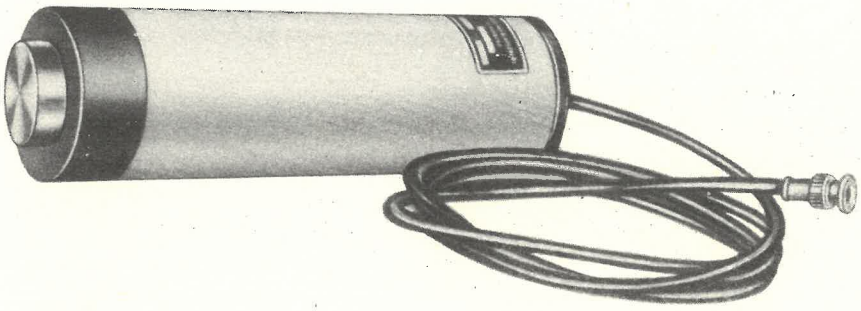
UNIVERSAL SCINTILLATION PROBE

TYPE SSU-3W

OPERATING INSTRUCTIONS



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CONTENTS

1. APPLICATION

Universal probe, type SSU-3W (without amplifier) is intended for measuring alpha, beta and gamma radiation emitting samples. It is adapted for operation with the following types of supplying and counting units:

a/ Universal Radiometer, type RUST-1 (battery)
b/ Universal Radiometer, type RUST-2 (battery)
c/ Universal Radiometer, type RUS-5a (valve)
d/ Universal Radiometer, type MSP-3 (valve)
e/ Universal Radiometer, type URL-1 (valve)
f/ Transistor Scaler, type PT-67 (transistor)
g/ Valve Scaler, type PEL-5a, with pre-amplifier PWW-5a using the following types of screens and stands:

a/ Universal Lead Castle, type DO-1 consisting of:

base segment	1 piece
segment with door	1 piece
intermediate segment	2 pieces
screen segment (top)	1 piece

b/ Manual Sample Changer, type 005
c/ Screen segment, type 006 or 007
d/ Stand, type S-1
e/ Lightproof table, type OSZ-1
f/ Lightproof stand, type SZ-1

2. TECHNICAL DATA

2.1. General parameters

Probe construction and outfit enable to obtain the following functional variants (counters):

- scintillation alpha counter without window
- scintillation alpha counter with window
- scintillation beta counter without window
- scintillation beta counter with window

- scintillation gamma counter (with NaJ/Ti scintillator)
- unit with G-M counter with window (counter is mounted by means of an adapter).

2.2. Electric and radiometric parameters

2.2.1. Supply

D.C. stabilized high voltage 800 - 1400 V, depending on used photomultiplier and scintillator.

2.2.2. Current input

Current consumed by photomultiplier divider does not exceed 35 μA.

2.2.3. Output impulse

50 mV, negative polarity
(for R_{in} = 50 kOhm, C_{in} = 40 pF of counting device impedance). Signal is transmitted through H.V. supply cable.

2.2.4. Background (without lead shield)

Depends on functional system. There are given:

$\leq$ 1 c.p.m. for alpha scintillator
$\leq$ 70 c.p.m. for beta scintillator
$\leq$ 3800 c.p.m. for gamma scintillator.

2.2.5. Efficiency

Efficiency depends on functional system. It is stated in Test Certificate.

Efficiency with scintillators
- alpha with window (^{239}Pu) $>$ 50%, flat source
  without window (^{239}Pu) $>$ 50%, flat source
- beta with window (^{204}Tl) $>$ 18%, flat source
  with window ($^{90}Sr + ^{90}Y$) $>$ 35%
  without window (^{204}Tl) $>$ 18%
  without window ($^{90}Sr + ^{90}Y$) $>$ 30%
- gamma (for ^{60}Co
  2 μCi, dist. 30 cm) $>$ 1600 c.p.m.

2.2.6. Reduction to gammas

For beta scintillator

$$K = \frac{\text{Efficiency with } {}^{90}Sr + {}^{90}Y}{\text{Efficiency with } {}^{60}Co} \geqslant 15$$

2.2.7. Active area

13 sq.cm (for alpha and beta scintillators).

2.2.8. Photomulplier

M12FS35 with magnetic screen

or

M12FS52A with magnetic screen

2.2.9. Scintillators

- alpha with window	ZnS/Ag with foil 1 mg/sq.cm, type S212458
- alpha without window	ZnS/Ag without foil, type S211458
- beta with window	plastic 1 mm on metaplex base with foil 1 mg/sq. cm, type SPF-35
- beta without window	plastic 1 mm on metaplex base without foil, type SPF-34
- gamma	NaJ/T1 Ø 25x25 or Ø 40x25, type SKG-IDU

2.2.10. Probe parameters in conjunction with G-M counter

Counters, type AOH-42 or BOH-42 can be used with this type of probe.

2.2.10.1. Active area: 5 sq.cm.

2.2.10.2. Background: < 40 c.p.m., (without screen).

2.2.10.3. Output impulse: 100 mV, negative polarization.

2.2.10.4. Efficiency with ${}^{90}Sr + {}^{90}Y$ (on Al base 1 mm)
45% with window mass < 1.5 mg/sq.cm.

2.3. Operation parameters

2.3.1. Lightproofness

When scintillators gamma or alpha and beta with windows are used, the probe is fully lightproof. Screening foil 1 mg/sq.cm. does not increase background when luminated with light of 500 lux intensity.

When using scintillators without windows, stands or lightproof screens must be used.

2.3.2. Climatic parameters

Working temperature +5°C + +35°C

Relative humidity $\leqslant 80\%$

Atmospheric pressure: 760 $\pm$ 30 mm Hg;

parameters may get worse as compared with those at temperature 20 $\pm$ 2°C by:

$\pm$ 20% for beta and gamma scintillators,

$\pm$ 25% for alpha scintillators.

2.3.3. Resistance to vibrations

25 $\pm$ 2 Hz/3g.

2.3.4. Connections with supply unit

By means of coaxial cable of length equal 2 m, terminated with plug type BNC-2.5.

2.3.5. Dimensions and weight

- Probe diameter	65.5 mm
- Length (max.)	240 mm (without scintillator)
- Weight	3 kg (with outfit)

Note: Fundamentals, specific probe parameters measured by Technical Inspection Dept., are given in TEST CERTIFICATE which in enclosed to this Instruction Manual.

3. OUTFIT

A set consists of:

- probe (with H.V. divider, photomultiplier, screen etc.)

- blackout disc
- scintillator ZnS/Ag with foil 1 mg/sq.cm.
- scintillator ZnS/Ag without foil
- scintillator, plastics with foil 1 mg/sq.cm.
- scintillator, plastics without foil
- scintillator NaJ/Tl in housing
- G-M counter adapter (AOH-42)
- centring wing for G-M counter
- bottle with paraffin or silicone oil
- Instruction Manual
- Guarantee Book
- Individual packing.

4. OPERATION

4.1. Circuit diagram description

Circuit diagram is shown in Fig. 1. The probe consists of photomultiplier and H.V. divider. One of the chosen scintillator contacts the photomultiplier face. Ionizing radiation falling on scintillator causes emission of short-duration light.

Scintillations are changed into electric pulses by photomultiplier cathode.

These pulses (after amplification in dynodes arrangement) can be recorded by radiometer or scaler.

In order to simplify probe servicing and operation, it has been arranged, that the signal transmitting cable is at the same time supplying the photomultiplier with high voltage. Load resistor is mounted in the scaler. A typical input circuit is shown in Fig. 2. If adapter is used with counter AOH-42 or BOH-42 probe becomes a single counter unit with windows.

Supply and signal offtake does not change. The circuit diagram with G-M counter is shown in Fig. 1e or Fig. 1d depending on photomultiplier with which the probe is equipped.

