EC Mark III

Easy Chair P.E. Mark IIIA
Report No. 1

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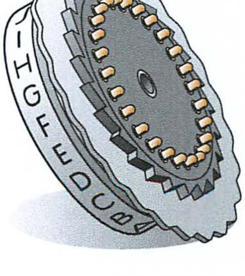
Project Easy Chair



Project Easy Chair - P.E. MARK IIIA

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Report No. 1

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INTRODUCTION

As requested in the Memorandum of November 24th 1958 from the Contracting Group to Nederlandsch Radar Proefstation, topic (2), and in accordance with the existing research contract, topic (1.3), a study was made of the possibilities of the use of a battery in the passive element.
The results of this study are laid down in this report. They can be devided into 5 parts, i.e.:

1. A preliminary survey of the possible ways to combine a passive element and a battery.
2. Measurements of reflection and modulation characteristics of crystal rectifiers at 378 Mc/s under conditions as envisaged for this particular application.
3. Development of a passive element circuit based on this application and the results obtained from items 1 and 2.
4. A life test on batteries.
5. A theoretical prediction of performance to be expected under actual conditions by using this new development.

1. PRELIMINARY SURVEY OF POSSIBILITIES

Several ways of combining a passive element and a battery are possible. The main advantage for a system of this kind will be an improved range performance, a requirement being a relatively long battery life. This requirement demands a passive element circuit presenting an average load for the battery which is as small as possible.
Four systems have been considered in particular, each of which will be discussed briefly in the following.

1.1. A battery can be used as a storage element, accumulating power during intervals when no communication from passive element to base station is required, the power being radiated by the base station, and the accumulated power being used for actual passive element operation when necessary.
This scheme looks attractive but a number of practical difficulties will be encountered.
The ~~active~~ average r.f. activation power level of passive elements used now is about -40 dBW or 100 microWatts. This required power level is at present the main factor limiting the maximum range.
In order to realize a gain from the new arrangement a decrease of this power level must be possible, e.g. to -46 dBW, or 25 microWatts, or even better.
The d.c. output power delivered by the crystal in that case is 3 or 4 microWatts at most. When this amount of power is available for battery charging, the charging current for a 1,2 Volts unit would be about 3 microAmps.

/2

It is questionable if and how much this small current will surpass the inherent self-discharge current of the battery.
Moreover,this charging power must be delivered at a voltage level in accordance with the battery voltage.
As far as our experience goes, no batteries are available which have a nominal voltage considerably less than 1 Volt. Therefore the electrical constants of the crystal detector and associated r.f. circuits might even prevent the generation of such a high voltage from a r.f. power as low as mentioned.
The passive element circuitry will have to be extended due to the required switching process, which must somehow be initiated from the base station.
This extra circuitry will also impose a load on the battery, thereby decreasing the proportion of total time that will be available for actual operation.
Another way of using the above-mentioned arrangement could be considered if a very good r.f. path between base station and passive element is present. In this case the recharging of batteries might be feasable during hours when a strong r.f. field is less likely to arouse suspicion, e.g. at night.
Due to the increased performance of the passive element in this arrangement the actual r.f. field during E.C. operation can be weaker than normally required for existing Mark III equipment, thereby also decreasing chances of detection.

1.2. A second system considered was one in which the battery is used to supply d.c. voltage to the passive element circuit, and in which the d.c. current drawn by the passive element is governed by the presence of an incident r.f. signal. In this case battery power is only consumed during actual operation of the E.C. system.
As far as performance and chances of realization are concerned this system looks more promising than the previous one.
Apart from normal passive element circuit details a new element will have to be added, viz. a second crystal detector for detection of the presence of r.f. activating power. The d.c. output of this detector must switch on the passive element circuit but this detector cannot be combined into one circuit with the existing modulating crystal because the d.c. conditions of this modulating crystal are upset by the modulating voltage as soon as the passive element starts operating.
This extra detector crystal will extract some of the precious activating r.f. power and will therefore decrease the overall performance to some extent.
The laboratory believes nonetheless that this arrangement could be realized but that the amount of work involved would prevent the presentation of this report within the period allowed.

/3

1.3. A possibility considered was one in which the passive element could work in conjunction with a battery, offering improved performance as long as the battery lasted, after which period the passive element would resume operation in the usual way as in E.C. Mark III equipment.
The difficulty lies here in the big difference between the voltage generated by available battery types and the most efficient output voltage and current values for crystal detectors at the low r.f. power levels encountered.
Design of a passive element circuit for either one of these voltages would seriously reduce efficiency for the other condition or reduce battery life considerably and unnecessarily.
Besides, some type of isolating elements between the two voltage sources must be used, for example series diodes in each supply circuit. The inevitable voltage drop across these units will impair efficiency again.

1.4. The system in first instance chosen for development was a passive element circuit directly powered by a battery.
No switching means have been incorporated but the efficiency has been made relatively high so that battery life is saved as much as possible within limits.
No serious complications are involved and good performance and dependability can be expected as long as the battery will satisfy the minute power requirements.
This circuit might be a basic element whenever the arrangement described in section 1.2 will have to be worked out further.
The circuit arrangement chosen is described in detail in section 3.

2.1. <u>MEASURING SET-UP FOR REFLECTION-MODULATION CHARACTERISTICS</u>

The measuring set-up was practically similar to the set-up used at a former occasion (See: Final Research Report dated 10th Jan. 1958, par.2.1.3).
A brief description will be given here.
A 378 Mc/s signal and a 100 kc/s sinusoïdal voltage were impressed on the crystal terminals at the same time. Due to the non-linearity of the crystal this gives rise to the generation of modulation sidebands separated by 100 kc/s from the 378 Mc/s signal.
A narrowband receiving system, also coupled to the crystal terminals, indicates on an output meter the magnitude of these sidebands.
When a reading is obtained the 100 kc/s voltage is removed from the crystal and the 378 Mc/s signal source is modulated by another 100 kc/s signal. This modulation is adjusted until a same receiver output meter reading is obtained. From the attenuator reading and the measuring set-up constants the absolute value of sideband power can be evaluated. This figure is compared with the r.f. power fed to the crystal and the ratio is defined as reflection loss R, expressed in dB.

$$R = \frac{\text{available r.f. power from both sidebands}}{\text{available incident r.f. power at crystal terminals}}$$

Other constants are defined thus:

E = r.m.s. value of 100 kc/s modulation voltage at crystal terminals, expressed in mV.

p = available incident r.f. power at crystal terminals, expressed in dBW.

R.f. matching means were provided between measuring set-up and crystal to be tested. The matching was in all cases adjusted for maximum d.c. crystal output with 100 kc/s modulation removed at an incident power level P = -50 dBW. This match proved to be quite close to the matching adjustment providing optimum reflection modulation, the difference being only about 0.1 - 0.3 dB from maximum.
An adjustable line was inserted in the set-up in order to make sure that the phase relation between sidebands from the crystal and the r.f. carrier was optimum at the receiver input.
The receiver bandwidth was chosen such that only first order sidebands were taken into account.
Three crystal types were tested: CS2A (British, B.T.H.)

IN21C (American, BOMAC)

IN23D (" ")

From each crystal type three units were used for the test. These units were newly supplied from the manufacturer and may well be representative as an average. The results for the three units of each type were averaged and are given in the next section.

2.2. MEASUREMENTS OF R VERSUS E AND P

E (mV. r.m.s.)	R (dB)		
	CS2A	IN21C	IN23D
600	6,3	4,2	3,5
500	6,3	4,2	3,5
350	6,5	4,6	3,9
250	7,3	5,5	5,0
175	9,2	7,4	7,2
125	11,2	9,4	9,8
88	14,1	12,5	13,0
63	16,9	15,1	15,6
44	19,8	18,1	18,7
31	22,9	20,9	21,6
22	26,1	24,0	24,6
16	28,7	26,9	27,5

P = -44 dBW

E (mV. r.m.s.)	R	(dB)	
	CS2A	IN21C	IN23D
600	6,3	4,0	3,2
500	6,3	4,0	3,2
350	6,3	4,0	3,4
250	6,7	4,1	3,9
175	7,4	4,5	5,3
125	8,8	5,4	7,3
88	11,3	7,4	10,3
63	13,4	9,6	13,4
44	15,9	12,5	16,5
31	18,9	15,1	19,3
22	22,3	18,4	22,8
16	24,7	21,0	25,5

P = -54 dBW

E (mV. r.m.s.)	R	(dB)	
	CS2A	IN21C	IN23D
600	6,5	4,1	3,5
500	6,5	4,1	3,5
350	6,5	4,1	3,5
250	6,5	4,1	3,5
175	7,5	4,6	5,3
125	8,8	5,5	8,8
88	11,1	7,4	>12
63	>12	10,1	>12

P = -64 dBW

Some of these results are shown in the curves of Fig. 1

2.3. RECTIFICATION EFFICIENCY OF CRYSTALS

P = -50 dBW matched to crystal
D.C. load resistance 600 Ohms
No modulation voltage impressed:

CS2A : direct current in load 31 μA
IN21C : " " " " 49 μA
IN23D : " " " " 31 μA

Forward and reverse resistance, as measured with AVO model 8 multirange meter:

CS2A : 420 - 19.000 Ohms
IN21C : 275 - 37.000 "
IN23D : 400 -200.000 "

/6

SECRET

2.4. EFFECT OF D.C. BIAS ON R FOR CRYSTAL IN21C

$E_{D.C.}$ (mV)	△ R (dB) P = -44dBW	P = -50dBW	P = -54dBW
0	0	0	0
50	0	0,2	0,3
100	0,2	0,7	0,85
150	0,7	1,55	1,8
200	1,8	2,9	3,25

E = 250mV. r.m.s.

The change in reflection loss is always such that the loss is increased as a result of the bias supplied.

2.5. D.C. VOLTAGE-CURRENT CHARACTERISTIC FOR CRYSTAL IN21C

$E_{D.C.}$ (mV)	$I_{D.C.}$ (mA)
+350	5,85
+300	3,75
+250	2,0
+200	0,84
+150	0,28
+100	0,13
+ 50	0,08
0	0
-100	0,001
-200	0,005
-300	0,007
-400	0,01
-500	0,013
-600	0,016

No r.f. or modulation voltage supplied to crystal

2.6. EVALUATION OF REQUIRED 100 kc/s MODULATION POWER

The necessary 100 kc/s power can be deduced from the measurements in sec.2.5. This deduction is valid for a crystal type IN21C and a modulating voltage E = 250 mV. r.m.s. but includes several values of d.c. bias for the crystal.

$E_{D.C.}$ (mV)	P mod. (μW)
0	385
50	180
100	70
150	20
200	6

2.7. THE 100 kc/s VOLTAGE WAVE FORM

The actual wave form of the reflected and modulated r.f. power was monitored on a c.r.o. The modulating voltage was, as mentioned before, sinusoïdal.
The reflected modulated r.f. power proved to be sinusoïdal too for low values of modulating voltage but became progressively more flat-topped as the point of optimum reflection efficiency was approached. The level at which this symmetrical limiting occurred was dependent on the incident r.f. power level. In each instance however the transition from sinusoïdal to clipped reflection coïncided roughly with the points in Fig. 1, where the curves started deviating from the 45° slope.
For r.f. levels P between -44 dBW and -64 dBW this point was reached for modulating voltages of about 150 to 50 mV. r.m.s. respectively.
D.c. biasing of the crystal only resulted in making the reflected modulation waveform less symmetric.

2.8. CHOICE OF CRYSTAL TYPE TO BE USED

One important choice can be made now, viz. the type of crystal to be recommended for future use.
It will be quite clear that the types IN21C and IN23D are superior to the type CS2A used up to now.
Under optimum conditions the type IN23D can give an improvement in reflection characteristics of about 0,7 dB as compared with the type IN21C. Under actual conditions however, in which the modulating power in limited, this gain decreases rapidly or even becomes negative.
For the application treated in this report it seems therefore that the type IN21C must be recommended.
As far as rectification efficiency goes, the type IN21C is superior to the two other types, so that it is further recommended that newly made passive elements for the existing EC Mark III equipment will be fitted with IN21C crystals also.
Prices of the CS2A and the IN21C units are almost equal, whilst IN23D units cost three times as much.
The BOMAC crystals in this range are also available in physically symmetrical and slightly smaller units for the same price, bearing the type number IN416C instead of IN21C.

2.9. CHOICE OF OPERATING CONDITIONS FOR THE CRYSTAL IN21C

From the foregoing results a design value for operating conditions was chosen to be:

Modulating voltage: equivalent to 250 mV r.m.s. sinusoïdal wave form (700 mV peak-to-peak).
D.c. bias: 100 mV.
Modulating power 100 kc/s: 70 μW.
Reflection loss: about 5,3 dB.

The d.c. bias should be obtained automatically in order to be self-adjusting under conditions of varying modulating voltage and r.f. excitation power.
This autobias can be obtained by inserting a resistor of between

/8

 SECRET

300 and 400 Ohms into the crystal d.c. circuit. This resistor must be shunted by a condenser in order to prevent the introduction of 100 kc/s losses at the same time.
It should be mentioned here that the d.c. current in the crystal circuit is almost entirely due to the presence of the modulating voltage and that the rectified r.f. power is much smaller for all practical levels of r.f. activation.
As follows from sec.2.7. there is little point in choosing a sinusoïdal modulating voltage with a view on spectrum occupied and consequently increased secrecy about what is going on, unless a significant sacrifice could be allowed in reflection efficiency. With a further view on optimum efficiency for the transistorized output stage of the passive element circuit a more or less square modulating wave-form is recommended.

3. DEVELOPMENT OF A PASSIVE ELEMENT CIRCUIT

The new circuit to be described here will for the present be denominated as the Mark III/A type.
The desired characteristics may be summarized as follows:

a. It should operate from a mono-cell battery with the lowest possible current drain and down to a voltage as low as possible.
b. It should give an output voltage consistent with the recommendations given in sec.2.9.
c. It should give an output frequency in the 100 kc/s frequency range, frequency modulated to a value of preferably at least 12 kc/s peak-to-peak excursion for a microphone voltage of 84 microVolts r.m.s. for audio frequencies in the range 400 - 6000 c/s.
d. It should be independent as far as possible from circuit element tolerances and ambient conditions.

Various circuit arrangements were considered. A few of them were tried experimentally. The one finally chosen is described in the following section.

3.1. CIRCUIT DESCRIPTION OF PASSIVE ELEMENT

The circuit diagram is given in Fig. 2.
The transistor V3 and transformer T1 are the main elements of the 100 kc/s oscillator circuit. The oscillator is of the relaxation type, the frequency being governed to a very large extent by the transformer inductance and the amplitude of the switching current flowing through transistor V3.
The average current flowing through transistor V3 passes through transistor V2, which acts as a variable emitter resistance for V3. Any variation of this resistance will cause a corresponding frequency variation of the oscillator V3. Frequency modulation as required is thus obtained by applying the microphone voltage to the control electrode of V2, being the base. For increased microphone sensitivity this microphone voltage is amplified by transistor V1 before application to V2 base.

/9

 SECRET

Transistor V1 is connected as an emitter resistance for transistor V4. The voltage drop across transistors V1 and V2 is of the order of 0,4 Volts and acts as their supply voltage at the same time. Condensers C2 and C4 take care of the necessary a.c. separation for audio and subcarrier frequencies between transistors V1 - V4 and V2 - V3.
The base current of oscillator V3 flows through T1 secundary and on to V4 base. V4 is thus switched from an isolating into a conducting state by a frequency modulated nominal 100 kc/s frequency.
Resistor R4 governs V3 bias and V4 drive.
The collector circuit of V4 contains an auto-transformer T2 for providing optimum match to the load.
This load consists of the r.f. modulating crystal D1 and associated biasing network R6 - C5.
Resistor R5 serves to suppress ringing in the output transformer.
The battery terminals are shunted by condenser C6 in order to preserve a low impedance a.c. path under all conditions.
A good degree of ~~impe~~independence from transistor parameters is obtained in V3 and V4 by using them mainly as switching elements in relatively high-amplitude conditions.
Transistors V1 and V2 derive a reasonable degree of ~~impe~~independence by returning their base biasing circuits to their collectors, thus introducing d.c. feedback, the more effective because of the relatively high d.c. variational resistance offered by transistors V3 and V4.

3.2. PERFORMANCE OF PASSIVE ELEMENT MK IIIA.

A number of measurements have been performed on the MK IIIA passive element. These measurements have not been as extensive as theoretically desirable through lack of time, but may for the present satisfy practical requirements. Three units have been made and the results given are averaged over these three.

Ambient temperature: 20° C.
Audio band (-3dB) : 350 - 8000 c/s
Modulating voltage : 84 microVolts r.m.s. 1000 c/s
R.f. incident power: -50 dBW.

Battery voltage	1,50	1,25	1,0	V
Subcarrier frequency	100	98,5	97	kc/s
Subcarrier voltage at crystal terminals	570	470	370	mV.p/p
D.c. current through crystal circuit	0,31	0,25	0,19	mA
D.c. current drawn from battery	0,17	0,12	0,08	mA
Frequency modulation	18	13,6	8,9	kc/sp/p
Reflection loss (probably)	5,3	5,5	5,8	dB

Preliminary checks on the temperature dependence have shown that ambient temperatures of the order of 35°C can be tolerated without undue decrease in performance.
Frequency modulation decreased a few dB, subcarrier frequency shifted about 10 kc/s and battery drain increased about 40%, as compared to the values for 15 - 20°C.

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3.3. MICROPHONE CONSIDERATIONS
Optimum performance with the new MK IIIA passive element is seriously influenced by the microphone arrangement, in fact considerably more than in the existing MK III system. An increase of microphone sensitivity of e.g. 5 dB would roughly produce an increase of about 1 dB in allowable path attenuation for the MK III system, whilst the MK IIIA system, due to the linear operation, would allow an increase in path attenuation of 2,5 dB. The numerical examples given below are based on a sound pressure at the microphone itself of 0,32 $dyne/cm^2$ r.m.s. peak value. This value is obtained when conversational speech is picked up at a distance of 10 feet from a man's mouth, taking into account a loss of 10 dB for an acoustic probe of about 6 inches in length with a pin hole aperture.

3.3.1. One microphone to be considered is the SHURE MC 30 miniature type, having a nominal output impedance of 2.000 Ohms.
When directly connected to the MK IIIA passive element input terminals, showing an input impedance of 5.000 Ohms, a voltage under the above mentioned conditions of 71 microVolts is developped. Modifying the input circuit of the P.E. as indicated in Fig. 2, providing an input impedance of about 11.000 Ohms, will raise this figure to 85 microVolts, a gain of 1,6 dB.
The use of a matching transformer from 2000 Ohms to 5000 Ohms in the original input connection of the P.E. may theoretically raise the modulating voltage to 79 microVolts, a gain of 0,8 dB, but this gain will be lost by the additional transformer.
The use of a matching transformer from 2000 Ohms to 11000 Ohms with the modified passive element input circuit may theoretically raise the modulating voltage to 112 microVolts, a gain of 3,8 dB, but transformer losses may reduce this figure to some 2,5 dB.
The gain obtained by matching will be reduced further by a loss in high frequency response due to the highly inductive output impedance of this type of microphone. It is therefore that, when using the MC 30 microphone, a direct connection to a modified input circuit of the MK IIIA P.E. is recommended for optimum performance.

3.3.2. When ultimate reduction in size and weight is not required a type B microphone will offer improved audio fidelity.
With the acoustic sound pressure assumed before, direct connection of the 300 Ohms microphone output to the MK IIIA P.E. will produce a modulating voltage of 26 microVolts.
Direct connection of this microphone to the modified P.E. input circuit would raise this value to 27 microVolts, hardly to be considered as an improvement.
Another way of improvement is the substitution of the existing microphone output transformer by one providing optimum match for a 5000 Ohms load. This change will require no additional components and will not add transformer losses, but will raise the modulating voltage to 56 microVolts, a gain of 6 dB.
The use of a microphone output transformer providing optimum match to 11.000 Ohms and modifying the P.E. input circuit would provide 83 microVolts, a gain of 9,5 dB.

/11

This last arrangement is the one recommended by the laboratory. For system performance evaluations a value of 84 microVolts r.m.s. will be used, applicable for both types of microphones considered.

4. BATTERY LIFE TESTS

4.1. MEASUREMENTS.

Three types of readily available dry batteries were given a life test which is still going on whilst this report is being written. Results from one of these types will be given here, namely a 1,5 Volts unit with outside dimensions of 50 mm (length) and 13,5 mm (diameter). Two makes were used: BEREC D14 (British) and WITTE KAT H13 (Dutch). The number of batteries of this type involved were 12 and 6 respectively.
The period over which results were available is up to now slightly longer than 2½ months, in any case appreciably shorter than the envisaged expectancy.
The batteries to be tested were therefore divided in some groups, each group having a different accelerating factor. The results of these tests are graphically represented in Fig. 3.
The X-coördinates are normalized to the quotient t/R, t being the time in hours elapsed since the start of the test, R the load resistance connected across the battery terminals.
The Y-coördinates indicate battery voltage at each instant. When no other factors have to be taken into account, all the experimental curves, and also the one corresponding to the ultimate operating condition will combine to one curve.
The load resistances chosen were 5700,2700,1500 and 750 Ohms. The corresponding current drain from a fresh battery was therefore about 0,25, 0,5, 1,0 and 2 mA respectively.
The battery voltage was measured at regular intervals with a high-sensitivity multirange meter.
The batteries were obtained from a local dealer, no date was available about the stock time before the beginning of the tests.
The graph gives the average values of all batteries in each group.
The shape of the curves for the two makes was slightly different but the curves tend to converge again at the end of the useful life.
At the end of the useful life the zinc container of the battery showed on the outside signs of serious corrosion.
The ambient temperature was within the range of normal room temperatures, 15 to 25° C.
No data can be given about the rate of self-discharge. The laboratory will try to get some figures from the manufacturers.

4.2. PRELIMINARY CONCLUSIONS IN CONNECTION WITH MK IIIA PASSIVE ELEMENT

When the average voltage of the dry battery during useful life is assumed to be 1,25 Volts, the average load resistance offered to them by the passive element is about 10.000 Ohms. The end of operation of the passive ~~line~~ element is assumed to be reached when the battery voltage has decreased to 0,9 - 1,0 Volts.

/12

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No definite conclusion canbe drawn at present as to the ultimate life expectancy under actual conditions. The curves obtained are all more or less accelerated in time, which decreases the detoriating effect of self-discharge or chemical discomposition becoming apparent. A disturbing factor is the excursion of individual points from a smooth curve, a typical value for this dispersion being e.g. 0,05 Volts on some occasions. This effect produces uncertainties, making a tendency which otherwise could have shown up clearly. This fact may be explained by the ambient temperature changes from day to day, not registered during the measurements, or an anisotropic chemical decay process inside the battery.
The laboratory up to now has no knowledge available about the magnitude of the effect and so any figure given below is mentioned only with restriction and hesitation.
It should be stated first that the period over which battery characteristics have been measured extends over about 2½months and that the life expectancy for the batteries tested and reported above is well in excess of that period.
The green curve (1500 Ohms load, 6,7 times acceleration) indicates a maximum t/R ratio of 0,9 . 1,0, meaning 9000 - 10.000 hours of continuous operation under actual conditions, or 12 - 13,5 months.
The red curve (2700 Ohms load, 3,7 times acceleration), when extrapolated and assumed to have a shape like the green one, might indicate 0,75 - 0,85 t/R units, meaning 7.500 - 8.500 hours of continuous operation under actual conditions, or 10 - 11,5 months.
The black curve (5700 Ohms load, 1,75 times acceleration) does not deviate enough from the majority of other points to show any tendency.
The laboratory believes that a life expectancy of over 6 months may be a realistic prediction for the present and for the battery type and makes tested.
The makes tested are however not the only ones existing and it may well be that other manufacturers can supply better units.

5. PERFORMANCE OF A MK IIIA SYSTEM

In this section a comparison will be made between the existing MK III performance and performance to be obtained with the new development. The figures given will refer to allowable attenuation between base station antenna terminals and passive element r.f. terminals. These figures leave out antenna gains at both ends and propagation conditions on the path.
The main constants of the system are assumed to be:

Transmitter power	40W
Receiver noise figure	11 dB
Receiver i.f.bandwidth	40 kc/s
Receiver audio bandwidth	6 kc/s
Duplexer loss transmitting	1,5 dB
Duplexer loss receiving	10 dB for each channel
Modulating voltage for passive element	84 μV. r.m.s.

These figures comply with the base station equipment of the MK III type.
The figures are graphically illustrated in Fig. 4. /13

5.1. EXISTING PASSIVE ELEMENT MK III

For a receiver output signal-to-noise ratio of 30 dB an attenuation of 53,85 dB is allowable. For 20 dB signal-to-noise ratio this figure improves to 55,85 dB, but due to the rapid falling-off characteristics this condition will be of little actual value.

5.2. EXISTING PASSIVE ELEMENT MK III WITH CRYSTAL IN21C

An improvement of about 1,25 dB can be expected. Therefore 30 dB and 20 dB output signal-to-noise ratio will be obtained for 55,1 dB and 57,1 dB attenuation respectively.

5.3. PASSIVE ELEMENT MK IIIA

For 30 dB and 20 dB output signal-to-noise ratio the allowable attenuation is 59,25 dB and 64,25 dB respectively.
The latter condition might eventually be used actually due to the more gradual falling-off characteristics of the new type.

5.4. ADAPTED BASE STATION EQUIPMENT AND MK IIIA PASSIVE ELEMENT

Improved performance can be obtained with the new type of passive element when the base station equipment is adapted to the specific properties.
In the first place, due to the linear operation of the new passive element as a reflector, the duplexer no longer serves as a means for obtaining system balance. It can now be redesigned to provide duplexing with minimum overall insertion loss.
The existing duplexer gave about 11,5 dB overall insertion loss, whilst a redesigned one for this purpose would give about 10 dB overall insertion loss in each receiving channel. This means a two-way gain of 1,5 dB.
Another gain can be realized by decreasing the receiver bandwidth from 40 kc/s down to 20 kc/s.
The existing value of 40 kc/s between -3 dB points was chosen to accomodate, besides the regular modulation sidebands, a good margin for frequency instability of the passive element subcarrier frequency. This frequency was to a large extent dependent on incident r.f. power and could therefore shift appreciably by people moving about in the vicinity of the beam.
The new type of passive element is considerably better in this respect and hardly an allowance will have to be made for this drift.
The improvement to be obtained from the reduction in bandwidth suggested will be about 3 dB on the two-way path.
Both improvements together would improve the signal-to-noise ratio by 4,5 dB, or would for the same signal-to-noise ratio allow an increase of attenuation of 2,25 dB.
For 30 dB and 20 dB output signal-to-noise ratio the attenuation may therefore amount to 61,5 dB and 66,5 dB respectively.

5.5. REDUCED-POWER POSSIBILITIES

It will be clear that for instances and applications where extreme range is not required, the new type of passive element will allow a considerable reduction in transmitted power, thereby decreasing equipment size and weight and offering smaller chances of detection by a third party.

When for instance the allowable attenuation only should equal that of the existing equipment, e.g. 53,85 dB for a 30 dB signal-to-noise ratio, the transmitter power could be reduced to 3,3 Watts.

Adapted base station equipment (see sec. 5.4.) would even allow a reduction to 1,2 Watts.

Although this might not be very important at present, the contracting group should nevertheless in time be aware of this possibility.

5.6. EXPERIMENTAL CONFIRMATION

The figures given before, with the exception of those mentioned in sec. 5.4. were checked in a test-bench set-up and were found to be in good agreement.

