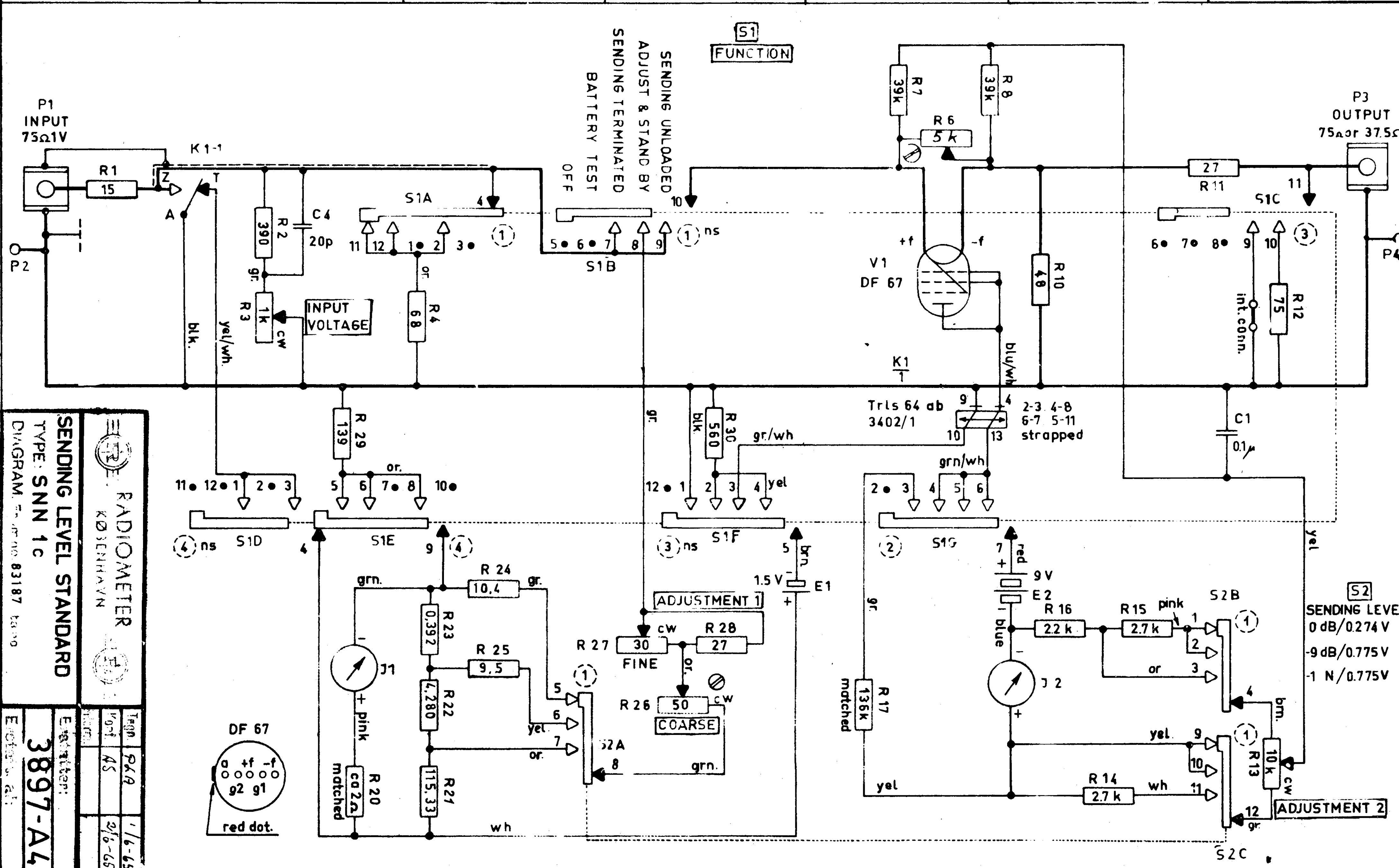


Fig. 3/1 EQIUVALENT DIAGRAMS OF THE OUTPUT NETWORK IN THE FREQUENCY RANGE 1kc-1Mc



PICTORIAL DIAGRAM OF SNN 1



RADIOMETER
KØBENHAVN

SENDING LEVEL STANDARD

TYPE: **SNN 1c**

DIAGRAM. Fremst. no. 83187 tegn.

Tegn.	PLA	1/6-65
Konf.	AS	2/6-65
Godk.		

Erstatter:

3897-A4

Erstattes af: