MINISTRY OF SCIENCE, HIGHER EDUCATION, AND TECHNOLOGY

Research and Educational Instrument Factory "KABID"

OPERATING INSTRUCTIONS

Distortion Meter

Type PMZ-9

Scientific Instrument Designing and Production Works "KABID-ZOPAN

Leading Enterprise

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POLAND

CONTENTS

1. Applications

The Type PMZ-9 Automatic Non-Linear Distortion Meter is intended for direct measurement of nonlinear distortion factor of voltage waveforms whose fundamental frequency is contained in the range from 20 Hz to to 20 kHz.

The measurement is performed automatically. The manipulations are limited to the setting of input voltage level, selection of one of the three frequency ranges, and selection of required distortion measuring range. The instrument provides also facilities for frequency measurement in the sound-frequency range.

2. SPECIFICATIONS

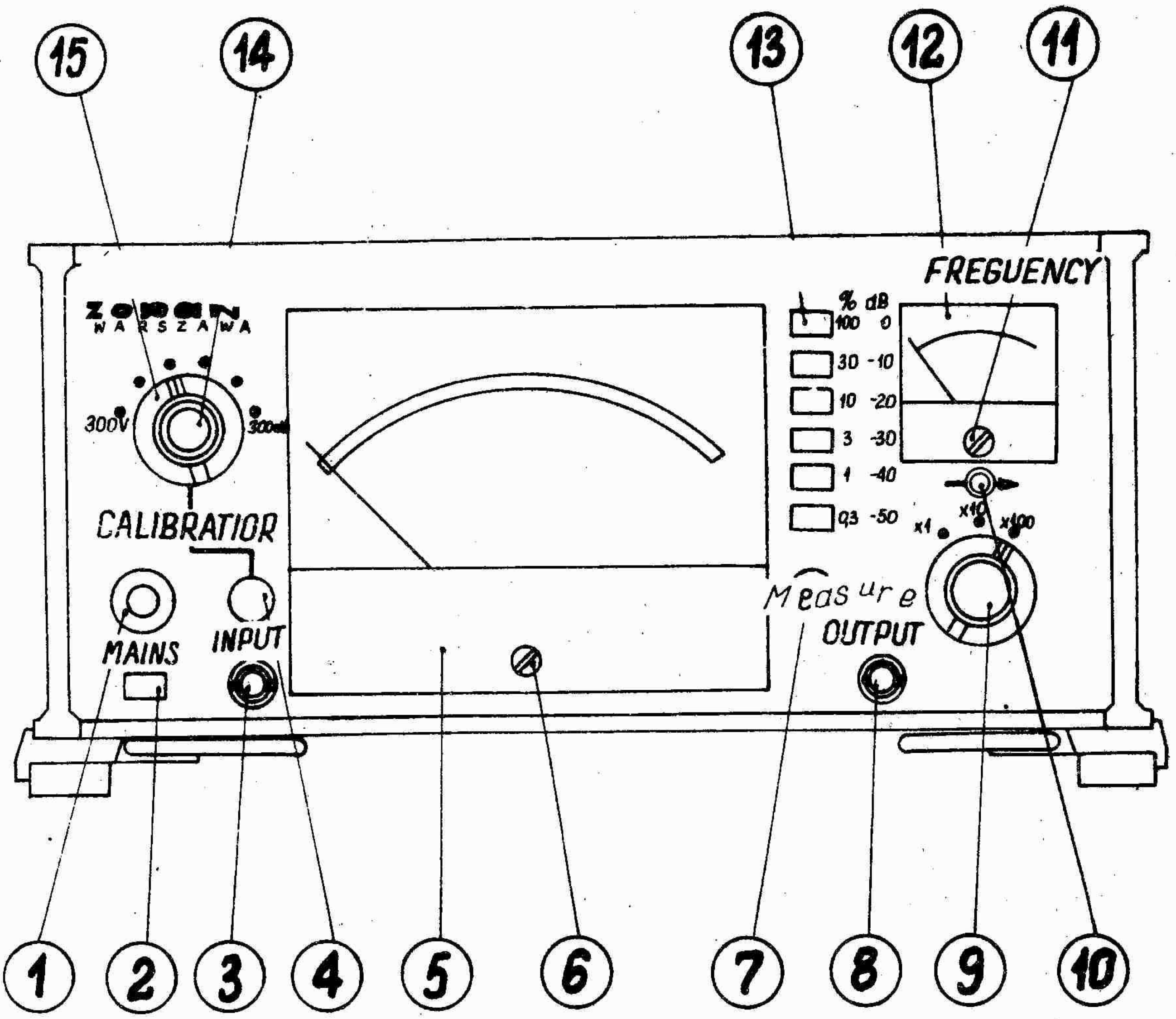
2.1. Measurement of nonlinear distortion factor	
2.1.1. Fundamental frequency range	20 Hz to 20 kHz
2.1.2. Fundamental frequency ranges	20 Hz to 200 Hz 200 Hz to 2 kHz 2kHz to 20 kHz
2.1.3. Harmonic frequency range	up to 100 kHz
2.1.4. Measuring ranges of non-linear distortion factor	30%, 10%, 3%, 1% and 0.3%
2.1.5. Measuring accuracy of non-linear distortion factor:	
a/ internal voltmeter accuracy at 1 kHz	± 3% of f.s.d.
b/ reference level characteristic unequality with respect to the level at fundamental frequency	± 0.5 dB
c/ maximum attenuation of the second and the remaining harmonics with respect to the reference level at fundamental frequency:	± 0.5 dB

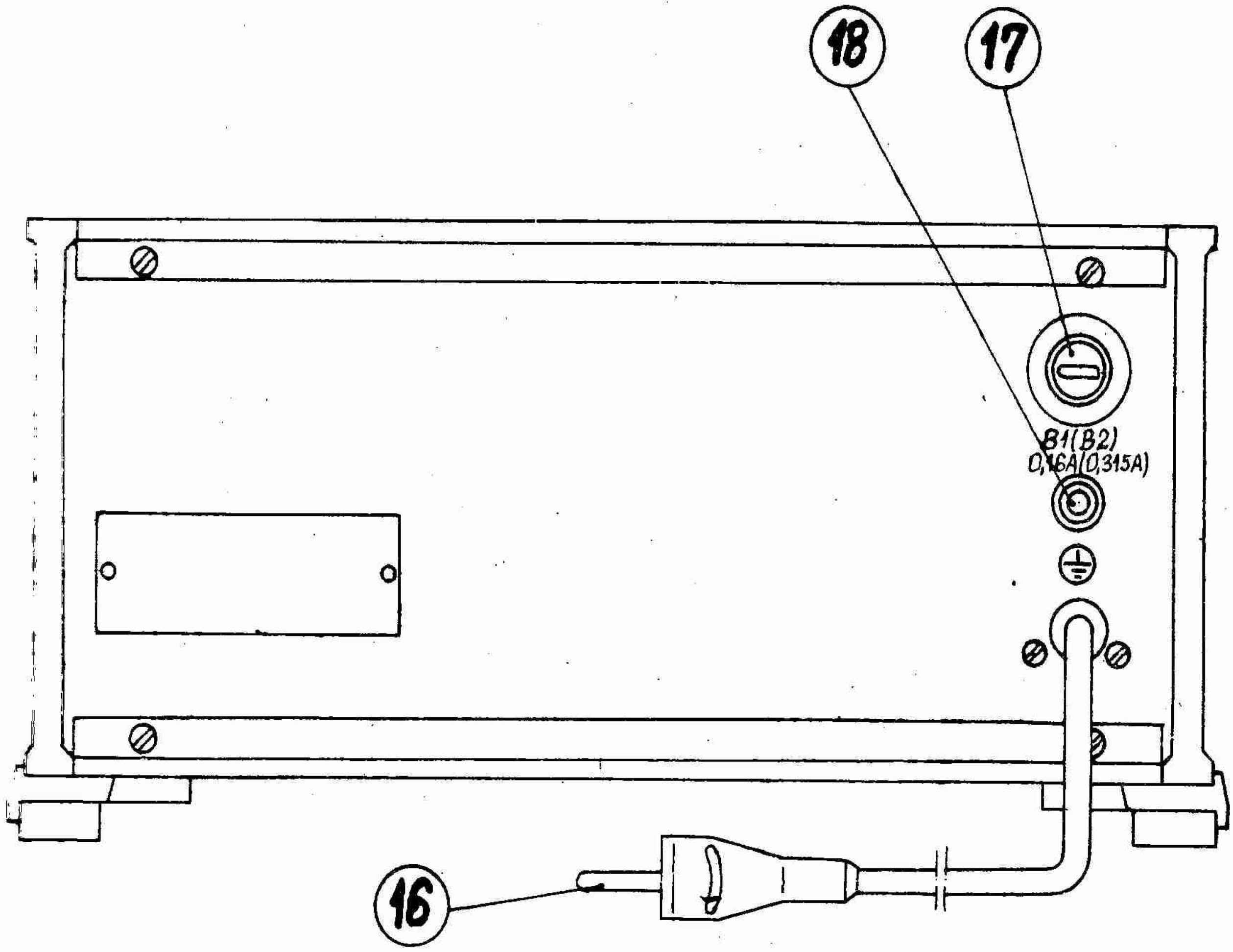
d/ fundamental-frequency signal rejection		$\geqslant$ 80 dB
e/ inherent distortion		$<$ 0.04%
2.1.6. Minimum input voltage		300 mV
2.1.7. Maximum input voltage		300 V
2.1.8. Input resistance		1 MOhms ± 10%
2.1.9. Input capacitance		$\leqslant$ 60 pF
2.2. Frequency measurement		
2.2.1. Measuring range		20 Hz to 20 kHz
2.2.2. Measuring ranges		20 Hz to 200 Hz 200 Hz to 2 kHz 2 kHz to 20 kHz
2.2.3. Measuting accuracy		± 5% of f.s.d.
2.3. Ambient temperature range		+ 5°C to 40°C
2.4. Mains supply voltages		110, 220 V ± 10%; 50 Hz
2.5. Power consumption		11 VA
2.6. Dimensions	height	96 mm
	width	300 mm
	depth	340 mm
2.7. Weight	6.5 kg approx.	

3. OPERATION

3.1. Layout of Controls and Connectors

1. Mains-on indicator
2. MAINS on/off switch. The on-condition is indicated by glowing indicator /1/
3. INPUT socket. Used to connect the tested signal to the instrument input
4. CALIBRATION - pushbutton switch. When depressed, the stepwise and


15
14
13
12
11
FREGUENCY
ZOPAN
WARSZAWA
% dB
100 0
30 -10
10 -20
3 -30
1 -40
0,3 -50
300V
CALIBRATIOR
MAINS
INPUT
Measure
OUTPUT
x1
x10
x100
1
2
3
4
5
6
7
8
9
10


18
17
B1(B2)
0,16A(0,315A)
16

continuous calibration of the Instrument is possible by means of the CALIBRATION switch /15/ and CALIBRATION potentiometer /14/.

5. Deflection meter - indicates the nonlinear distortion factor value and the distortion level

6. Meter /5/ mechanical zero adjustment

7. MEASURE - pushbutton switch. Depression of the pushbutton initiates the automatic process of fundamental-frequency signal rejection from the tested signal.

8. OUTPUT - socket. Used to connect an oscilloscope to enable qualitative evaluation of the harmonic content

9. Switch - used to select the fundamental-frequency signal range

10. Overrange indicator - when lighted, indicates that the input fundamental frequency is higher than the maximum frequency of the range selected by means of the switch /9/. The switch should be then advanced by one step.

11. Meter /12/ mechanical zero adjustment

12. Deflection meter - indicates the value of fundamental frequency of tested signal

13. DISTORTION - pushbutton selector switch used to select the measuring range of the nonlinear distortion factor.

14. CALIBRATION - potentiometer used for continuous adjustment of the reference level.

15. CALIBRATION - rotary switch used for stepwise setting of the reference level

16. Mains cord

17. Fuse

18. Instrument ground terminal.

3.2. Operation Safety Regulations

To ensure working safety for the operating personnel, the instrument is fitted with a three-wire mains cord. One of the cord wires provides the connection of the instrument housing to the neutral or earth conduc-

tor of the supply mains when the mains receptacle is compatible with the instrument mains cord plug.
When the mains receptacle providing earth connection is not available, the instrument should be earthed by connecting its fround terminal /18/ at the rear panel to suitable earth installation.

3.3. Preliminary Procedures

The Type PMZ-9 Automatic Non-Linear Distortion Meter is operated from a.c. mains of 50 Hz frequency. The instrument is intended for 220 V mains operation. To convert the instrument for 110 V operation, proceed as follows:

- refer to the wiring diagram A-5866-407 and remove the jumper from the mains transformer terminals 2-3 and link the terminal pairs 1-3 and 2-4.

3.4. Preparatory Procedures

The instrument is designed for operation under the following climatic conditions:

ambient temperature	+5°C to +40°C
relative humidity	up to 80% at 30°C
atmospheric pressure	800 to 1600 millibars

If, before commencing the measurement, the instrument has been stored under conditions different to those specified above, it should be connected to mains not earlier than after a 12-hour reconditioning period.
To prepare the instrument for measurements, proceed as follows:

1/ release the MAINS pushbutton /2/

2/ earth the instrument according to the instructions given under 3.2.

3/ connect the instrument to supply mains by means of mains cord /16/

4/ depress the MAINS pushbutton /2/.

The instrument is ready for operation after 3 minutes from switching on.

3.5. Measurement Procedures

3.5.1. Distortion measurement

When measuring distortion, an important factor is the stability of the tested signal amplitude. Any amplitude change affects the distortion me surement error directly. In case of instability of the tested signal frequency, the automatic frequency control circuit compensates the frequency changes within ± 5% at the beginning and ± 2% at the end of each range, which permits correct measurements to be performed.

3.5.1.1. To determine the Distortion Level Percentage

1. Perform the steps specified under 3.4.
2. Set the CALIBRATION switch /15/ to its 300 V position.
3. Set the DISTORTION range selector switch /13/ to its 100%position.
4. Connect the source of tested voltage to the INPUT socket /3/
5. Depress and release the CALIBRATION pushbutton /4/.
6. Set the CALIBRATION switch/15 and CALIBRATION potentiometer /14/ to obtain full deflection on the scale "1" of the meter /5/.
7. Depress and release the MEASURE pushbutton /7/.
8. The meter /5/ indication will decrease and if the decreasing indication reaches the mark "1" on the scale "3", depress the "30%" pushbutton of the DISTORTION switch /13/.

   N O T E :

   If the reading of the meter /5/ does not decrease after the MEASURE pushbutton has been depressed and released, set the proper range of fundamental frequency by means of the switch /9/. If the overrange indicator /10 glows, advance the switch /9/ setting by one step CW.

   If the pointer of the meter /12/ does not deflect or reads below the division marked "20", reduce the switch /9/ setting by one step CCW. In both cases, after correct setting of the switch /9/ is obtained, depress the MEASURE pushbutton /7/ again.
9. Select higher sensitivity ranges in succession by means of the DISTORTION switch /13/ until a satisfactory meter /5/ reading is established.
   Read the measurement result from the meter scale with allowance for the measuring range is indicated by the depressed pushbutton of the DISTORTION switch /13/.

3.5.1.2. To determine the Distortion Level in Decibels

Having performed the measurements according to item 3.5.1.1., read the measurement result in decibels as a sum of the dB setting of the front panel DISTORTION range selector switch /dB value being identified on the surface adjacent to the pushbutton pressed in/ and the dB value indicated on the meter /5" scale.

3.5.2. Frequency Measurement

To carry out a frequency measurement, perform the steps 1 through 8 specified under 3.5.1.1.

The measurement result is to be read on the scale of the meter /12/ with the allowance for the measuring range determined by the setting of the switch /9/.

4. OPERATING PRINCIPLES

The operating principles of the Automatic Non-Linear Distortion Meter, illustrated in the block diagram included, is based on the definition of the overall distortion factor expressed as the ratio of the r.ms. voltage value of the distorted signal less the fundamental component to the r.m.s. voltage value of the distorted signal. The Instrument represents by itself an AC voltmeter which, in the "100%" position of the DISTORTION measuring range switch, is calibrated for the full scale deflection on the meter scale.

After the initiation of automatic tuning process, during which the rejection of the fundamental-frequency signal is performed, the instrument measures the voltage distorting the fundamental waveform.

A Wien bridge is used to provide the selectivity feature to the circuit. The process of tuning the Wien bridge to the fundamental frequency is performed automatically. The coarse tuning depends on appropriate resistances which are being connected in parallel to the photoresistors F1 and F2 included in the bridge reactance arms, while the fine tuning consists in continuous adjustment of the resistance of the photoresistors F1, F2 and F3 by means of the lamps Ż1 and Ż2 driven by the error signal which is proportional to the phase difference between the output of the error amplifier and the fundamental frequency signal.