Actual and realistic tests in the laboratory building were also convincing. Locations for the passive element which could not be reached hitherto were well within working range with the new arrangement.

SECRET

LIST OF COMPONENTS FOR PASSIVE ELEMENT MK IIIA (see Fig. 2)

R1	resistor	15.000 ohms		¼ W	L.C.C.	(French)
R_2	"	22.000 "		"	"	"
R_3	"	330.000 "		"	"	"
R_4	"	22.000 or 27.000 ohms		"	"	"
R_5	"	18.000 ohms		"	"	"
R_6	"	390 "		"	"	"

C1	condenser	0,25 mF	3 V	electrolytic	tantalum	Philips
C2	"	5 mF	6 V	"	"	"
C3	"	2,5 mF	6 V	"	"	"
C4	"	4700 mmF	ceramic high-K		"	T.C.C.
C5	"	2,5 mF	6 V	electrolytic	tantalum	Philips
C6	"	2,5 mF	6 V	"	"	"
C7	"	50 mmF	ceramic			

V1, V2, V3, V4 transistor OC44 Philips
D1 silicon diode IN21C BOMAC

L1 inductance, primary of transformer type S3 ~~Philips~~ Fortiphone
T1 transformer Ferroxcube pot core type D14-8
terminals 1 - 2 170 turns 0,11 mm enamelled copper
terminals 3 - 4 85 " " " "
no air gap

T2 autotransformer on Ferroxcube pot core type D14-8
terminals 1 - 3 450 turns 0,09 mm enamelled copper
" 1 - 2 180 turns, tapped on 1 - 3