4.2. Mechanical construction description

The probe is constructed of segments of standard diameter 65.6 mm. In probe head, depending on chosen variant, (2.1.), the scintillator is mounted.

The photomultiplier, mounted in the base is pressed against scintillator by a central spring fitted at the probe bottom. The base is a part of subassembly in which the H.V. divider resistors are mounted.

The coaxial cable for divider unit and for the photomultiplier is connected through a bushing. From the probe the cable passes through a bushing which serves also as an elastic protector against sharp bends. If G-M counter is used; an adapter for the counter is mounted in photomultiplier socket. It enables mounting of the counter, reduces the differences in counter and photomultiplier lengths and by specially arranged contact pins secures the electric supply through photomultiplier socket. For coaxial mounting of G-M counter window in the probe head, a centring ring is used, which is a part of probe outfit.

5. SERVICING

The probe SSU-3W is delivered in typical packing adequate for transport and storing.

IT IS STRONGLY RECOMMENDED TO GET FAMILIAR WITH THIS OPERATING INSTRUCTIONS BEFORE USING THIS PROBE. During storing, the scintillator is not fitted probe; for protection of photomultiplier against damage and unwanted exposure, in the place of scintillator a blackout disc is fitted (Fig. 3).

5.1. Preparation of probe for operation

5.1.1. Scintillation version (Fig. 3)

- Unscrew the head and remove blackout disc. Make sure that the disc does not turn during unscrewing.
- Take the proper scintillator and clean its contact surface with gauze dipped in alcohol. Place the blackout disc, after cleaning, in case in place of scintillator.
- Clean the front of photomultiplier and place in its centre a drop of oil (a bottle of oil is included in the probe outfit) by means of a brush or a stick. Take care to keep photocathode free from all contaminations.
- Carefully touch the photocathode with scintillator and by circular movement distribute the oil on the whole contact area in order to obtain good optical contact.

If this task is properly done, oil traces will appear on the whole circumference of photomultiplier face, when attempting to remove scintillator in the direction of probe axis a strong resistance is encountered.

- Place the scintillator head and screw it up tightly. During this operation the scintillator must not be rotated.

Note: All actions connected with uncovering of photomultiplier front, should be executed at minimum possible illumination. Before using probe for measurement, it should be left for about 1 - 1.5 hours without high voltage.

5.1.2. Preparation of scintillator NaJ/Tl for mounting in the head

This scintillator is executed to COMECON (Council for Mutual Economic Assistance) recommendations and therefore half-rings with sealing gaskets must be used.

The proper arrangement of half-rings with sealing gaskets is shown in Fig. 3.

5.1.3. Counter version (Fig. 3)

- Unscrew the head and remove blackout disc.
- Unscrew probe tube. Now the photomultiplier with stand and H.V. divider, bushing etc., are accessible.
- Unscrew photomultiplier screen. Be careful as photomultiplier is of all glass construction.
- Remove photomultiplier from socket.
- Install G-M counter in the socket of the adapter.
- Fit reducer together with G-M counter in photomultiplier stand.
- Screw on probe tube (housing).
- Place centring ring on the counter face.
- Screw up scintillator head.

5.2. Setting of operation voltage

Read off from TEST CERTIFICATE of this Instruction Manual the value of high voltage corresponding to probe working point for chosen and fitted scintillator. If

probe is to operate in conjunction with radiometers MSP-3, URL-1 or RUS-5a, then the voltage set on meter scale corresponds to voltage on socket BNC-2.5. If probe is connected to radiometer RUST-1 or RUST-2, the high voltage value adjusted by means of switches should be determined by radiometer TEST CERTIFICATE. H.V. supply units of portable radiometers are graduated without external load.

Connecting of scintillation probe causes reduction of voltage on radiometer socket "PROBE", proceed then as follows:

a/ From TEST CERTIFICATE read off the required value of H.V.

b/ In radiometer TEST CERTIFICATE in column "U measured under load" find the voltage value nearest to the value determined under "a".

c/ Read off the value of "U measured under no-load" corresponding to the value found in "b" (in the same line).

Thus found voltage can be set by means of RUST-1 or RUST-2 Radiometer switches.

Example: The TEST CERTIFICATE of probe SSU-3W gives 1240 V as the working voltage. From conversion table of radiometer TEST CERTIFICATE appears that the value of 1242 V (the nearest to 1240 V) in column "U measured under load" corresponds to the voltage of 1324 V in column "U measured under no-load".

This value should be set be means of radiometer switches: coarse 1300 V and fine 25 V (see column "U_{nom}").

Note: The above example is to be regarded as a pattern of a method of setting proper value of high voltage when probe is to be used with radiometers type RUST-1 or RUST-2.

After performing the above described preliminary tasks, probe may be connected to the radiometer.

Valve type instruments (RUS-5a, MSP-3, URL-1) should be allowed a heating period of 15 minutes and their H.V. controllers should be turned fully counter clockwise (minimum value of H.V.). Raise slowly the high voltage to its nominal value, watching at the same time the meter indications. With voltage, corresponding to working point, pulse frequency indicated by meter, with no effect of external

radioactive sources, should not be greater than the background given in TEST CERTIFICATE. A higher pulse frequency (without external radiation source) is the sign of probe being non-lighproof due to foil damage or stand being non-lightproof. For measurement with scaler PEL-5a the following set-up should be formed:

- Probe
- Scaler PEL-5a, discrimination treshold 5 V
- Pre-amplifier PWW-5a, gain x 100
- H.V. supply unit, e.g. ZWN-2.5.

5.3. Measuring procedure

5.3.1. Measuring of alpha emitters

Measurements of samples emitting alpha particles should, in principle, be made by using scintillator ZnS/Ag without windows. In this case probe should be placed in lightproot manual sample changer, type OSZ-1, it enables a swift sample change in lightproof conditions. A light-proof stand, type SZ-1 can also be used, but in this case H.V. must be switched off before each change of sample.

After placing a new sample and closing the door, the H.V. can be switched on after approx. 1 hours but not earlier. The scintillator ZnS/Ag screened with foil surface mass about 1 mg/sq.cm can also be used for measurements. In this case it must be taken into account, that a part of alpha particles will be absorbed in the window. The magnitude of this absorption depends on radiation energy.

In this case, table type OSZ-1, stand OS-1 or stand S-1 can be used, because probe is lightproof itself.

5.3.2. Measuring of samples emitting beta particles

As in case measuring samples emitting alpha radiation, best results are obtained when using plastics scintillator without windows.

Lightproof table type OSZ-1, stand SZ-1 or lead castle, version DO-1 (with a changer 005) must be used then. In energy of beta particles is greater than 0.5 MeV it is advantageous to use plastics scintillator with foil, because absorption in the window does not exceed 5%. So equipped probe is lightproof and facilitates measurements (any stand can be used). Lightproof stand type SZ-1 and a segment

with door of the lead castle, make it possible to vary the distance between scintillator surface and measured sample. In this way isotope identification is possible by means of absorbents placed between radiation source and scintillator. In circumstances of large background, it is recommended to place the probe in lead castle, type DO-1 (made of lead).

In place of segment with door, probe changer segment type 005 can be used (keeping the same Pb equivalent as in case of other segments). Changer 005 is light-proof what facilitates and speeds up sample measurement. Beta measurements can be also executed by means of G-M counter with windows, placed in probe using an adapter. Any stand or sample changer can be used.

If the lead castle is used, the probe background is being advantageously lowered.

5.3.3. Reduction of gamma background

When measuring samples emitting beta radiation, a remarkable influence on obtained results may be exerted by gamma radiation emission or which comes from surroundings. Therefore in many cases the important factor is the reduction of gamma background expressed as:

$$\frac{\text{probe efficiency for beta radiation}}{\text{probe efficiency for gamma radiation}}$$

For type SSU-3W, this quantity is determined for plastics scintillator using radiation sources $^{90}Sr + ^{90}Y$ and ^{60}Co.

5.3.4. Measurement of samples emitting gamma radiation

Gamma radiation measurements can be made by using scintillator type SKG-1D and stand type S-1.

Other types of tables described in p. I can be also used.

5.3.5. Final remarks

a/ When measuring samples of relatively low activities, very important becomes mean square value of error, that is incurred in measuring background.

From this we obtain the minimum measurable activity:

$$A_{min} = \frac{5\sqrt{N}}{t}$$

where: N - total number of pulses when measuring background

t - time of background measurement.

If accurate measured results are to be obtained, the measuring time should be sufficiently long.

b/ When scintillators type ZnS/Ag or NaJ/T1 are used, pulse frequency must not exceed 10,000 c.p.s. otherwise photomultiplier will be overloaded and measuring results will be erroneus.

c/ In the 150,000 c.p.m. range for determining measured sample activity, the following formula gives a good accuracy:

$$A_m = \frac{n_1}{n_2} A_k$$

where A_m - measured activity

n_1 - pulse frequency in A_k measurement

n_2 - pulse frequency in standard measurement

A_k - standard source activity

5.4. Additional notes on operation

5.4.1. Probe design makes it possible to use other organic and inorganic scintillators of 40 mm diameter, recommended by COMECON (Commission for Peaceful Utilization of Atomic Energy in Tbilisi 1965).

It refers specially to scintillators Naj/T1, e.g. well type Ø 40 mm can be mounted without difficulty. Scintillators of other dimensions, e.g. 25x25 mm require an additional fitting ring.

5.4.2. If probe is not to be used for a long period of time, we recommend to replace the scintillator by a blackout disc.

5.4.3. Although the coaxial cable connecting probe and the radiometer is sufficiently flexible, frequent, sharp bendings should be avoided, because the insulation or central wire may get damaged.

5.4.4. If high voltage of a value exceeding 1400 V is accidentally applied to probe, reduce the H.V. to a minimum value and disconnect probe from radiometer. Reconnect not earlier than after 15 minutes.

5.4.5. It must be remembered that strong magnetic fields may lower measuring results, although the photomultiplier is provided with magnetic screen.

6. MAINTENANCE AND REPAIRS

If probe is correctly used, no maintenance is required, except as stated in points 5.4.2.; 5.4.3.; and 5.4.4. Probe must be carefully stored and kept clean.

All contaminations may lead to wrong measuring results. For instance dirty plug BNC-2.5 may cause sparking and what follows, increase the background or measuring results of the sample. Probe repairs should be made in special workshops dealing with this type of instruments.

UNCOVERING THE PHOTOMULTIPLIER WHEN UNDER HIGH VOLTAGE WILL CAUSE A PERMANENT DAMAGE.

When replacing the photomultiplier, voltages on particular electrodes should be properly matched by selecting appropriate resistors for H.V. divider. For photomultiplier M12FS35 or M12FS52A it is sufficient to select resistors R_{14}, R_{13}, R_{12}.

When replacing the photomultiplier, probe characteristics N = f/U/, e.g. pulse frequency as a function of photomultiplier voltage should be measured.

We recommend the following system:

- scaler PEL-5a with pre-amplifier PWW-5a (or similar scaler)
  Input sensivity = 50 mV neg. pol.
  having: R_{in} = 50 kOhm
  C_{in} = 40 pF
  Resolution time 1 μ sec.

- Supply unit H.V. ZWN-2.5

Some positions of TEST CERTIFICATE such as source selection, distance, efficiency, background etc. can be used as auxiliary parameters.

Working point should be selected on the smallest slope of characteristic curve, and efficiency should be comparable with that given in TEST CERTIFICATE.

Background level should not be exceeded.