As the result of this, the fundamental-frequency signal is attenuated by about 80 dB, while the harmonic frequencies are passed through the selective amplifier and measured by the measuring circuit as the signal distortion. The calibration is performed before the bridge balancing process. During the calibration the selective amplifier employing the Wien bridge represents the amplifier having 1 V/V gain over the entire range of the distortion meter operation. The calibration procedure begins with depressing the CALIBRATION pushbutton. This actuates the monostable IC1 which generates a positive pulse to reset the counters L1 and L2 and the flip-flop P1. The outputs of L1 counter decades go then to their "0" logic levels, which corresponds to a voltage of about 0.4 V. This 0.4 V level at the inputs of the pulse-number /conductance converter amplifiers sets the transistors to cut-off condition. This causes the opening of the n.o. contacts in the converter circuit and disconneting of the resistance matrix in this circuit.
The positive pulse which resets the counter L1 and L2 and the flip-flop P1 causes, at the same time, the saturation of the transistor in the lamp extinguish amplifier fitted in the amplifier block of the pulse-number/conductance converter. The current flowing through the coil connected in the transistor collector circuit causes the closing of contacts through which a voltage level of 0.5 V is applied to the outputs of the amplifiers WŻ1 and WŻ2 and, in consequence, the lamps Ż1 and Ż2 are extinguished. With the lamps dead, each of the photoresistors F1, F2 and F3 included in the Wien bridge circuit represents a high resistance /above 1 MOhms/.
Under these conditions /i.e. with the pulse-number/ conductance converter resistors being disconnected from the bridge and the lamps Ż1 and Ż2 extinguished /, the Wien bridge will no longer represent a filter, and the gain of the selective amplifier is 1 V/V. Then, the meter M1 reading is set to full scale, with the DISTORTION divider selector switch set to "100%" position, by means of the CALIBRATION divider and potentiometer. The process of rejecting the fundamental component of the input signal and the measurement of the signal distortion is started on the actuation of the monostable IC1, by depressing the MEASURE pushbutton. The monostable output produces a negative pulse which starts the time base circuit BT.
The time base circuit BT produces a positive output pulse of duration τ = Txn.

Where T is a period corresponding to the upper frequency of the given frequency range,

n - counter capacity.

This time interval equals :

1.8 s approximately for the frequency range 20 Hz - 200 Hz

180 ms approximately for the frequency range 200 Hz - 2 kHz

18 ms approximately for the frequency range 2 kHz - 20 kHz.

The fine adjustment of the time base pulse duration on individual ranges is accomplished by changing the resistance of the potentiometers R1 through R3. The time base circuit output 2 provides a negative pulse of a duration equal to that of positive pulse at the output 1. This negative pulse closes the gate B3 and disables the circuit restarting for the time the counters L1 and L2 perform the pulse counting.

The pulse at the output 1 of the time base circuit enters the input 3 of the gate B1 and the input 3 of the gate B2. At this instant, the gate B2 has logic "ones" at its inputs 1, 3 and 4, and is open for the signal from the pulse shaping circuit UF, i.e., for the squarewave signal of a frequency that is equal to that of the input signal. The squarewave signal at the output of the gate B2 is fed to the counter L2. After the counter L2 has counted 4 pulses, the fifth pulse causes the change in the logic states of the counter output 3 from "1" to "0" and at the output 2 from "0" to "1". The logic "0" at the output 3 of the counter L2 is coupled to the inputs 1 and 4 of the gate B2 to close the gate for the signal from the pulse shaping circuit UF. The initial subtraction of the four cycles of tested signal, before the signal is fed to the counter L1, is necessary to tune the Wien bridge at the extreme frequencies of the ranges.
The logic "1" at the output 2 of counter L2 is transferred to the input 4 od the gate B1. Because the input 1 of the gate B1 is at "1" and the input 3 is also at "1" for the duration of the time base pulse, the gate B1 is open for the signal from the pulse shaping circuit UF for the time base pulse duration.

The signal from the pulse shaping circuit UF passes the gate B1 to the counter L1 where the squarewave pulses are counted until the time base pulse generation is completed. A logic "0" is then established at the input 3 of the gate B1 to close the gate. At the end of counting, the state of the counter L1 is proportional to the frequency of the measured signal. The logic levels at the outputs of counter L1 decades are used to control the inputs of the converter amplifiers.

The pulse-number /conductance converter is a resistive matrix consisting of two identical resistances, each resistance being determined by a parallel connection arrangement of ten resistors weighted in 8421 code. Each pair of equal resistors is connected by the n.o. contacts controlled by means of the respective amplifier of pulse-number/conductance converter. When the amplifier input is at logic "1" /about +2.4 V/ the amplifier transistor is turned into saturation. A voltage of about +24 V appears then at the driving coil of the n.o. contacts to close them and to switch the resistor pairs associated with appropriate output of the counter L1 decade. In this way, the state of the counter L1 is, at the end of counting, converted into two equal resistance being inversely proportional to the fundamental frequency. These resistances are inserted parallelly to the photoresistors F1, F2 into the reactance arms of the Wien bridge, and, together with the circuit capacitances, determine the time constants which provide the coarse tuning of the bridge to the fundamental frequency.

The line alignment of the phase and amplitude of the fundamental-frequency component in the Wien bridge is accomplished by the continuously operating automatic frequency control circuit consisting of two control loops. One control loop consists of a phase comparator and the lamp amplifier WŻ2. The comparator circuit receives the measuring amplifier output and the reference voltage from the input of the rejection amplifier circuit. The comparator circuit compares the phase of both signals. In a situation where the signals are in phase, the voltage level at the lamp amplifier input rises thus causing an increase of voltage across the lamp Ż2. The photoresistor F3 connected in the bridge resistance arm and coupled by means of light beam to the lamp Ż2 responds to any increase of light beam intensity by reducing the photoresistance. In the other extreme situation, where the signals are shifted in phase by 180°, the lamp amplifier input voltage decreases thus resulting in a decrease of the lamp filament supply voltage and an increase of the resistance of the photoresistor F3. These changes in the resistance of the photoresistor F3 run in a continuous manner during the bridge tuning action and tend to balance the bridge resistance arms. The other control loop consists of the phase shift network, phase comparator and lamp amplifier WŻ1.

Changes in the fight beam of the lamp Ż1 result in changing the resistance of the photoresistors F1 and F2, Due to the action of the feedbacks, the Wien bridge becomes precisely tuned to the fundamental frequency. The voltage of this frequency is attenuated down to the level of minus 70 dB.

For the remaining frequencies or the harmonics of the fundamental frequency, the rejection amplifier features the gain of about 1 V/V and does not present any filter properties. The signal consisting of harmonic-frequency voltages being the nonlinear-distortion components, is applied to the DISTORTION divider which is a six-stage attenuator limiting the input to the measuring amplifier at a level of 1 mV.

This 1 mV level after is amplified by the measuring amplifier and rectified by the detector bridge to drive the meter M1 to f.s.d. reading. The meter reading with the allowance for the range divider position is the percentage value of the non-linear distortion factor of the input signal.

The meter M2 whose measuring circuit is driven by the N/I /pulse-number/current/ converter indicates the frequency of input signal. The meter is calibrated in hertzes and the current flowing through its circuit is proportional to the state of the counter L1 after the counting has been completed. For the frequencies higher than the upper frequency of range, the counter capacity is exceeded and the flip-flop P1 actuates via the amplider WŻ3 the overrange indicator. The frequency range should be then advanced by one step.

5. DETAILED CIRCUIT DESCRIPTION

5.1. Input Circuit

The input circuit consists of the CALIBRATION voltage divider and an impedance converter. The divider is an attenuator having a resistance of 1 MOhms and provides a voltage attenuation of 50 dB in 10 dB steps.

The flat frequency response of the divider is achieved by means of the compensating capacitances C2 through C11. The divider output is connected to the impedance converter circuit. The converter has high input resistance /about 30 MOhms/ and operates as a linear amplifier of a gain of 1 V/V. The circuit is protected against damaging overload by means of the lamp Ż1 and reverse-biased diodes D1 through D4.

The FET T1 used at the input ensures low noise and a high input impedance. The low output impedance of the converter enables good operation with the following rejection amplifier.

5.2. Rejection Amplifier

The rejection amplifier circuit consists of the preamplifier /transistors T3, T4 and T5/, Wien bridge and bridge amplifier /IC1, T6 and T7/. The preamplifier input is coupled via resistive divider R1, R2 and R3 to the output of the impedance converter.

The potentiometer R2 provides continuous adjustment of the reference level in the range of about 12 dB on each range of the CALIBRATION divider.

The preamplifier circuit is designed for high open-loop gain. The negative feedback from the junction of R19 and R20 to the junction of R10-C5 establishes the operating point the transistor T3, while the negative feedback between the emitters of transistors T5 and T3 stabilizes the preamplifier circuit operation. The Wien bridge, when measuring distortion, operates as a rejection filter for the fundamental frequency input signal and is inserted into the rejection amplifier circuit as an interstage coupling network between the preamplifier and bridge amplifier.

In case when the amplitude of the fundamental frequency signal at the junction of resistance arms/R22 and R23 is equal to the amplitude of the fundamental frequency signal at the junction of the reactance arms /input 16/, and the both signals are in phase, there is no fundamental-frequency signal at the drain of integrated circuit IC1, while the signal consisting of harmonics of the fundamental frequency passes the bridge amplifier /IC1, T6 and T7/ to the measuring amplifier circuit. The negative feedback from the collector of transistor T7 do the emitter of transistor T7 to the emitter of transistor T3 improves the selective attenuation of the rejection amplifier. During the calibration process /with the lamps extinguished, the photoresistors present a resistance of about 1 MOhms/, the rejection amplifier operates with gain of 1 V/V in the entire range of measuring frequencies.

5.3. Measuring Amplifier

The measuring amplifier circuit consists of the DISTORTION divider /measuring range/, amplifier circuit and rectifier.

The five-stage amplifier /transistors T1 through T5/ amplifies the 1 mV input level to give, at the output, the current required for full scale deflection on the meter scale. The negative feedback from the emitter of transistor T4 to the base of transistor T1 establishes the operating point of transistor T1 and eliminates the drift due to temperature fluctuations. The negative feedback from the collector of transistor T5 to the emitter of transistor T1 ensures flat frequency response and operation linearity to the amplifier. The rectifier circuit is arranged to a bridge employing the diodes D1 and D2 in its upper arms and the capacitors C16 and C18 in lower arms. The diodes are biased via resistor R36 to ensure better linearity at large variations of the signal amplitudes. A further improvement of the circuit operation linearity is achieved by including the rectifier circuit in the overall feedback loop. The meter responds to the mean value of the current and is calibrated in r,m.s. values for sinusoidal waveforms.

5.4. Logic Circuit

The function of the logic circuit is to transfer the information that is necessary for coarse tuning of the Wien bridge to the fundamental frequency - to the pulse-number /conductance converter circuit. This information is the number of pulses corresponding to the input signal fundamental frequency and counted by the counter.

The circuit consists of the fundamental-frequency counter /IC5, IC6 and IC7/, auxiliary counter /IC3/, pulse shaping circuit /IC4/, time base monostable circuit /T2, T5, T6/ , another monostable /IC1/ and gates /B1, B2 - IC2/ which control the operation of the logic circuit.

The input signal from the output of the impedance converter is fed to the input 16 and, via isolating amplifier /T7/, to the pulse shaping circuit /IC4/. The squarewave signal developed at the pulse-shaping circuit output is applied via gate B1 do the counter /IC5, IC6 and IC7/. After the pulse counting has been completed, the counter state is proportional to the input fundamental frequency. Depressing the CALIBRATION pushbutton results in developement of a negative pulse at the inputs 3and 4 of the monostable IC1. The monostable, when triggered, generates a positive pulse at its output 6 to reset the counters IC5, IC7 and IC3.

The outputs 9, 8, 7, 11, 5, 4, 3, 6, 1 and 2 of the counter decades are then set at logic zeroes. By pressing the MEASURE pushbutton, a negative pulse is generated at the output 1 of the monostable IC1. This negative pulse triggers the time base monostable /T2, T5, T6/. A positive pulse of the duration $\tau = T.n$ is developed at the collector of transistor T1.

T - the period of upper frequency on a given frequency range

n - capacity of the counter /IC5, IC6, IC7/.

The decade changes of the pulse duration are accomplished by switching one of the capacitors C7, C8 or C9. The precise adjustment of individual ranges is carried out by appropriate setting of the potentiometers R35, R36 and R37. The negative pulse of a duration equal to that of the positive pulse is coupled from the emitter of the emitter follower /T4/ to the input 5 of the monostable /IC1/to close the internal gate thus disabling the retriggering of the circuit for the time the counters perform pulse counting.

The positive pulse at the collector of transistor T1 is applied to the inputs 10 and 1 of the gates B1 and B2 of the circuit IC2 to keep these inputs at logic "ones". At this time, the inputs 1, 4 and 5 of the gate B2 are at logic "ones" and the gate is open for the signal from the pulse shaping circuit /IC4/. The output 6 of the gate B2 is a squarewave which enters the counter IC3. After the counter IC3 has counted four pulses, this fourth pulse causes the transistion of output 12 from logic "0" to "1" , and via inverter T3, changes the logic states at the inputs 4 and 5, of the gate B2 from "1" to "0" to close the gate for the signal from the pulse shaping circuit. At the same time, the transition of the output 12 from "0" to "1" is transferred to the input 13 of the gate B1 which becomes open for the duration of the time base monostable output pulse.

The squarewave at the output 8 of the gate B1 enters the counter /IC5, IC6 and IC7/ to be counted until the time base monostable ends the generation of its output pulse. The logic levels at the outputs of the counter /IC5, IC6 and IC7/decades are used to drive the amplifiers of the pulse-number/conductance converter.

5.5. Pulse-Number/Conductance Converter N/G

The pulse-number conductance converter N/G consists of ten amplifiers /transistors T3 through T12/ and the resistance matrix R16 through R35 including two identical resistances, either being a parallel connection arrangement of ten resistors having their values weighted in 8421 code.

The amplifier inputs /9, 10 and 17 through 25/ are controlled by the logic levels at the outputs of the counter decades. The collector loads of the amplifiers are the windings of the relays PK1 through PK10. Each relay has two n.on. contacts to insert a pair of equal resistors into the Wien bridge circuit.

With the logic "0" /about 0.4 V/ at the amplifier input, the amplifier transistor is cut-off which corresponds to open contacts of the relay. The logic "1" /about 2.4 V/ turns the amplifier transistor into saturation. A voltage of +24 V appears across the relay coil and the relay contacts close to insert an appropriate pair of resistors into the bridge circuit, each resistor pair being associated with appropriate output of the counter decade in the logic circuit.
In this way, the voltage levels corresponding to the logic states of the counter outputs which are fed to the inputs of the converter amplifiers are converted into two equal resistances being inversely proportional to the fundamental frequency of the input. These resistances together with the bridge capacitances determine the time constants which provide coarse tuning of the Wien bridge to the fundamental frequency.

Operating in conjunction with the pulse-number /conductance converter N/G is the pulse-number /current converter N/I. This consists of ten resistors R6 through R15 having their values weighted in 8421 code.

These resistors are connected in the collector circuits of transistors T3 through T12. The collector voltage changes result in changing the current in proportion to the fundamental frequency.

The meter M1 is calibrated in hertzes.

The amplifier T13 drives the relay PK11 whose n.on. contacts when closed /during calibration procedure/ apply -0.5 V to the lamp amplifier thus causing the lamps to be extinguished. During the counting process, the cathode og diode D2 receives a negative time base pulse which, after being passed via inverter T2 turns the transistor T13 into saturation thus causing the contacts of the relay PK11 to be closed and the lamps Ż1 and Ż2 to be extinguished.

5.6. Automatic Frequency Control Circuit AC

The automatic frequency control circuit AC performs the final tuning of the Wien bridge to the fundamental frequency by means of automatic, continuous adjusting the resistance of the photoresistors in the Wien bridge arms.

The automatic frequency control circuit employs two control loops. The reference voltage from the input of the rejection amplifier is applied to the isolating emitter follower /T7/. This emitter follower output is fed to the pulse shaping circuit /T8, T9/ whose square-wave output enters the phase detector /T4/. The preamplifier /T1/ is controlled by the signal from the measuring amplifier output.

This signal is amplified by the error amplifier /T2 and T3/ and compared by the phase detector T4 which the squarewave. In a situation where the base of transistor T4 is at its low potential, i.e. during the negative half-cycle of the squarewave, the transistor T4 is cut-off. The collector outputs of transistors T2 and T3, as being equal and of opposite phases will then cancel each other. When the base of transistor T4 is fed with positive half-cycle of the squarewave, the transistor T4 is conducting and shorts the collector output of transistor T3 to ground. The collector output of transistor T2 is then fed via emitter follower T5 to the lamp amplifier T6.

In case the signal at the collector of transistor T2 is in phase with the distortion signal will be passed to the base of transistor T5, while the negatibe half-cycle will be shorted to ground. For the other extreme case, when the signal at the collector of T2 is shifted in phase by 180°, the positive half-cycle of the distortion signal is shorted to ground, while the negative half-cycle passes to the base of transistor T5.

For the error signals being in phase with the reference voltage, the level at the base of T5 rises to about zero while for the error signals in opposite phase - decreases to about - 1 V.