7. STORAGE AND SHIPPING REQUIREMENTS

The Probe should be stored in rooms free from volatile sulphur compounds, vapours of acids and bases with no perceptible vibrations and shocks and in distance of 1.5 m from heating system devices (it is the nearest permissible distance). The temperature may in the room vary not in excess of +5°C to +35°C and the relative humidity should not exceed the interval of 40% to 80% .

During storing, the probe should be, after each 6 month period, connected to one of the devices mentioned in 5.2. The probe indications should be examined for correctness according to TEST CERTIFICATE (for scintillator type SKG-1D).

The probe can be shipped by any means provided that all precautions have been undertaken to eliminate the risk of mechanical damages (vibrations, shocks), wetting (rain, snow), and the effect of extremely high or low temperature (below -25°C and over +45°C).

For the time of shipping the probe should be placed into its individual packing.

In the case when trucks are used for transportations, it is recommended to use shock-absorbing plates of sponge rubber, or a special transport packing.

8. LIST OF MAIN SUB-ASSEMBLIES

Item No.	Circuit reference	Sub-assembly description	Characteristic designation	Remarks
1	2	3	4	5
1		Scintillator ZnS/Ag	S211458	without foil
2		Scintillator ZnS/Ag	S212158	with foil 1 mg/sq.cm
3		Scintillator plastic	SPF-34	without foil

1	2	3	4	5
4		Scintillator plastic	SPF-35	with foil 1 mg/sq.cm
5		Scintillator NaJ/Tl	SKG-1DU Ø 40x25 SKG 1SU	with halft-rings and sealing
6		Photomultiplier	M12FS52 (M12FS35)	with screen and stand
7		Coaxial adapter	BNC-2.5	plug
8		Coaxial cable	WL-75-0. 63/ 3.7	2 meter long
9	R1	Resistor 2.7 MOhm	MLT-0.5- -2.7 M-I-A	
10	H2-R11	Resistor 5.1 MOhm	MLT-0.5- -5.1 M-I-A	
11	$R_{12} + R_{14}$	Resistor 2.2 MOhm	MLT-0.5- -2.2 M-I-A	matched
12	R_{13}	Resistor 7.5 MOhm	MLT-0.5- -7.5 M-I-A	matched
13	R_{15}	Resistor 5.1 MOhm	MLT-0.5- -5.1 M-I-A	
14	C_1	Capacitor 1 nF/2.5 kV	KSF-041- -1000-10- -2500	
15		Adapter		
16		Centring half-ring		
17		Blackout disc		
18		Bottle with oil		
19		Individual packing		foam styrene

TEST CERTIFICATE UNIVERSAL SCINTILLATION PROBE TYPE SSU-3W

Serial No. .....

1. Number and data of Attestation Certificate issued by Radiation Protection Department of the Office of Polish Government High Commission for Nuclear Energy:

from

2. Photomultiplier type ..... No. .....

3. Efficience and recommended working voltage

		Alpha		Beta		Gamma
		ZnS/Ag without foil	ZnS/Ag with foil	Plastic without foil	Plastic with foil	NaJ/Tl No
Working voltage (V)						~ 900V
Efficiency		%	%	%	%	cpm
Background cpm						
Control radiation source	Isotope					
	Size/Activity					
	Thickness and base material					
	Distance form scintillator					

The probe parameters were measured at:

- counting system sensitivity 50 mV
- R_{in} of counting system 50 kohm
- C_{in} of counting system 40 pF

4. To this certificate are enclosed:
   - Photomultiplier specification
   - Scintillator specification

It is certified that this product is in conformity with Technical Conditions WT-68/S22.

The Unit designed for operation in moderate climatic conditions.

TECHNICAL INSPECTION

Date .....