The voltage changes resulting from the phase comparison by the detector are amplified by the lamp amplifier T6 and cause the respective changes in the light beam of the lamp whose filament is connected in the collector circuit of T6. The changes in the light beam cause continuous changes in the resistance of the photoresistor F3 to balance the resistive arms of the Wien bridge. The mechanism of the operation of the second control loop is similar to that of the first one, the only difference being that the reference voltage applied to the phase detector /T12/ is shifted in the phase shifter T15, T16 by 90° with respect to the reference voltage. Any change in the light beam of the lamp Ż1 affects simultaneously the changes in the resistances of the photoresistors F1 and F2 to balance the reactance arms of the Wien bridge.

5.7. Regulated Power Supply Z

The Power supply provides stabilized voltages of +5 V, +25 V and -25 V. The rectifier circuit /D1 and D2/ is a source of +5 V. The integrated IC1 us used as the voltage regulator.

The rectifier D3 and D4, D5, D6 is the source of +25 V and - 25 V supplies. The integrated circuit IC2 performs the function of the +25 V regulator. The +25V output voltage adjustment is accomplished by selecting the value of resistor R9. The - 25 V output is derived from the negative voltage regulator /T2, T3/.

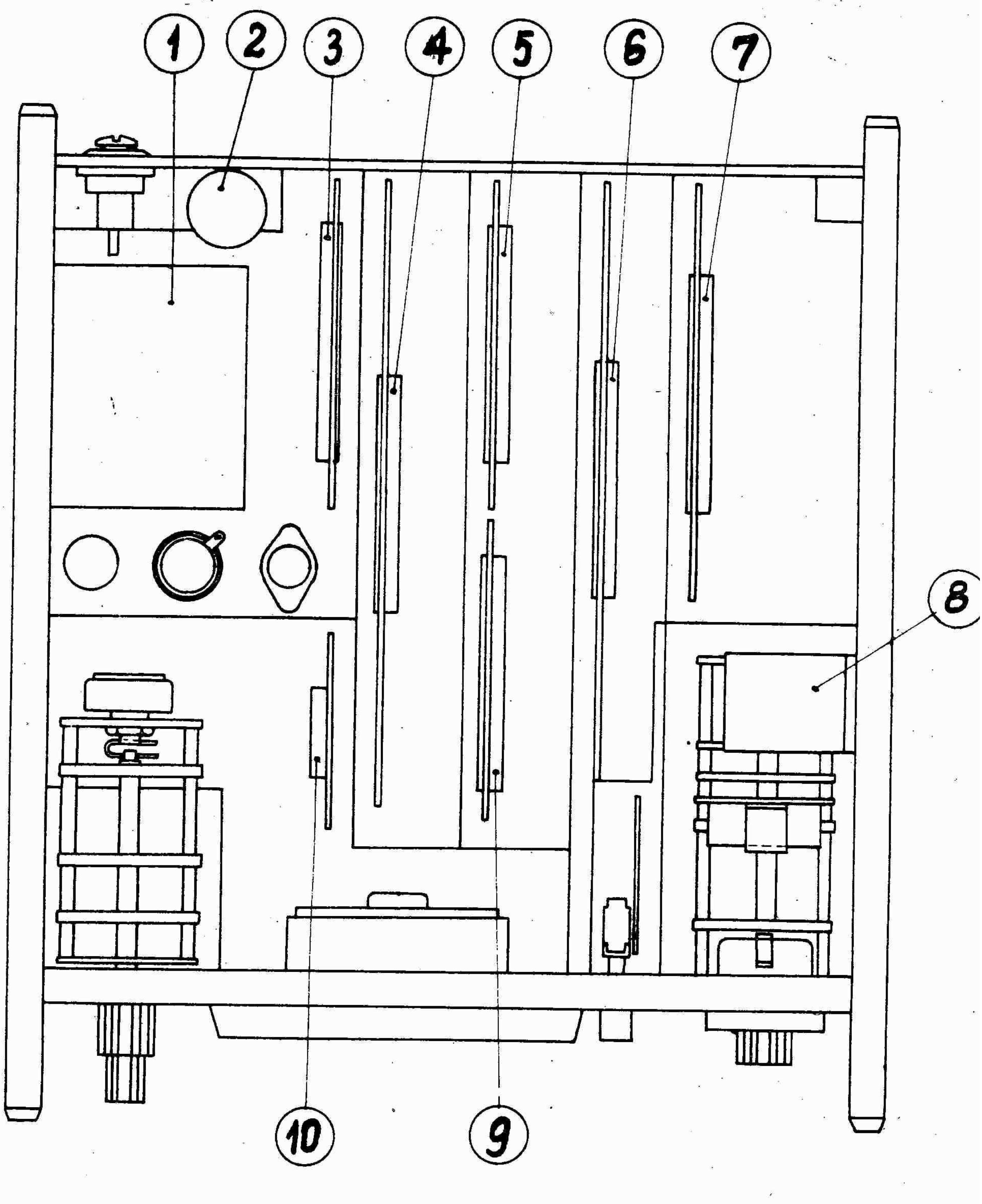
6. CONSTRUCTION

The instrument constructional design provides easy access to individual components and subassemblies. The figure below shows the layout of individual PC board and subassemblies /top view/.

1. Mains transformer
2. Mains filter
3. Power supply Z board
4. Automatic frequency control circuit AC board
5. Logic circuit UL board
6. Pulse-number /conductance converter N/G board
7. Rejection amplifier WZ board
8. Photoelectric transducer FR
9. Measuring amplifier WP board
10. Input circuit UWE board.

All adjustment components and printed circuit boards are easily accessible by removing the instrument top cover.

Each board may be inserted into a PCB extender which facilitate the location of possible faults.



PMZ-9 Top view with top cover removed

7. GENERAL REMARKS ON MAINTENANCE AND REPAIRS

7.1. Access to Instrument Inside

To gain access to the instrument inside, remove the top and bottom covers of the instrument.
To do this, remove the securing screws and then pull the covers to the rear if the instrument.

7.2. Voltage Checks

To make troubleshooting and possible repairs easier, the nominal values of DC voltages at characteristic circuit points are given in the tables below with respect to the instrument ground, for the supply mains voltage 220 V.

1. Power supply Z

Transistor electrode / Transistor	B	C	E
T1	+35 V	+25,5 V	+35, 6 V
T2	-43 V	-35 V	-12,4 V
T3	-35 V	-25 V	-35,6 V
IC1	1	2	3
	+9 V	+ 5 V	0

Input circuit UWE

Transistor electrode / Transistor	/G/ B	/D/ C	/S/ E
T1	-	/+16,5 V/	/+4,5 V/
T2	+16,5 V	+ 4,8 V	+ 17 V

Rejection amplifier WZ

Transistor electrode / Transistor	/G/ B	/D/ C	/S/ E
T1	+23 V	+ 25 V	+ 22,3 V
T2	-23 V	- 25 V	- 22.3 V
T3	+ 1 V	+ 3,5 V	+ 0,4 V
T4	+ 3,5V	+13,5 V	+ 2,9 V
T5	+13,5V	+22,3 V	+13 V
IC1	-	/-1,8 V/	/-19,1 V/
T6	-19,2V	- 6 V	- 19,7 V
T7	- 6 V	- 15 V	- 5.4 V

Measuring amplifier WP

Transistor electrode / Transistor	B	C	E
T1	+0,67 V	+ 7,5 V	+ 0,04 V
T2	+ 9,4 V	+ 3 V	+ 10 V
T3	+ 3 V	+ 6 V	+ 2,4 V
T4	+ 6 V	+ 0.65V	+ 6.6 V
T5	0 V.	- 3 V	+ 0,65 V

Logic circuit UL

Transistor electrode / Transistor	B /G/	C /D/	E /S/
T1	+0,65 V	+ 0,08 V	0 V
T2	+3,64 V	0 V	+ 3,6 V
T3	+ 0,1 V	+ 5 V	0 V
T4	+ 2,9 V	+ 5 V	+ 2,3 V
T5	+ 3,5 V	+ 3,6V	+ 2,9 V
T6	+ 3 V	+ 3,5V	+ 3,6 V
T7	-	/ 5 V/	/+ 1,2 V/
T8	+ 0,1 V	+ 3,6V	0 V

Automatic frequency control circuit AC

Transistor electrode / Transistor	B	C	E
T1	0 V	+ 5 V	- 0,6 V
T2	- 0,03 V	+ 13 V	- 0,6 V
T3	- 0,03 V	+ 13 V	- 0,6 V
T4			
T5	- 0,5 V	+ 20 V	- 1 V
T6	+ 1,4 V	+ 15 V	+ 0,8 V
T7	- 2,9 V	+ 14 V	- 3,5 V
T10	-0,03 V	+ 13 V	- 0,6 V
T11	-0,03 V	+ 13 V	- 0,6 V
T13	- 0,5 V	+ 20 V	- 1 V
T14	+ 1.4 V	+ 15 V	+ 0,8 V
T15	- 0,15V	+ 13 V	- 0,7 V
T16	- 0,14V	+ 13 V	- 0,7 V

Pulse-number/conductance converter N/G

Transistor electrode / Transistor	B	C	E
T1	+24.7 V	+ 0.6 V	+ 24.4 V
T12	0.2 V	+ 25 V	0 V
T13	+ 1.5 V	0.8 V	+ 0.7 V
T14	+ 1.2 V	+ 1.5 V	+ 0.7 V

7.3. Troubleshooting

1. No supply voltages, mains-on condition indicator dead - check the fuse B1
2. Absence of +15 V supply - check the positive voltage regulator circuit
3. Absence of +25 V supply - check the positive voltage regulator circuit
4. Absence of +5 V supply - check the integrated circuit IC1
5. The distortion percentage meter does not deflect in CALIBRATION position - check the lamp Ż1 in the input circuit and then check the individual circuits of the emplifying channel /input circuit, rejection amplifier, measuring amplifier/
6. An increase of the instrument inherent distortion - carry out the adjustment of the operating point of the transistor T1 in the input circuit /UWE board/; use an external distortion meter to measure the PMZ-9 distortion at the slider of the potentiometer CALIBRATION and adjust the operating point by means of the potentiometer R14 for minimum distortion.

   In case of excessive meter indications, carry out the adjustment procedure of the operating point of the integrated circuit IC1 in the rejection amplifier circuit /WZ board/. This is done by adjusting the transistor operating point by means of potentiometer R30 for a minimum indication of the PMZ-9.

N O T E :

When adjusting the meter inherent distortion, use a signal generator providing output distortion not exceeding 0.05%.

7. Improper operation of the bridge coarse tuning circuit /no response of meter pointer to depressing of the MEASURE pushbutton/. Measure the duration of the time base pulse at the collector of transistor T1 at the PCB of logic circuit UL.

   The duration of time base pulses should be:

   1.8 s ± 2% for the frequency range x 1
   180 ms ± 2% for the frequency range x 10
   18 ms ± 2% for the frequency range x 100.

   If the difference exceeds ± 2%, adjust the time base pulse for the required width by means of the potentiometer R35 for the range x 1, R36 for the range x 10, and R37 for the range x 100.

8. Failure of fine bridge tuning /meter indication does not decrease during dostortion measurement for the DISTORTION selector switch ranges of higher sensitivities/.

   Check the operating points of the transistor T6 and T14 in the automatic frequency control circuit /board AC/. Adjust the resistance of the potentiometer R24 in the rejection amplifier circuit /board WZ/ for minimum distortion.

9. Measuring amplifier sensitivity too low /the meter pointer fails to deflect full scale for an input signal of 300 mV/ - increase the amplifier gain by means of the potentiometer R17 /board WP/.

10. Excessive error / > 5% of the frequency indicating meter - calibrate the frequency meter indication for the frequency of 20 kHz by means of the potentiometer R42 /board N/G/.

11. Hunting of the bridge circuit after depressing of CALIBRATION pushbutton /meter pointer strikes over scale/ - carry out the adjustment by means of the potentiometer R24 in the rejection amplifier circuit /board WZ/ - adjust the resistance of R24 for minimum distortion .

12. The meter pointer swigns when measuring distortion at a frequency close to power frewuency or its harmonics - check the ground connections

of the PC boards WP, UWE, WZ and Z to the instrument case.

7.4. Reassembling

When reassembling the instrument, reverse the procedure given under 7.1.

7.5. Component Selection Principles

1/ select the value of resistor R9 /power supply Z/ when the voltage at the contacts 10, 11 /board Z/ differs from +25V by more than ± 5% /by increasing R9/, the voltage at contacts 10 and 11 is decreased.

2/ the values of the capacitors C1, C2 and C5, C6 mounted on the FREQUENCY range selector switch /see Components Lists - N/G converter/ should be matched in pairs so that:

$$C1 + C2 = C5 + C6 = 0.5\ \mu F \pm 1\%$$

3/ the transistors T2, T3 and T10, T11 /see Components Lists - sutomati frequency control circuit AC/ should be selected in pairs with respect to the current gain factor h_{fe} /at $I_C = 1$ mA, $V_{CE} = 10$ V/. The factors h_{fe} of the paired transistors should be equal within 5%.

4/ the resistances of photoresistors F1 and F2 should be equal within ± 2% /at DC voltages + 5 V and + 10 V applied to the lamp Ż1/.

8. SHIPPING

The type PMZ-9 Automatic Distortion Meter is a laboratory instrument requiring great care in Handling. The instrument will meet its technical specifications after shipping in its original packing under the ambient conditions given below:

- ambient temperature	- 25°C to +55°C
- relative humidity	95% ± 3% at 25°C
- shock resistance	Group I acc. to Polish Standard PN-71/T-06500

9. STORAGE

The period of storage of the instrument in its protectibe-shipping packing should not exceed six months.

In a situation where the instrument is stored without packing, the following conditions should be met:

- ambient temperature	+5°C to +40°C
- relative humidity	40% to 80%
- no vapours, acids, bases of other corrosives	
- no perceptible vibrations or shocks.	

LISTS OF COMPONENTS

INPUT CIRCUIT UWE

Ckt.Ref.	Specification	Remark
R1	RESISTOR MŁT-1-390 Ohms /±5%/-A-435	
R2	" CASE/OROE 0.5 698 kOhms ± 1%	
R3	" CASE/OROE 0.5 221 kOhms ± 1%	
R4	" CASE/OROE 0.5 69.8 kOhms ± 1%	
R5	" CASE/OROE 0.5 22.1 kOhms ± 1%	
R6	" CASE/OROE 0.5 6.98 kOhms ± 1%	
R7	" CASE/OROE 0.5 3.25 kOhms ± 1%	
R8-R9	" MŁT-0.25 - 5.1 kOhms /±5%/-A-435	
R10	" MŁT-0,25 - 510 kOhms /±5%/-A-435	
R11	" MŁT-0,25 - 82 kOhms /±5%/-A-435	
R12	" C25 30 MOhms ± 1% 2 W RC2-A	Welwyn
R13	" MŁT-0.25 - 12 kOhms /±5%/-A-435	
R14	POTENTIOMETER CN. 15.2. - 47 kOhms ± 20%	
R15	RESISTOR MŁT-0.25 - 150 Ohms /±5%/-A-435	
R16	" MŁT-0.25 - 47 Ohms /±5%/-A-435	
R17	" MŁT-0.25 - 910 Ohms /±5%/-A-435	
C1	CAPACITOR MKSE-011 0.22 µF ± 10% 630 V	
C2	" KCR-IB-N47-3x8-6.8-10-400V-656	
C3-C7	TRIMMER CERAMIC 2222 802 20002 0.8 - 6 pF	Philips
C8	CAPACITOR KCR-IB-N47-3x8.2-10-400V-656	
C9	" KSO-2-500V B 100 pF ± 5%	
C10	" KSO-2 500V B 390 pF ± 5%	
C11	" KSO-2-500V B 1000 pF ± 5%	
C12-C13	" KSO-1 250 V B 390 pF ± 5%	
C14	" MKSE-011 0.1 µF ±10% 250 V	
C15	" KCR-IB-N47-3x12-30-10-250V-656	
C16	CAPACITOR ELECTROLYTIC 02/E type II 470 µF 10 V - 654	
T1	TRANSISTOR 2N3823	
T2	" BC 179A	
D1-D4	DIODE BAP 855	
D5-D7	" BZP611-C7V5	
Ż1	LAMP, TELEPHONE-TYPE, MINIATURE T5, 5S 24V/20 mA	