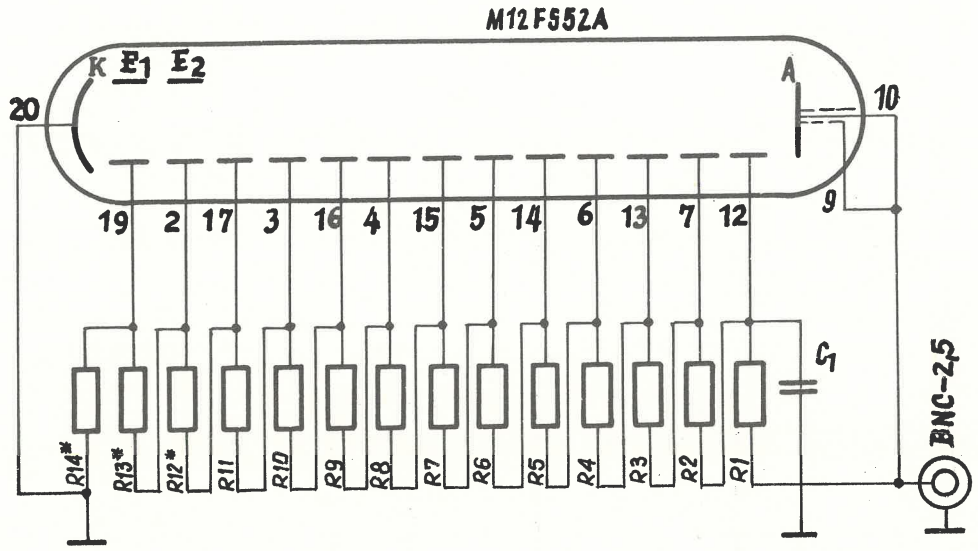

Fig. 1 Circuit diagram for M12FS52A

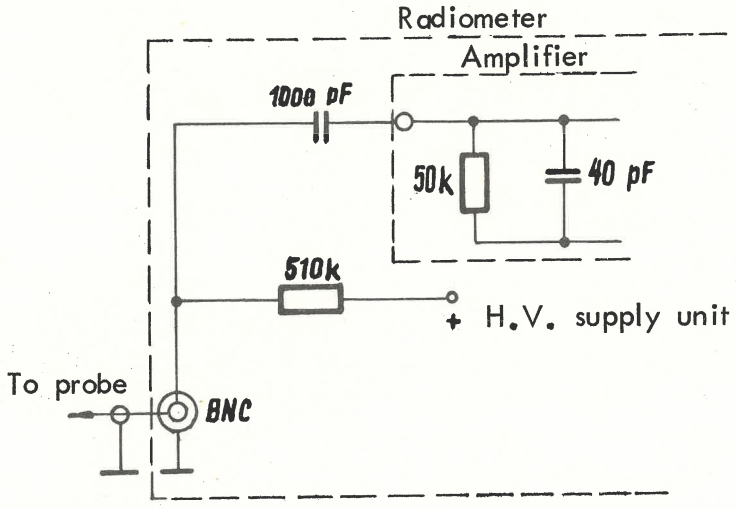

Fig. 2 Input circuit

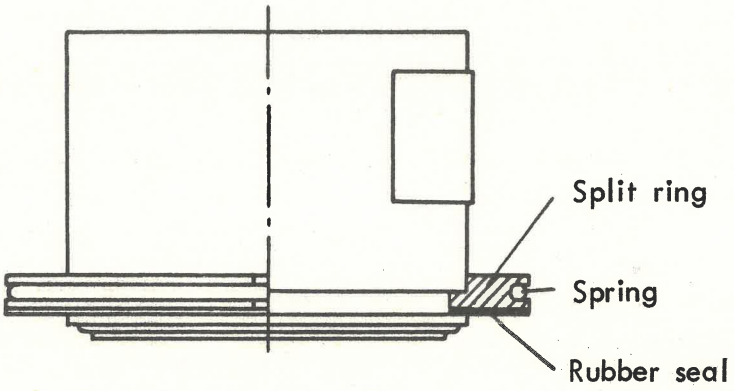

Fig. 3 Scintillator NaJ/Tl, complete