1	2	3
P3	SWITCH C-4542-267-1	
	REJECTION AMPLIFIER WZ	
R1	RESISTOR MŁT-0.25-10 kOhms /±5%/-A-435	
R2	" MŁT-0.25-47 Ohms /±5%/-A-435	
R3	POTENTIOMETER SP. 1,2 A 2W P-3 12 1 kOhms	
R4	RESISTOR MŁT-0,25 - 330 Ohms /±5%/-A-435	
R5	" MŁT-0.25 - 1 kOhms /±5%/-A-435	
R6	" MŁT-0,25 - 11 kOhms /±5%/-A-435	
R7	" MŁT-0,25 - 240 Ohm /±5%/-A-435	
R8	" MŁT-0,25 - 11 kOhms /±5%/-A-435	
R9	" MŁT-0,25 - 1 kOhms /±5%/-A-435	
R10	" MŁT-0,25 - 120 kOhms /±5%/-A-435	
R11	" MŁT-I.25 - 510 Ohms /±5%/-A-435	
R12	POTENTIOMETER C.N. 15.2. - 10 kOhms ± 20%	
R13	RESISTOR MŁT-0.25 - 12 kOhms /±5%/-A-435	
R14	" MŁT-0.25 - 200 Ohms /±5%/-A-435	
R15	" MŁT-0,25 - 3.6 kOhms /±5%/-A-435	
R16	" MŁT-0.25 - 200 Ohms /±5%/-A-435	
R17	" MŁT-0,25 - 2.2 kOhms /±5%/-A-435	
R18	" MŁT-0,25-6,8 kOhms /±5%/-A-435	
R19	" MŁT-0,25 - 150 Ohms /±5%/-A-435	
R20	" MŁT-0,25 - 20 kOhms /±5%/-A-435	
R21	" MŁT-0,25 - 200 Ohms /±5%/-A-435	
R22	" AT/OROE - 0,5 - 3,92 kOhms ± 1%	
R23	" AT/OROE - 0.5 - 2 kOhms ± 1%	
R24	POTENTIOMETER C.N. 15.2. - 680 Ohms ± 20%	
R25	RESISTOR AT/OROE - 0.5 - 15 kOhms ± 1%	
R26	" AT/OROE - 0.5 - 34.8 kOhms ± 1%	
R27	" 4036 G-11 MOhms /± 0,5%/	WELWYN
R28	" MŁT-0.25-30 kOhms /±5%/-A-435	
R29	" MŁT-0.25 - 7.5 kOhms /±5%/-A-435	
R30	POTENTIOMETER C.N. 15.2. - 4.7 kOhms ± 20%	
R31	RESISTOR MŁT-0.25 - 5.6 kOhms /±5%/-A-435	
R32	" MŁT-0,25 - 3.6 kOhms /±5%/-A-435	
R33	" MŁT-0,25 - 560 Ohms /±5%/-A-435	

1	2	3
R34	RESISTOR MŁT-0,25 - 300 Ohms /±5%/-A-435	
R35	" MŁT-0,25 - 330 Ohms /±5%/-A-435	
R36-R37	" MŁT-0,25 - 2 kOhms /±5%/-A-435	
R38	" MŁT-0,25 - 47 Ohms /±5%/-A-435	
R39	" MŁT-0,25 - 7.5 kOhms /±5%/-A-435	
R40	" MŁT-0,25 - 10 kOhms /±5%/-A-435	
C1	CAPACITOR, electrolytic 02/E type II 100 µF 10V-654	
C2-C3	" " 02/E type II 100 µF 25V-654	
C4	" " 02/E type II 2,2 µF 63V-654	
C5	" " 02/E type II 220 µF 10V-654	
C6	" " Oe/E type II 2,2 µF 63V-654	
C7	" KSO-1-250V-B-510 pF± 5%	
C8	" electrolytic 02/E type II 470 µF 16V-654	
C9	" KSO-1-250V-G-240 pF ± 5%	
C10	" KSO-1-250V-W-56 pF± 5%	
C11	" MKSE-011 0.1 µF ± 10% 250 V	
C12	" electrolytic 02/E type II 100 µF 10V-654	
C13	" " 02/E type II 220 µF 10V-654	
C14	" KSO-1-250V-G-150 pF ± 5%	
C15	" KSO-1-250V-G-100 pF±5%	
C16	" electrolytic 02/E type II 220 µF 16V-654	
C17	" " 02/E type II 470 µF 16V-654	
T1	TRANSISTOR BFP 620 gr.VI.	
T2	" BC 177	
T3	" 2N 2484	
T4-T6	" BC 179A	
IC1	INTEGRATED CIRCUIT TAA-320	
D1-D2	DIODE, ZENER BZP611-C8V2	

MEASUTING AMPLIFIER WP

Cct ref.	Specification	Remarks
R1	RESISTOR MLT-0.25 - 220 Ohms /±5%/-A-435	
R2	" CASE/OROE - 0.25 - 412 Ohms ± 0.2%	
R3	" CASE/OROE - 0.25 - 277 Ohms "	
R4	" CASE/OROE - 0.25 - 412 Ohms "	
R5	" CASE/OROE - 0.25 - 277 Ohms "	
R6	" CASE/OROE - 0,25 - 412 Ohms "	
R7	" CASE/OROE - 0.25 - 277 Ohms "	
R8	" CASE/OROE - 0.25 - 412 Ohms "	
R9	" CASE/OROE - 0.25 - 277 Ohms "	
R10	" CASE/OROE - 0.25 - 412 Ohms "	
R11	" CASE/OROE - 0.25 - 289 Ohms "	
R12	" MLT-0.25 - 51 Ohms /±5%/-A-435	
R13	POTENTIOMETER C.N. 15.2. - 10 kOhms ± 20%	
R14	RESISTOR MLT-0.25 - 3 kOhms /±5%/-A-435	
R15	" MLT-0.25 - 510 Ohms " -A-435	
R16	" AT/OROE-0.5-191 Ohms ± 1%	
R17	POTENTIOMETER DL 104 - 22 Ohms ± 10% 0.5W	
R18-R19	RESISTOR AT/OROE-0.5-10 Ohms ± 0.5%	
R20	" MLT-0.25 - 51 Ohms /±5%/-A-435	
R21	" MLT-0.25 - 6.8 kOhms " -A-435	
R22	" MLT-0.25-200 Ohms " -A-435	
R23	" MLT-0.25-2 kOhms " -A-435	
R24-R25	" MLT-0.25 -12 kOhms " -A-435 OWZ-0.25-15 Ohms±5%-445	
R26	" MLT-0.25-680 kOhms /±5%/-A-435	
R27	" MLT-0.25-3 kOhms " -A-435	
R28	" AT/OROE-0.5-47 Ohms ± 0.5%	
R29	" MLT-0.25 - 3 kOhms /±5%/-A-435	
R30	" MLT-0.25 - 100 Ohms " -A-435	
R31	POTENTIOMETER C.N. 15.2.-680±20%	
R32	RESISTOR MLT-0,25-100 Ohms /±5%/-A-435	
R33	" MLT-0.25-510 Ohms " -A-435	
R34	" MLT-0.25-2.5 kOhms " -A-435	
R35	" MLT-0.25-100 Ohms " -A-435	

1	2	3
R36	RESISTOR MLT-0.25-24 Ohms ± 0.5%/ -A-435	
R37	" OWZ-0.25-15 Ohms ± 5%-445	
R38	" MLT-0.25-510 Ohms /±5%/-A-435	
R39-R40	" MLT-0.25-2 kOhms " -A-435	
C1	CAPACITOR KCR-IB-N47-3x8-10-10-250-656	
C2	" KSO-1-250V-W-120 pF±5%	
C3	" KCR-IB-N47-3x8-10-10-250-656	
C4	" electrolytic 02/E type II 1000 µF 63 V-656	
C5	" KSO-2-500 V-W-1000 pF± 5%	
C6	" KSO-1-250 V-W-160- pF "	
C7	" KSO-1-250V-W-470 pF "	
C8	" electrolytic 02/E type II 100 µF-16 V-654	
C9	" KSO-1-250-V-G-100 pF ± 5%	
C10	" MKSE-011 0.1 µF ± 10% - 250 V	
C11	" KSO-1-250-V-W-750 pF ± 5%	
C12	" MKSE-011 0.1 uF ± 10%-250V	
C13	" electrolytic 02/E type II 100 µF 16C-654	
C14	" " 02/E type II 47 µF 25V - 654	
C15	" " 02/E type II 47 µF 16V - 654	
C16	" " 02/E type II 47 µF 25V - 654	
T1	TRANSISTOR 2N 2484	
T2	" BC179A	
T3	" 2N2484	
T4-T5	" BC 170A	
D1-D2	DIODE AAYP37	
D3	" BAP855	
M1	MILLIAMMETER MP-3 0...1 mA	
P5	SWITCH- SEGMENT TYPE, D-4542-282	

LOGIC CIRCUIT UL

Cct.Ref.	Specification	Remarks
R1	RESISTOR MŁT-0.25-2.2 kOhms /±5%/-A-435	
R2	" MŁT-0.25 - 2.2 kOhms " -A-435	
R3	" MŁT-0.25 - 2 kOhms " -A-435	
R4	" MŁT-0.25 - 10 kOhms " -A-435	
R5	" MŁT-0.25 - 510 Ohms " -A-435	
R6	" MŁT-0.25 - 10 kOhms " -A-435	
R7	" MŁT-0.25 - 3.3 kOhms " -A-435	
R8	" MŁT-0.25 - 51 kOhms " -A-435	
R9	" AT-OROE-0.5 - 100 Ohms ± 1%	
R10	" MŁT-0.25 - 120 kOhms /±5%/-A-435	
R11	" C22 - 2.4 MOhms ± 1% XE	WELWYN
R12	" MŁT-0.25 - 62 kOhms /±5%/-A-435	
R13	" MŁT-0.25 - 39 kOhms " -A-435	
R14	" AT/OROE-0.5-95.3 kOhms ± 1%	
R15	" MŁT-0.25 - 4.3 kOhms /±5%/-A-435	
R16	" MŁT-0.25 - 5.1 kOhms " -A-435	
R17	" MŁT-0.25 - 3.3 kOhms " -A-435	
R18	" MŁT-0.25 - 1 kOhms " -A-435	
R19	" MŁT-0.25 - 100 kOhms " -A-435	
R20	" MŁT-0.25 - 1 MOhms " -A-435	
R21	" MŁT-0.25 - 1 kOhms " -A-435	
R22	" MŁT-0.25 - 100 Ohms " -A-435	
R23-32	" MŁT-0.25 - 10 kOhms " -A-435	
R33	" MŁT-0.25 - 3.3 kOhms " -A-435	
R34	" MŁT-0.25 - 180 Ohms " -A-435	
R35-37	POTENTIOMETER T 2610P 20 kOhms	Amphenol
R39	RESISTOR MŁT-0.25-2.2 kOhms /± +%/-A-435	
C1	CAPACITOR KFPf-IIF-12x12-r-47000/-20/+50/-25-778	
C2-4	" KSO-1-250V-B-750 pF± 5%	
C5-6	" MKSE-011 0.1 uF ± 10% 250 V	
C7	" MKSE-011 0.047 uF ± 10%-250V	
C8	" MKSE-011 0.47 uF ± 10% -250V	
C9	" MKSE-011 4.7 uF ± 10%-250 V	

1	2	3
T1	TRANSISTOR BFP 520 VI	
T2	" BC 179A	
T3-T4	" BFP 520 VI	
T5	" BSY 52	
T6	" 2N2906	
T7	" 2N3823	
T8	" BFP 520 VI	
D1	DIODE AAY37	
D2	" BAP855	
D3-D4	" AAY37	
D5	" ", Zener BZP611-C20	
D6	" , Light-Emitting 5082-4440	Hewlett Packard
IC1	INTEGRATED CIRCUIT SFC 4121E	
IC2	" SFC 420E	
IC3	" SFC 490E	
IC4	" FCL 101	
IC5-IC7	" SFC 490E	
P2	SWITCH, SEGMENT-TYPE D-4542-263	
P4	" " D-4542-262	
P6/4	PLATE 4, switch P6 /C-4542-268/	

Pulse - Number /Conductance

N/G CONVERTER

Cct.Ref.	Specification	Remarks
R1	RESISTOR MŁT-0.25 - 47 kOhms/± 5%/-A-435	
R2	" MŁT-0.25-10 kOhms " -A-435	
R3	" MŁT-0.25 - 1 kOhms " -A-435	
R4	" MŁT-0.25 - 47 kOhms " -A-435	
R5	" MŁT-0.25 - 1 kOhms " -A-435	
R6	" MŁT-0.25 - 10 MOhms " -A-435	
R7	" MŁT-0.5-5.1 MOhms " -A-435	
R8	" MŁT-0.5-2.5 MOhms " -A-435	
R9	" MŁT-0.5 - 1.2 MOhms " -A-435	
R10	" AT/OROF-0.25 1 MOhms ± 0.5%	
R11	" AT/OROF-0.25 510 kOhms ± 05.%	
R12	" AT/OROE-0.25 240 kOhms "	
R13	" AT/OROE-0.25 120 kOhms "	
R14	" AT/OROE-0.25 100 kOhms "	
R15	" AT/OROE-0.25 51 kOhms "	
R16-17	" AT/OROF-0.25 576 kOhms "	
R18-19	" AT/OROE-0.25 287 kOhms "	
R20-R21	" AT/OROE-0.25 143 kOhms "	
R22-R23	" AT/OROE-0.25 57.6 kOhms "	
R24-R25	" AT/OROE-0.25 58.6 kOhms "	
R26-R27	" AT/OROE-0.25 28.7 kOhms "	
R28-29	" AT/OROE-0.25 14.3 kOhms ± 0.2%	
R30-R31	" AT/OROE-0.25 7.15 kOhms "	
R32-33	" AT/OROE-0.25 5.76 kOhms "	
R34-35	" AT/OROE-0.25 2.87 kOhms "	
R36	" AT/OROE-0.25 20 kOhms ± 0.5%	
R37-38	" AT/OROE-0.25 1 MOhms "	
R39	" AT/OROE-0.25 20 kOhms "	
R40	" MŁT-0.25 - 1 kOhms ±5%/-A-435	
R41	" MŁT-0-25 - 1 kOhms " -A-435	
R42	POTENTIOMETER CN. 15.2. - 47 kOhms ± 20%	
R43	RESISTOR MŁT-0-25 - 100 kOhms ±5%/-A-435	

1	2	3
C1 x/	CAPACITOR MKSE-018-0.47 µF ± 15% 250 V	
C2 x/	" KSF-020-30 nF± 5% 100 V	
C3	" KSF-o17-49990 PF ± 5% 100 V	selected t 0.05 µF ±
C4	" KSF-017-4903 pF ± 0,5% 100 V	selected t 5000 pF± 1
C5 x/	" MKSE-018-01-0,47 pF±5% 250 V	
C6 x/	" KSF-020-30 nF ± 5% 100 V	
C7	" KSF-017-49990 pF ± 5% 100 V	selected t 0.05 uF ±
C8	" KSF-017-4903 pF ± 5% 100 V	selected t 5000 pF ±
C9	" KSO-1-250V-B-180 pF ± 5%	
T1	TRANSISTOR BC179 B	
T2	" 2N2219	
T3-T4	" BF 520 gr V	
D1-D16	DIODE BAP 855	
PK1-Pk 11	RELAY K-8/2x1 8-4441-402-4 24 V	
F1-F2x/	PHOTORESISTOR RPP-121	
F3	" RPP-121	
Ż1-Ż2	LAMP, TELEPHONE-TYPE-MINIATURE T5-5S,24V/20 mA	w/o cap
M1	MICROAMMETER MP-40 100 uA	CZECHOSLOVAKI
P6/1	Plate, 1 switch P 6 /C-4542-268/	

x/ Components selected acc.item 7.5 of these Instructions

AUTOMATIC FREQUENCY CONTROL CIRCUIT AC

Cct Ref.	Specification	Remarks
R1	RESISTOR OWZ-0,25-10 Ohms ± 5%-445	
R2	" MŁT-0,25 - 10 MOhms /±5%/-A-435	
R3	" MŁT-0.25-200 Ohms " -A-435	
R4	" MŁT-0.25 - 10 kOhms " -A-435	
R5	" MŁT-0.25 - 200 Ohms " -A-435	
R6	" MŁT-0.25 - 22 kOhms " -A-435	
R7	" MŁT-0.25 - 27 kOhms " -A-435	
R8	" MŁT-0.25 -10 kOhms " -A-435	
R9	" MŁT-0.25 - 12 kOhms " -A-435	
R10	" MŁT-0.25 - 100 Ohms " -A-435	
R11-12	" MŁT-0.25 - 12 kOhms " -A-435	
R13	" MŁT-0.25 - 100 Ohms " -A-435	
R14-15	" MŁT-0.25 - 10 kOhms " -A-435	
R16	" MŁT-0.25-750 kOhms " -A-435	
R17	" MŁT-0.25 - 10 kOhms " -A-435	
R18	" OWZ-0.25 - 10 Ohms ± 5% - 445	
R19	" MŁT-0.25 - 10 kOhms /±5%/-A-435	
R20	" MŁT-0.25-22 kOhms " -A-435	
R21	" MŁT-0.25 - 2 kOhms " -A-435	
R22	" MŁT-0.25 - 36 kOhms " -A-435	
R23	" MŁT-0.25 - 360 Ohms " -A-435	
R24	" MŁT-0.25 - 160 Ohms " -A-435	
R25	" AT/OROE 0.5-93.1 kOhms ± 1%	
R26	" MŁT-0.25 - 100 kOhms /±5%/-A-435	
R27	" MŁT-0.25 - 5.1 kOhms " -A-435	
R28-29	" MŁT-0.25 - 10 kOhms " -A-435	
R30	" MŁT-0.25 - 180 kOhms " -A-435	
R31-34	" MŁT-0.25 - 10 kOhms " -A-435	
R35	" MŁT-0.25 - 30 kOhms " -A-435	
R36	" MŁT-0.25 - 68 kOhms " -A-435	
R37	" OWZ-0.25 - 10 kOhms " -A-435	
R38	" MŁT-0.25 - 10 kOhms /±5%/-A-435	
R39	" MŁT-0.25 - 12 kOhms " -A-435	
R40	" MŁT-0.25 - 100 Ohms " -A-435	
R41-42	" MŁT-0.25-12 kOhms " -A-435	

1	2	3
R43	RESISTOR MŁT-0.25 - 100 Ohms /±5%/-A-435	
R44-45	" MŁT-0.25 - 10 kOhms " -A-435	
R46	" MŁT-0.25 - 750 kOhms " -A-435	
R47	" MŁT-0.25 - 10 kOhms " -A-435	
R48	" MŁT-0.25- 39 Ohms " -A-435	
R49	" MŁT-0.25 - 10 kOhms " -A-435	
R50	" MŁT-0.25-22 kOhms " -A-435	
R51	" MŁT-0.25 - 2 kOhms " -A-435	
R52	" MŁT-0.25 - 36 kOhms " -A-435	
R53	" MŁT-0.25 - 350kOHms " -A-435	
R54	" MŁT-0.25-160 Ohms " -A-435	
R55	" AT/OROE-0.5-17.8 kOhms ± 1%	
R56	" MŁT-0.25 - 2.2 kOhms /±5%/-A-435	
R57	" MŁT-0.25 - 10 kOhms " -A-435	
R58	" MŁT-0.25 - 120 kOhms " -A-435	
R59-61	" MŁT-0.25 - 3.3 kOhms " -A-435	
R62	" MŁT-0.25 - 10 kOhms " -A-435	
R63	" MŁT-0.25 - 3.3 kOhms " -A-435	
R64-R68	" MŁT-0.25 - 10 kOhms " -A-435	
R69	" MŁT-0.25 - 30 kOhms " -A-435	
R70	" MŁT-0.25-68 kOhms " -A-435	
C1	CAPACITOR MKSE-011 0.22 uF ± 20% 250 V	
C2	" electrolytic 02/E type II 47 uF 10 V - 654	
C3	" " 02/E type II 470 uF 10 V - 654	
C4	" KFpF-IIE-12x12-r-10000-/-20/+50/-25V-778	
C5	" electrolytic 02/E type II 10 uF 16 V - 654	
C6-C7	" " 02/E type II 47 uF 25V-654	
C8	" KFPf-IIE-12x12-r-10000-/-20/+50/-25V-778	
C9	" electrolytic 02/E type II 2200 uF 10V-654	
C10	" KFPf-IIE-12x12-r-1000-/-20/+50/-25V-778	
C11	" MKSE-011 0.22 uF ± 20% 250 V	
C12	" KFPf-IIE-12x12-r-1000-/-20/+50/-25V-778	
C13	" KSO-1 250 V - 150 pF ± 5%	
C14	" electrolytic 02/E type II 47 uF 10 V-654	
C15	" " 02/E type II 10 uF 16 V-654	
C16	" KCR-IB-N47-3x12-33-10-250-656	

1	2	3
C17	CAPACITOR electrolytic 02/E type II 2.2 uF 63V-654	
C18	" " 02/E type II 10 uF 16V - 654	
C19	" KFPf-IIE-12x12-r-1000-/-20/+50/-25V-778	
C20	" electrolytic 02/E type II 10 uF 16 V-654	
C21-C22	" " 02/E type II 47 uF 25V-654	
C23	" KFPf-IIE-12x12-r-1000-/-20/+50/-25V-778	
C24	" electrolytic 02/E type II 2200 uF 10V-654	
C25	MKSE-011 0.1 uF ± 10% 250 V	
C26	Capacitor electrolytic 02/E type II 47 UF 10V-654	
C27	" " 02/E type II 22 uF 25V-654	
C28	" KFPf-IIE-12x12-r-10000-/-20/+50/-25-778	
C29-C30	" electrolytic 02/R type II 10 uF 16V-654	
C31	" KCR-IB-N47-3x12-33-10-250-656	
C32	" MKSE-011 0.047 uF ± 20% 250V	
C33	" MKSE-011 0.047 uF ± 20% 250V	
C34	" KSF-014 5100 pF ± 5% 100 V	
T1	TRANSISTOR BFP 520 gr. VI	
T2 T3x/	" BFP 520 gr. VI	
T4	" OC140	
T5	" BFP520 gr.VI	
T6	" 2N 2219	
T7-T9	" 8FP520 gr. VI	
T10-T11x/	" BFP520 gr. VI	
T12	" OC140	
T13	" BFP520 gr. VI	
T14	" 2N2219	
T15-T18	" BFP 520 gr. VI	
D1	DIODE AAYP37	
D2-D3	" BAP855	
D4	" AAYP37	
D5-D6	" BAP 855	
P6/4	Plate 4, switch P6 /C-4542-368/	
	x/ Components selected acc. to item 7.5 of these Instructions	

POWER SUPPLY Z

Cct. Ref.	Specifications	Remarks
R1	RESISTOR MŁT-0.5 - 120 kOhms /±5%/-A-435	
R2	" MŁT-0.5 - 150 Ohms " -A-435	
R3	" MŁT-0.5 - 51 Ohms " -A-435	
R4	" MŁT-0.5 - 820 Ohms " -A-435	
R5	" MŁT-0.5 - 3.3 kOhms " -A-435	
R6	" RDL 120 - 2A 4,7 Ohms /±20%/-0,5W-545	
R7	" MŁT-0,5 - 33 kOhms /±5%/-A-435	
R8	" MŁT-0.5 - 33 kOhms " -A-435	
R9 x/	" MŁT-0.5 - 2.4 kOhms " -A-435	
R10	" MŁT-0.5 - 3.3 kOhms " -A-435	
C1-C2	CAPACITOR, electrolytic KEN 100 uF 63 V 665	
C3	" " 02/E type II 1000 uF 16V-654	
C4	" " 02/E type II 4,7 uF 10V-654	
C5	" KCR-IB N-47-3x16-47-10-250V-656	
C6	" KFPf-IIE 12x12-r-10000-/-20/+50/-25-778	
C7-C8	" electrolytoc OE/2 type II 2.2 uF 40V-654	
Cpz	CAPACITOR INTERFERENCE-REJECTION-TYPE KPpz-016-0.4+2x2500-2x2-250	
T1	TRANSISTOR BD 255	
T2	" BC 179B	
T3	" 2N 2219	
IC1	INTEGRATED CIRCUIT SFC 2309	
IC2	" " SFC 2305	
D1-D2	DIODE BYP 401-50	
D3-D6	" BYP 401-100	
D7	" ZENER BZP611-C13	
D8	" " BZP611-C12	
B1/B2/	FUSE WTAT 0.16A/o.315A for 110 V a.c. mains operation	
Ne1	NEON MGL-110	
P1	SWITCH, MAINS, SEGMENT-TYPE, D-4542-264	
	x/ Components selected acc.to item 7.5 of these Instruction.	

E R R A T A

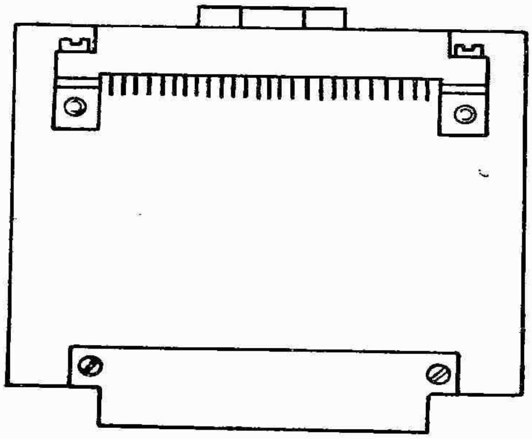
ge	Content	Is	Should be
4	point C correct:		maximum attenuation of second harmonic with respect to the referenc level at fundamental frequency
5-2.4	Voltage 110V,220V ±10%	50Hz	50-60Hz
5-2.6	Dimensions: high	96mm	142mm
7-3.3	In 8th line	50Hz	60Hz
	In 12th line	2-3,1-3	10-11,9-11
	In 13tH line	2-3	10-12
13	In 10th line	70db	80 dB
-7.5	lack of	after point 4/	5/Value of resistor R21 take in configurateon /Pł-Ul/in oder to recei ve in the output of the 8th integrated circuit IC4 pulse duration 1/2
0	R16 MŁT-0,25-47 ohms T2 BC 179A D1-D4 BAP 855 D5- D7 BZP611 -C7V5		MŁT-025-82 ohms BC 179B BAP 795 BZP630-C7V5
1	R13 MŁT-0,25-12 kOhms		MŁT-0,25-24 kOhms
2	lack of after point T4-T6 D1-D2 BZP611-C8V2		T7 BC 179B BZP630-C8V2
4	T2 BC179A T4-T5 BC170A D1-D2 AAYP37 D3 BAP855		BC179B BC179B AAP 152 BAP 795
5	R35-37 T 2610P 20 kOms R39 R39 R39 after R38		47P203kOhms SPECTROL R38 resistor AT/OROE-0,25 2000hms ±1% select from 150 Ohms tO 340 ohms by 10%
35	C7 MKSE-011 0,047uF ±10% 250V		KSF-020-47000 pF ±5% 100V
	C8 MKSE-011 047uf ±5% 250V		MKSE-018-01-0,47uF ±5% 250V
	C9 MKSE-011 4,7 uF ±10% 250V		MKSE-012 4,7 uF ±5% 100V

36	T2 BC 179A T5 BSY 52 T6 2N2906 D1 AAY 37 D2 BAP 855 B3-D4 AAY 37 D6 5082-4440 IC1 SFC 4121E IC2 SFC 420E		BC 179B BSXP 87 BSYP 06 AAP 152 BAP 795 AAP 152 CQYP 40 UCY 74121N UCY 7420N
39	R25 ATE/OROE 0,5-93,1 kOhms ±1%		ATE/OROE 0,5-3,92 kohms ±1%
40	R55 ATE/OROE 0,5-17,8 kOms ±1%		ATE/OROE 0,5-15koh ±1%
41	C18 CAPACITOR electrolitic 02/E typeII 10 U 16V-654		MKSE-018-01 0,33uF 250V
42	T4 OC 140 T6 2N2219 D1 AAYP 37 D2-D3 BAP 855 D4 AAYP 37 D5-D6 BAP 855		BFP 520 gr VI BSXP19 AAP 152 BAP 795 AAP 152 BAP 795
42	lack of	after C7-C8	TR transformer E-62069
42	T1 BD 255 T3 2N 2219		BD 355 BSYP 19

SA-4573-366 In some of the instroments the diodes type D3 and D4 are changed for resistor type R39

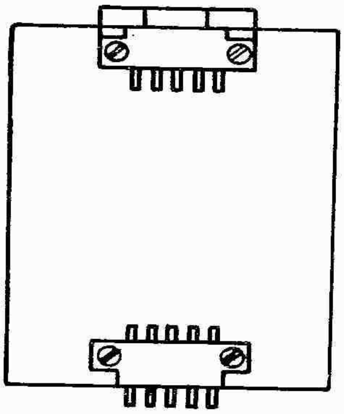
Accessories

1. Adaptor plug Pr-1



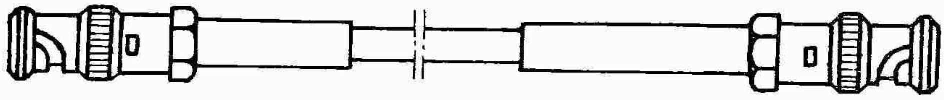
Drwg No D-4565-027-1
1 pc

2. Adaptor plug Pr-2



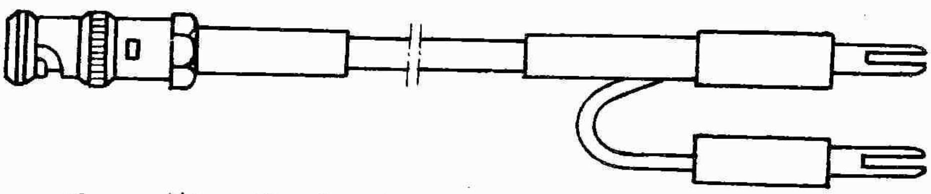
Drwg No D-4565-028-1
1 pc

3. Connection cable



Drwg No C-4578-033-1 1 pc

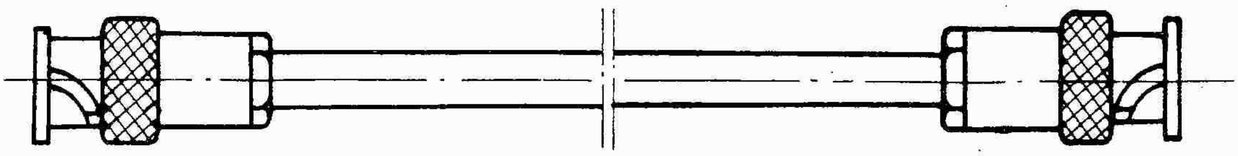
4. Connection cable



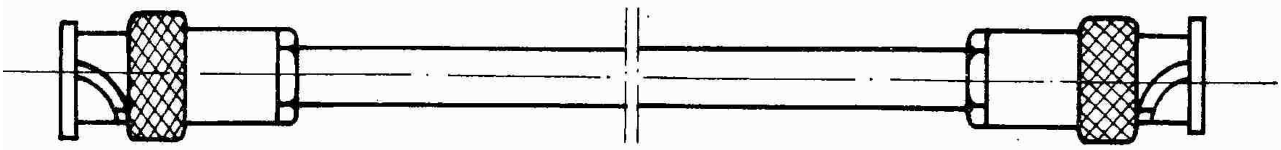
Drwg No C-4578-034-1 1 pc

5.	Fuse	WTAT 160 mA	2 pcs
6.	Fuse	WTAT 315 mA	1 pc
7.	~~Lamp, miniature, telephone-type,~~	~~T 5,5 S 24 V/20 mA.~~	

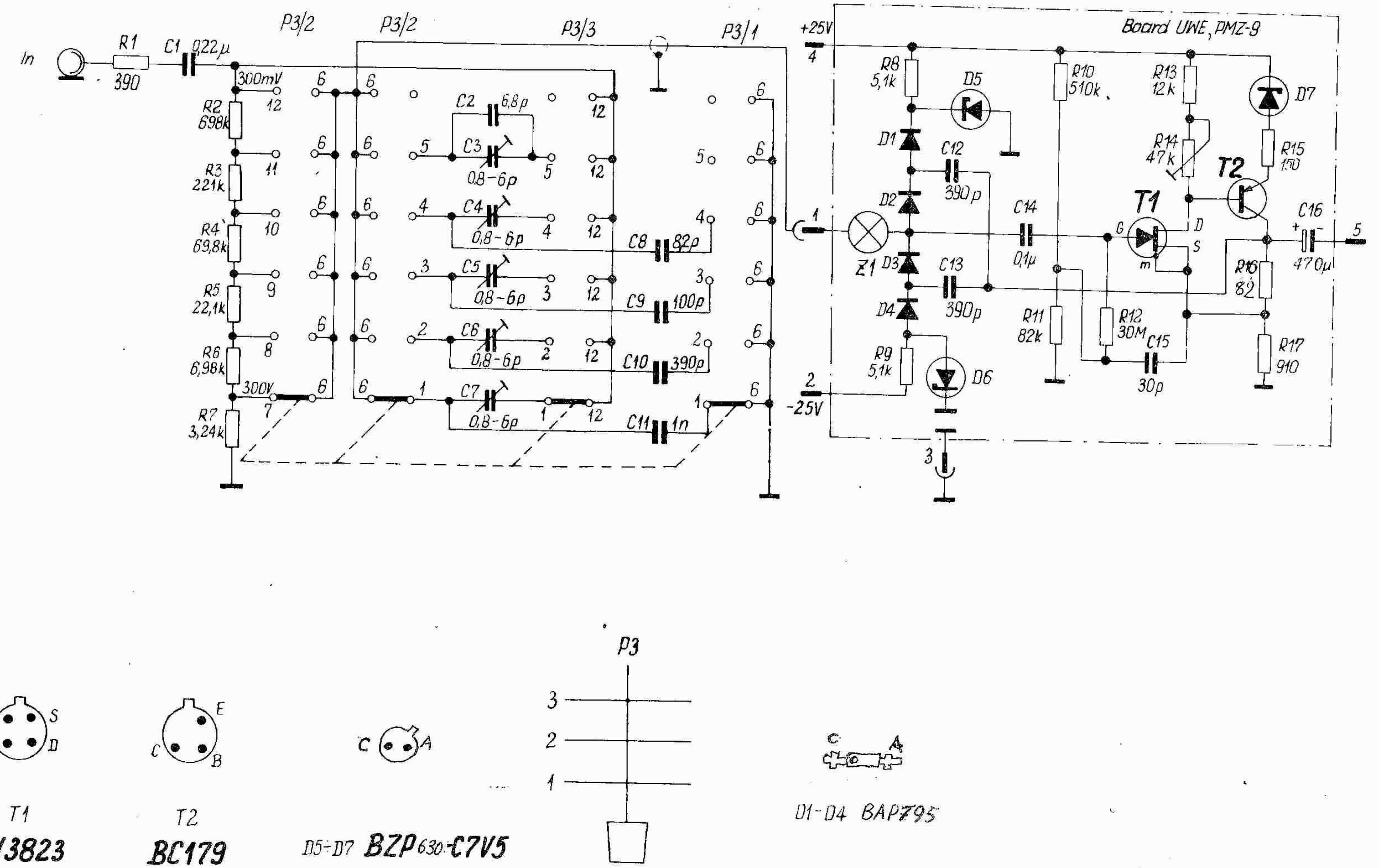
4. Intertonnecting Cable 50 Ω length of about 75 cm
Drg. No C-4578-033-8



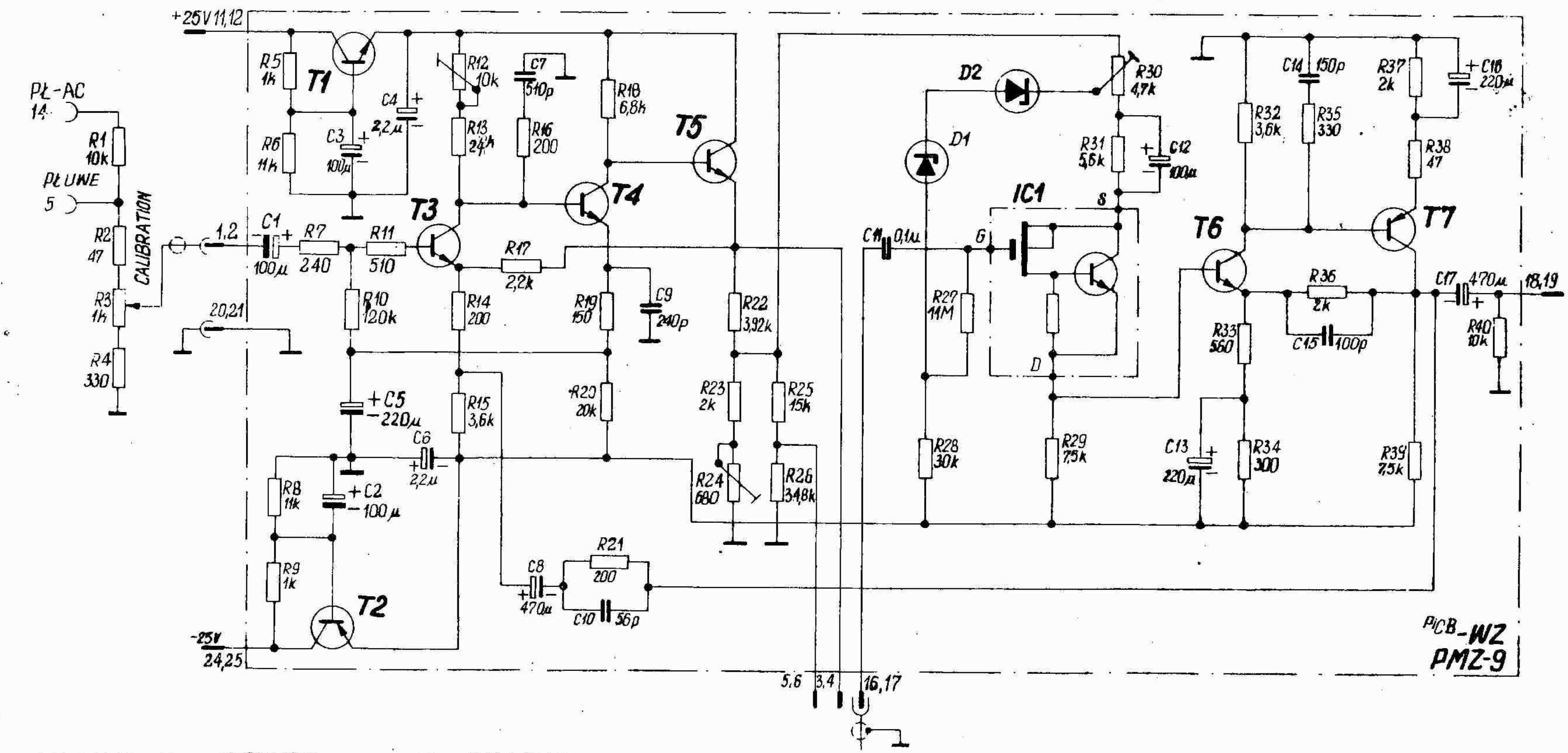
5. Intertonnecting Cable 50 Ω length of about 120cm
Drg. No C-4578-033-9



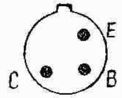
6.	Fuse	Btr	20/5	0,315 A	2 pcs
	"		"	0,5 A	4 pcs
	"		"	1 A	1 pc



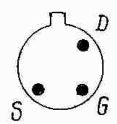
ZOPAN WARSZAWA	**INPUT CIRCUIT UWE** CIRCUIT DIAGRAM	Type **PMZ-9** **SB-4573-370**



T1,T4,T5,T6 - BFP520
T2 - BC177
T3 - 2N2484
T7 - BC179

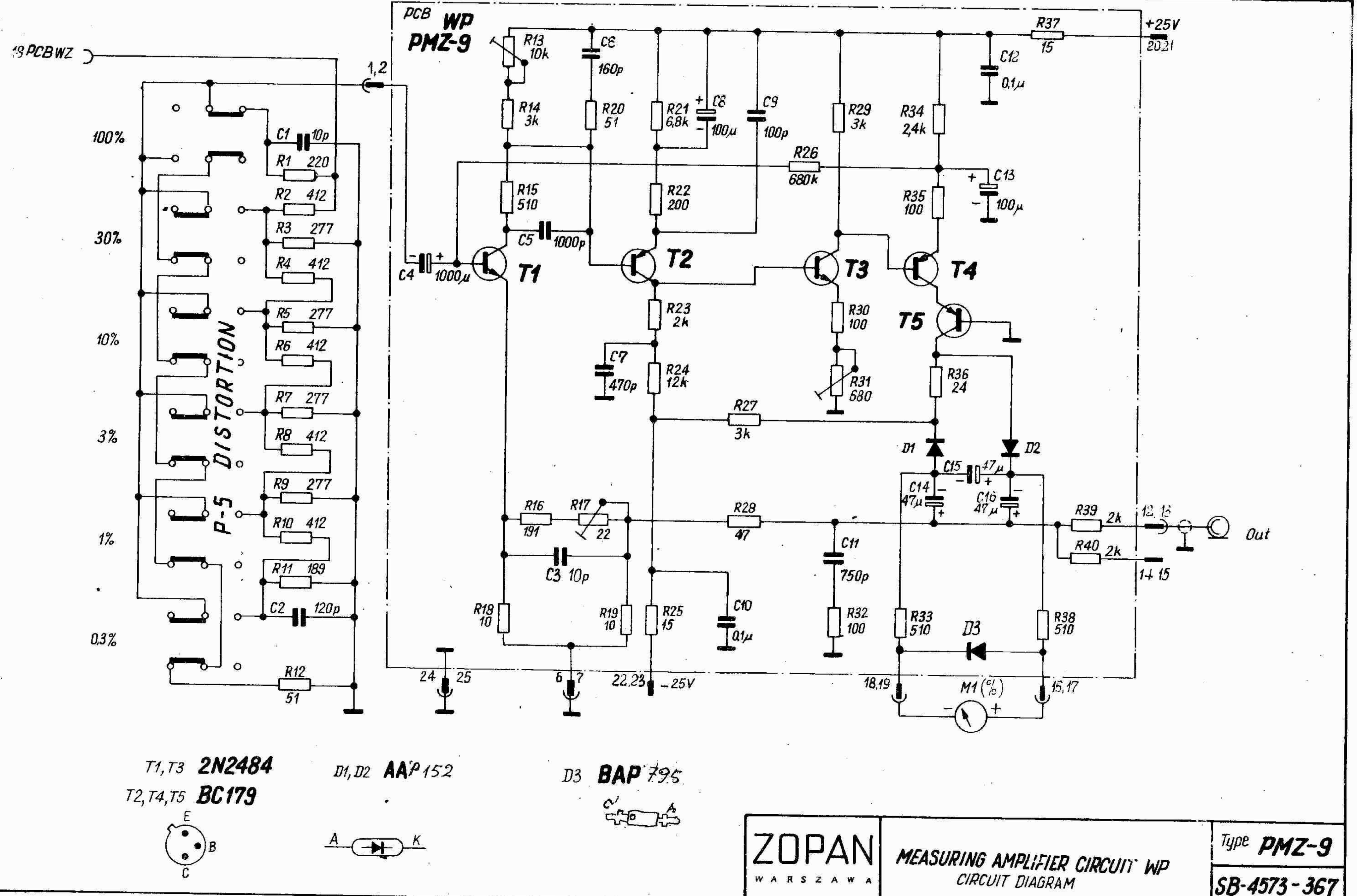


IC1 - TAA320



D1,D2 - BZP630-C8V2

ZOPAN WARSZAWA	REJECTION AMPLIFIER CIRCUIT WZ CIRCUIT DIAGRAM	Type PMZ-9 SB-4573-368

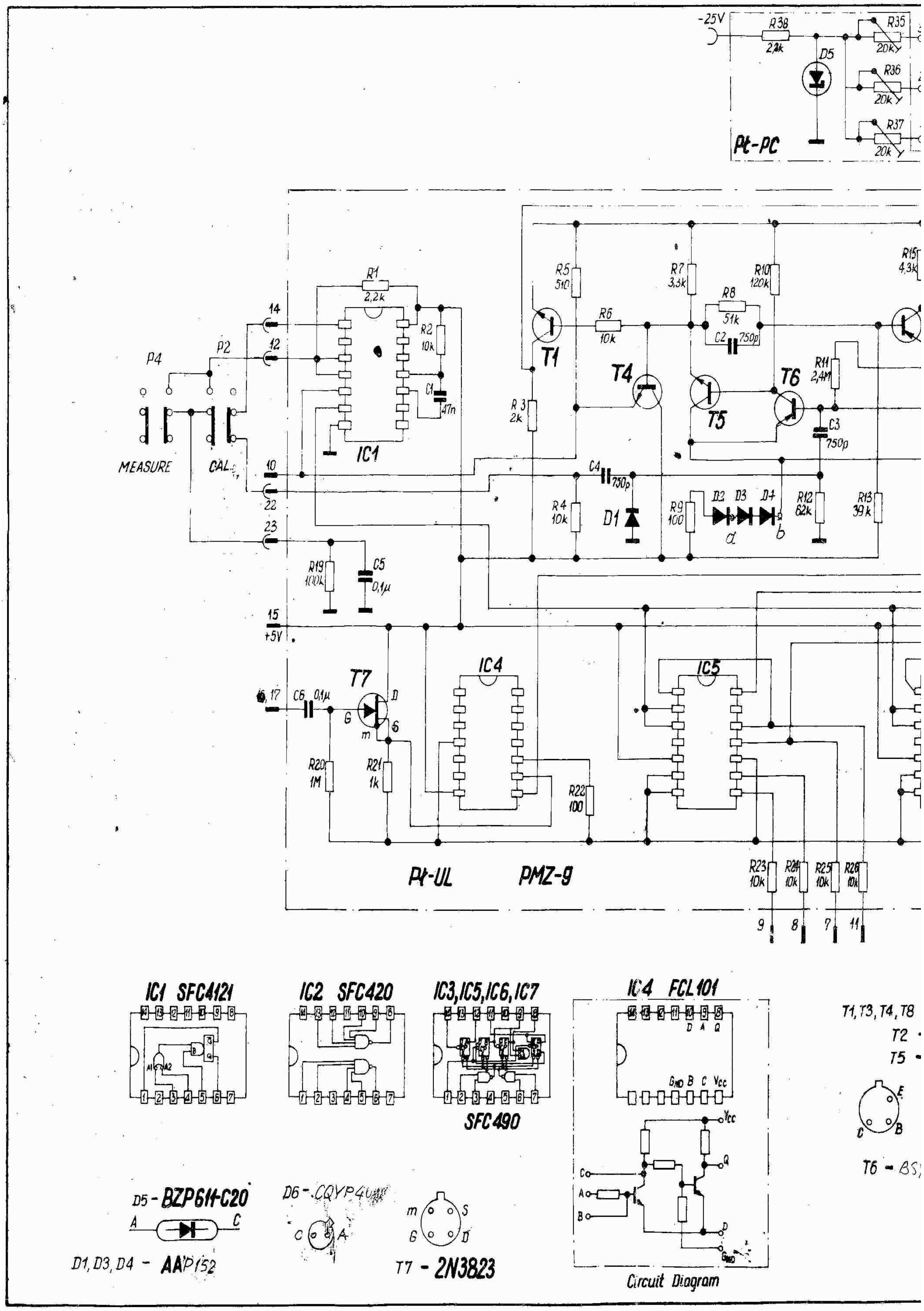


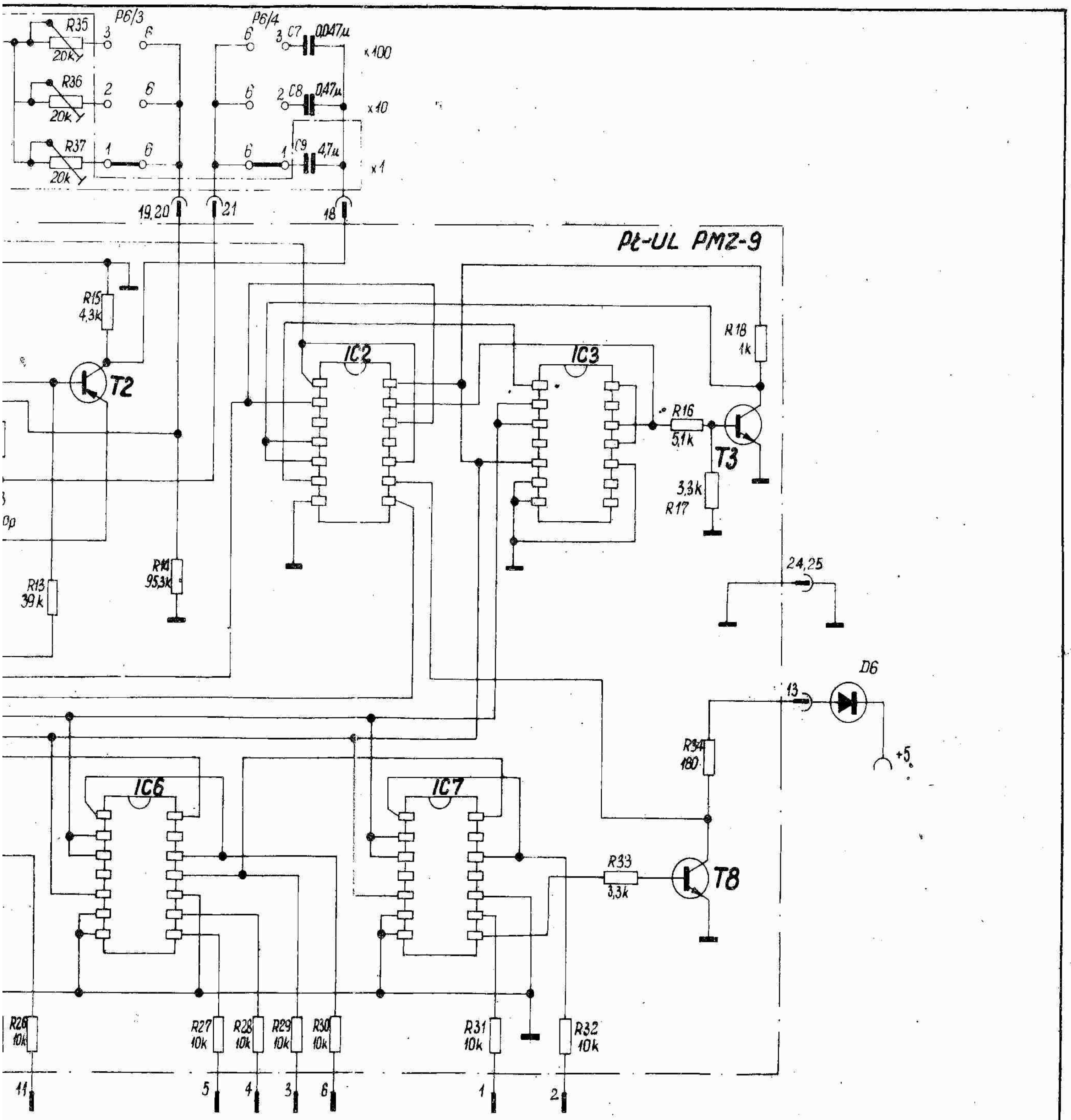
ZOPAN
WARSZAWA

MEASURING AMPLIFIER CIRCUIT WP
CIRCUIT DIAGRAM

Type **PMZ-9**

SB-4573-367

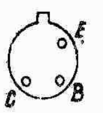

-25V
R38
2,2k
D5
R35
20k
R36
20k
R37
20k
Pt-PC
R1
2,2k
R2
10k
C1
47n
IC1
14
12
P4
P2
MEASURE
CAL
10
22
23
R5
510
R3
2k
T1
R6
10k
T4
R7
3,3k
R8
51k
C2
750p
R10
120k
T5
T6
R11
2,4M
C3
750p
R15
4,3k
C4
750p
R4
10k
D1
R9
100
D2 D3 D4
a
b
R12
62k
R13
39k
R19
100k
C5
0,1µ
15
+5V
16, 17
C6 0,1µ
T7
G
D
S
m
R20
1M
R21
1k
IC4
R22
100
IC5
R23
10k
R24
10k
R25
10k
R26
10k
9
8
7
11
Pt-UL
PMZ-9
IC1 SFC4121
IC2 SFC420
IC3, IC5, IC6, IC7
SFC490
IC4 FCL101
D A Q
GND B C Vcc
Vcc
C
A
B
Q
D
GND
Circuit Diagram
T1, T3, T4, T8
T2
T5
E
C
B
T6 - BS
D5 - BZP611-C20
A
C
D6 - CQYP40
D1, D3, D4 - AAP152
T7 - 2N3823



T1, T3, T4, T8 - **BFP520**

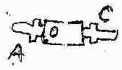
T2 - **BC179**

T5 - **BS**XP87

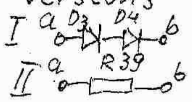


T6 - BSYP05

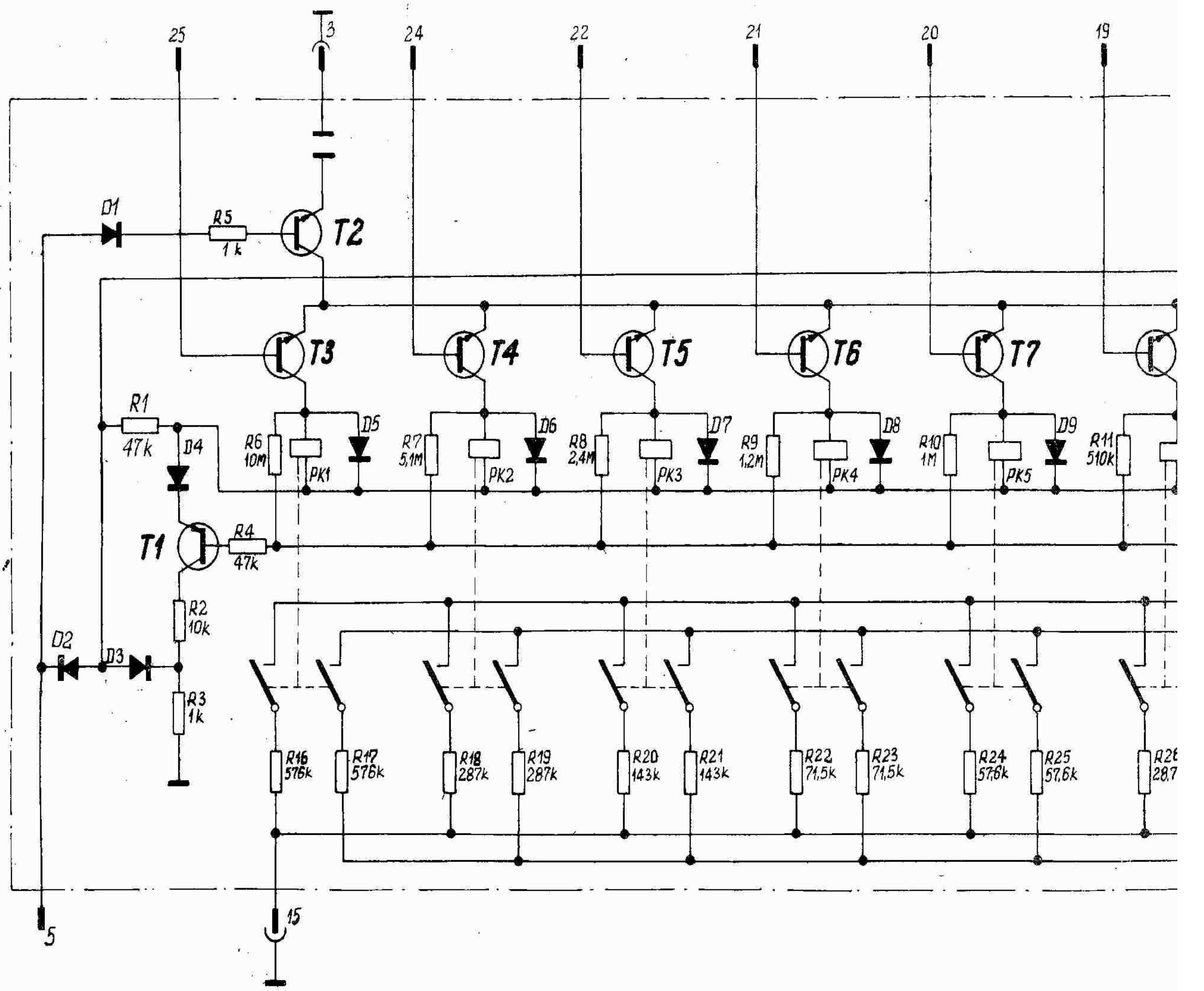
D2 - BAP795

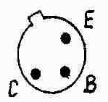


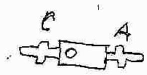
versions



ZOPAN WARSZAWA	**LOGIC CIRCUIT** CIRCUIT DIAGRAM	Type **PMZ-9** **SA-4573-366**





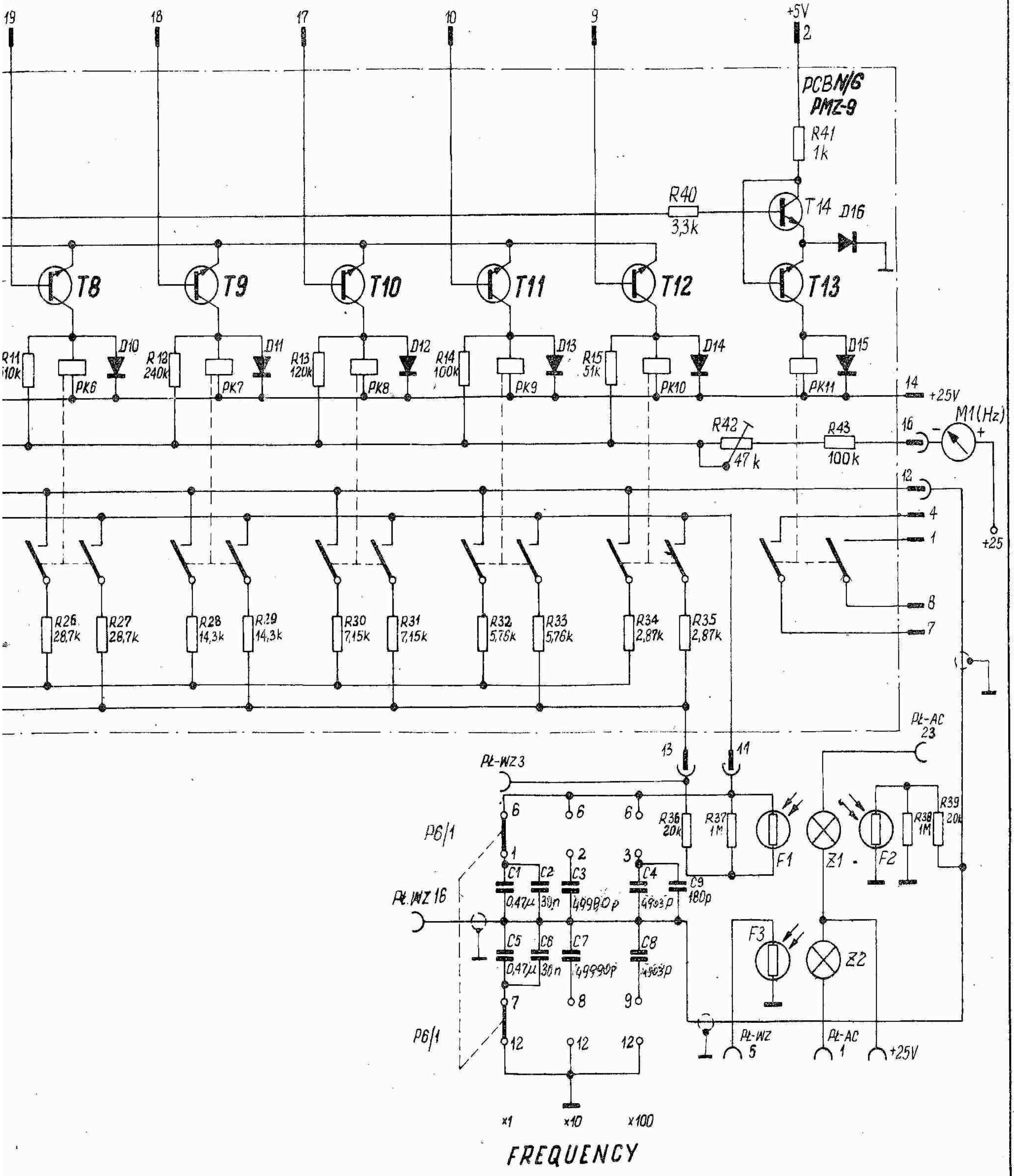


T1 - **BC179**

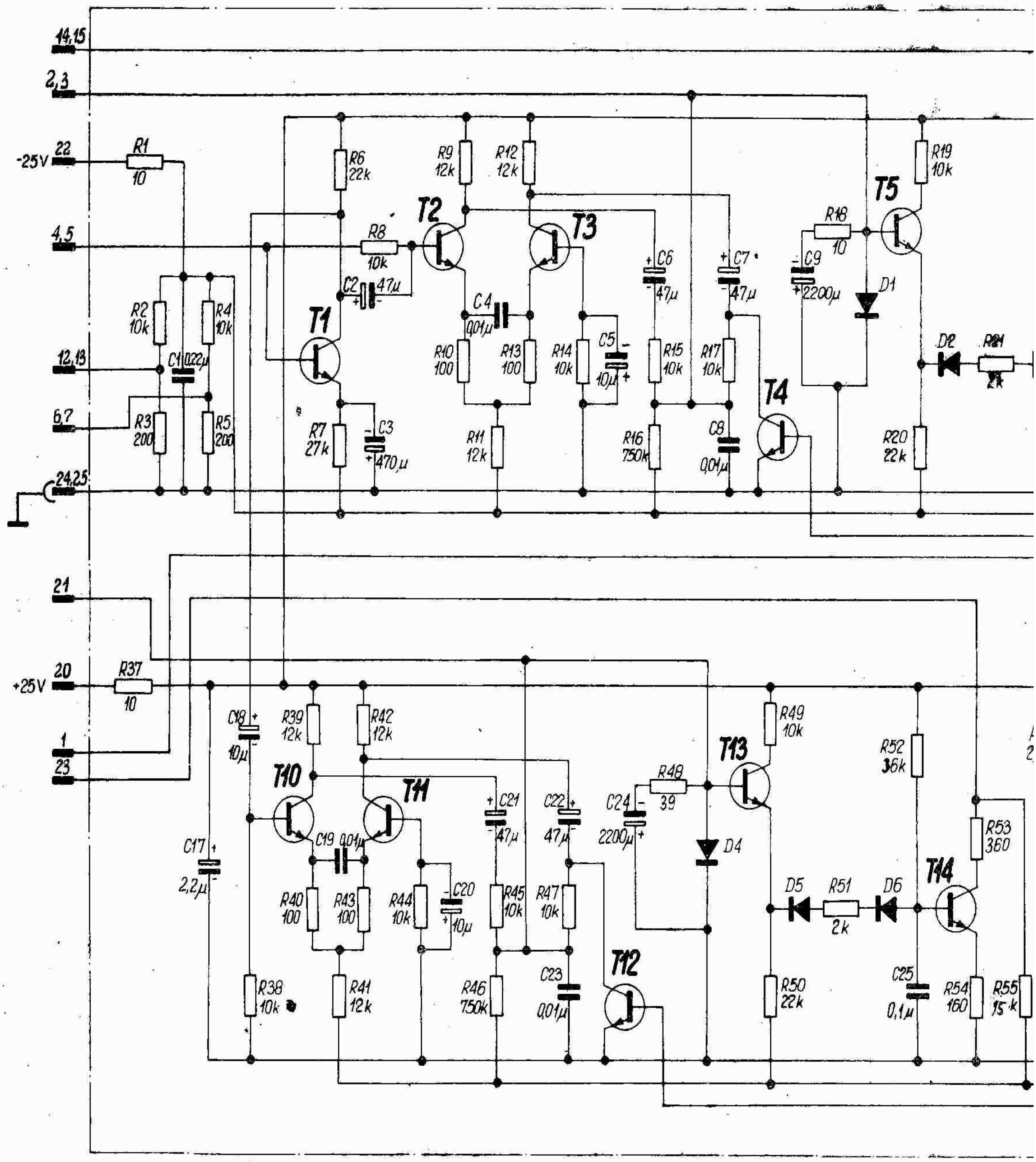
T3 ÷ T14 - **BFP520**

T2 - BSXP19

D1 ÷ D16 - **BAP 795**

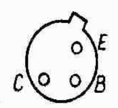


ZOPAN WARSZAWA	PULSE-NUMBER/CONDUCTANCE CONVERTER N/G CIRCUIT DIAGRAM	Type PMZ-9 SA-4573-364

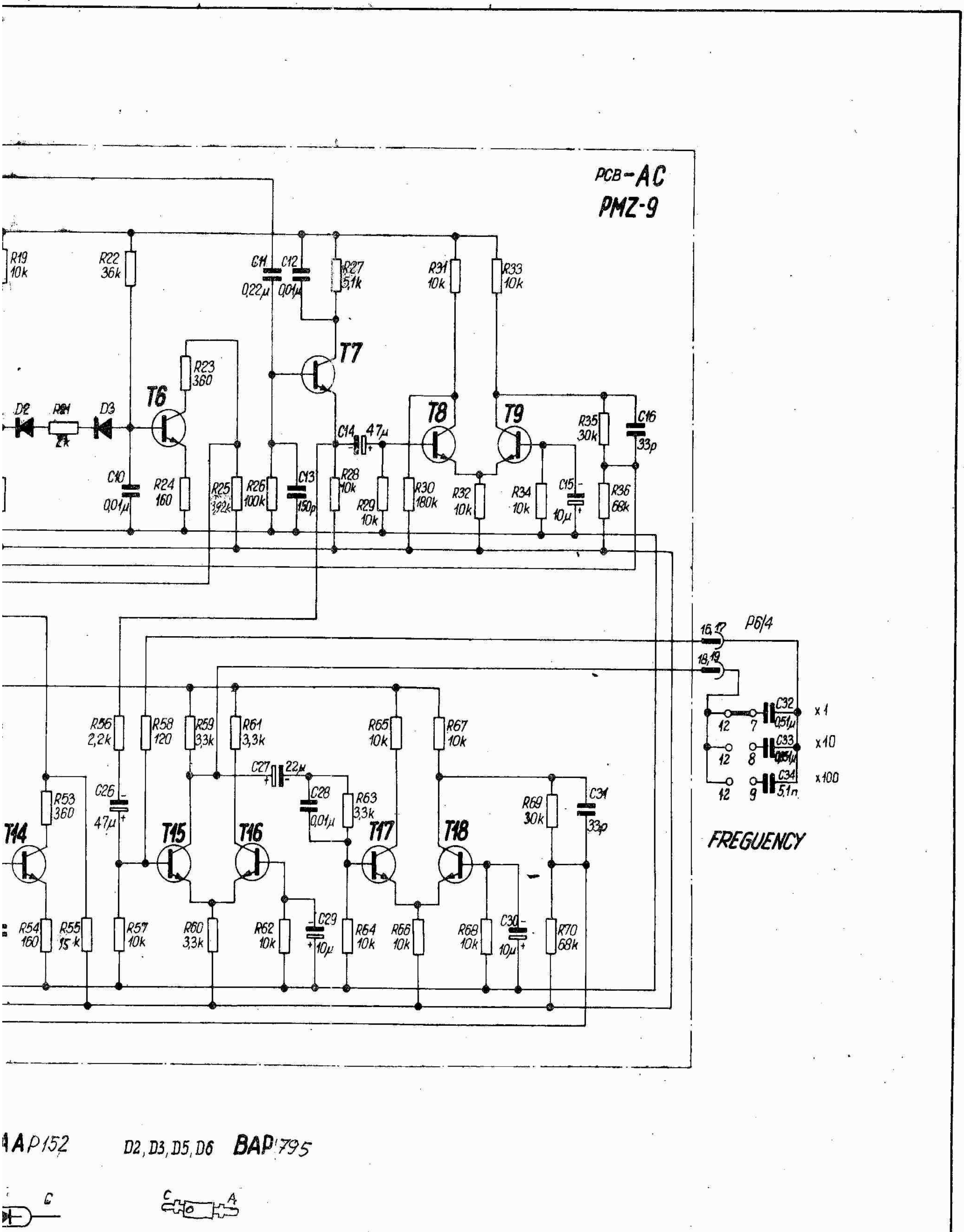


T1÷T3, T5, T7 T13, T15÷T18 **BFP520**

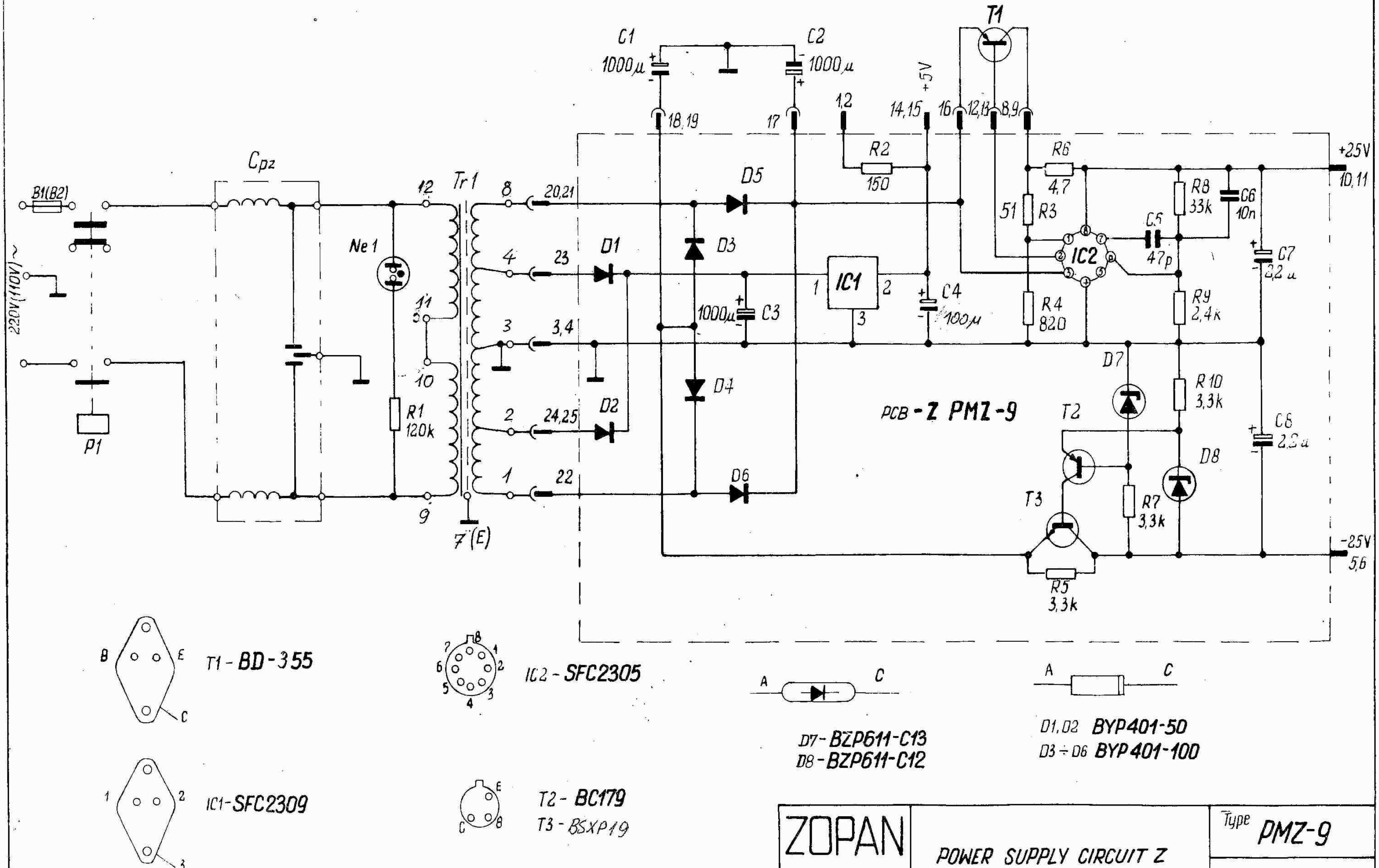
T6, T14 BSXP19



D1, D4 **AAP152**



ZOPAN WARSZAWA	AUTOMATIC FREGUENCY CONTROL CIRCUIT AC CIRCUIT DIAGRAM	Type PMZ-9 SA-4573-363

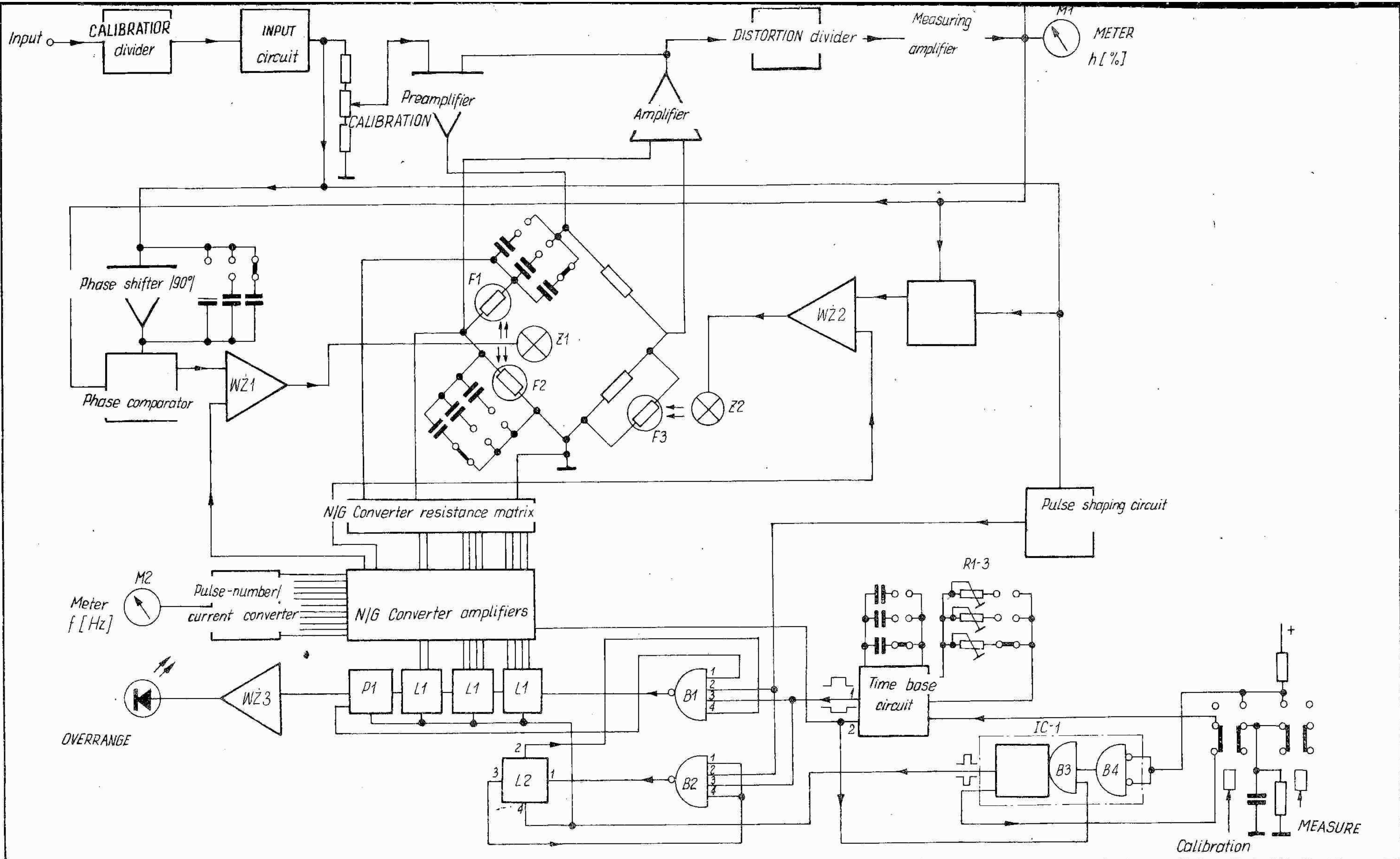


ZOPAN
WARSZAWA

POWER SUPPLY CIRCUIT Z
CIRCUIT DIAGRAM

Type PMZ-9

SB-4573-365

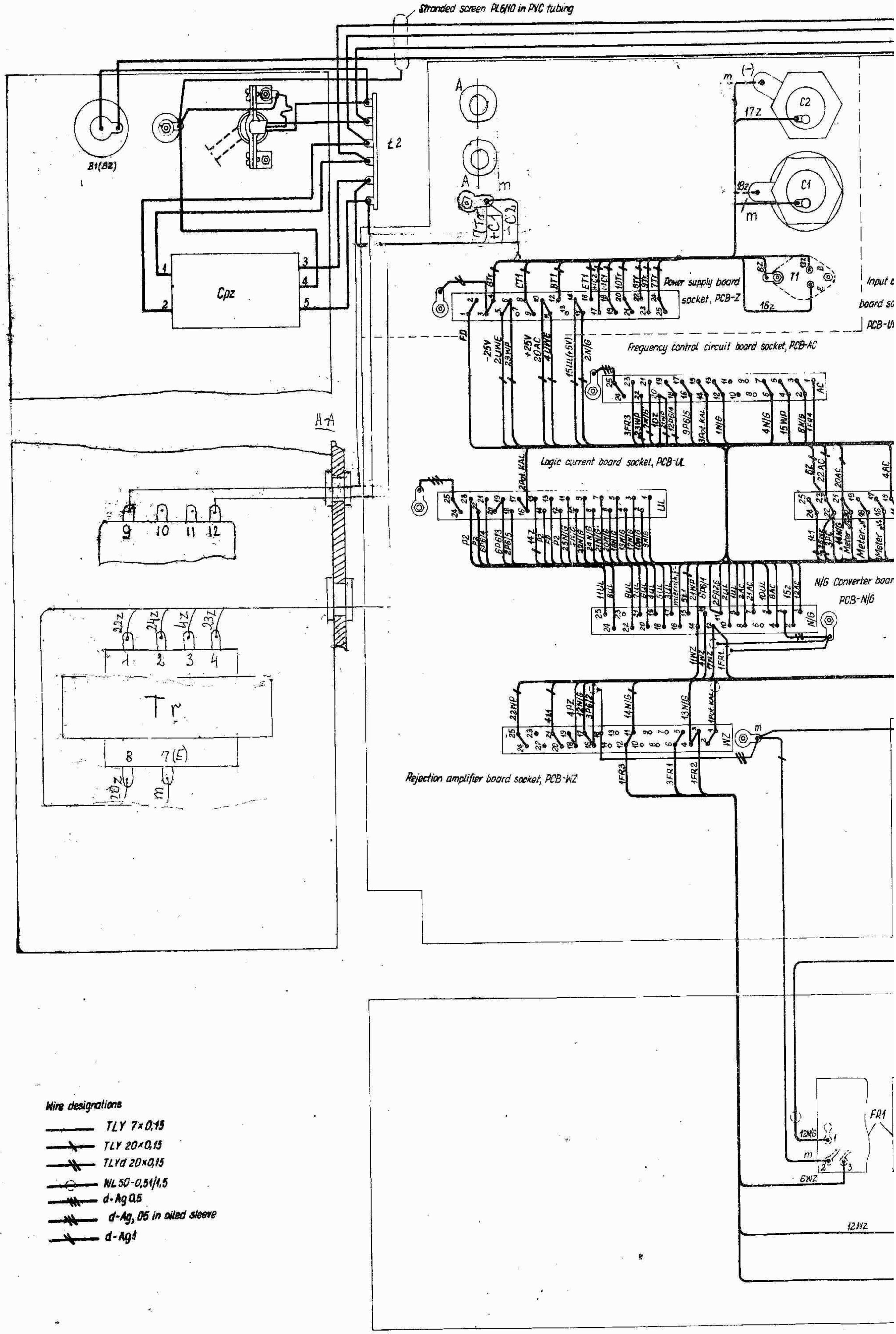


ZOPAN
WARSZAWA

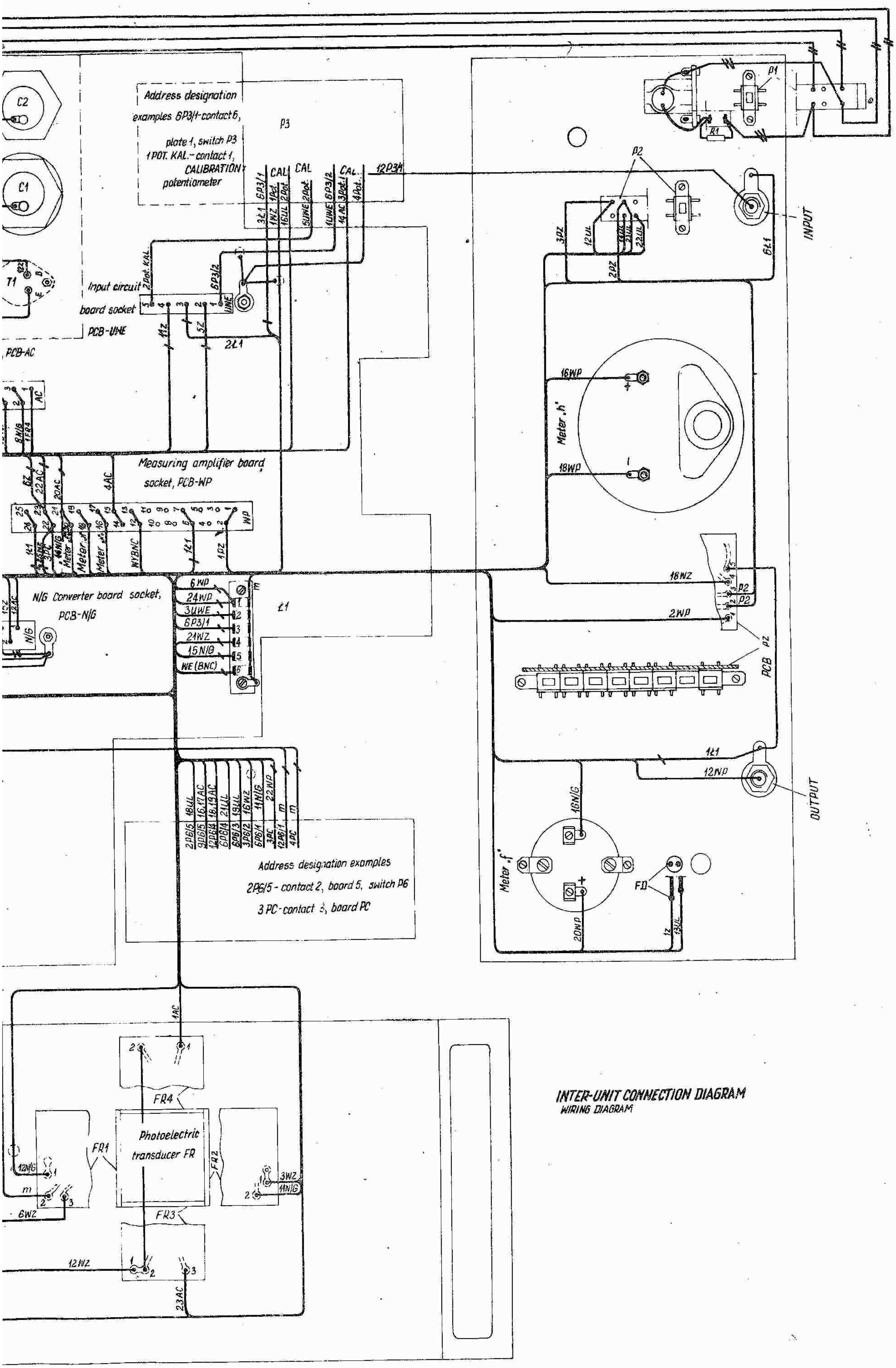
AUTOMATIC NON-LINEAR DISTORTION METER
BLOCK DIAGRAM

Type **PMZ-9**

B-5866-408



Stranded screen PL6/10 in PVC tubing
B1(B2)
Cpz
Power supply board socket, PCB-Z
Frequency control circuit board socket, PCB-AC
Logic current board socket, PCB-UL
N/G Converter boar
PCB-N/G
Rejection amplifier board socket, PCB-WZ
Input c
board so
PCB-U
Tr
C1
C2
T1
FR1
A-A
Wire designations
TLY 7×0,15
TLY 20×0,15
TLYd 20×0,15
NL 50-0,51/1,5
d-Ag 0,5
d-Ag, 05 in oiled sleeve
d-Ag 1



INTER-UNIT CONNECTION DIAGRAM

WIRING DIAGRAM