20.3.59

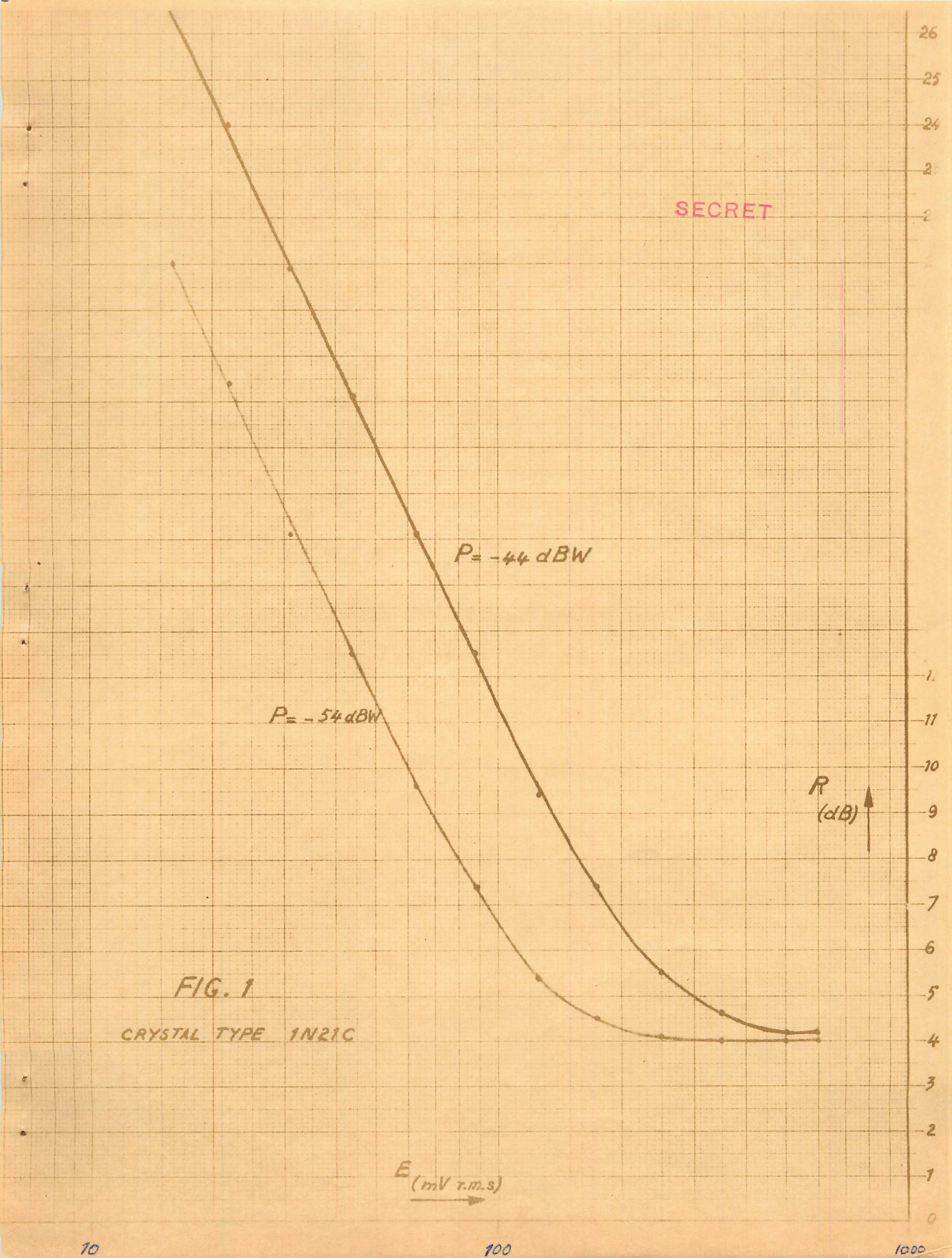


FIG. 1

CRYSTAL TYPE 1N21C

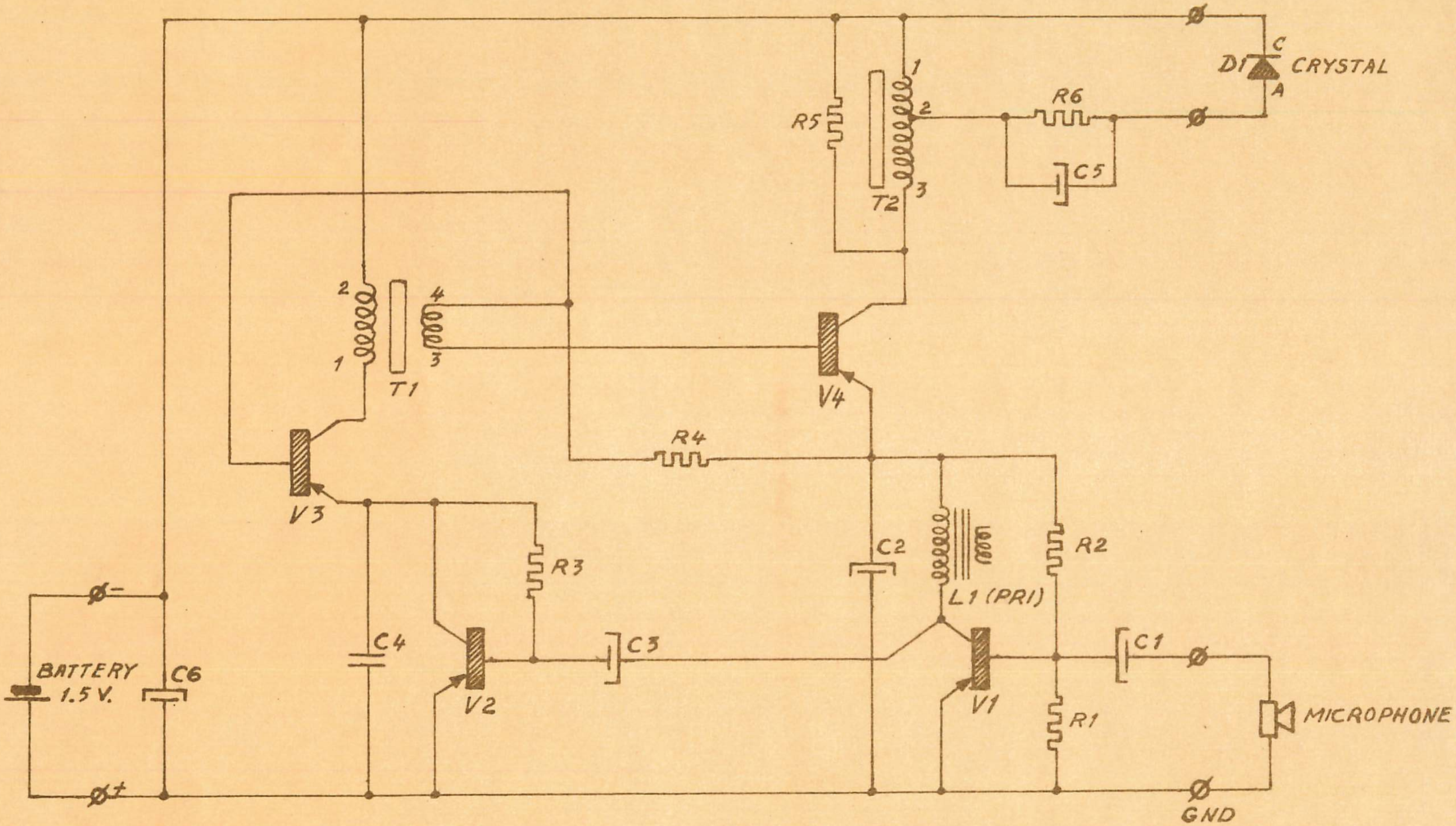
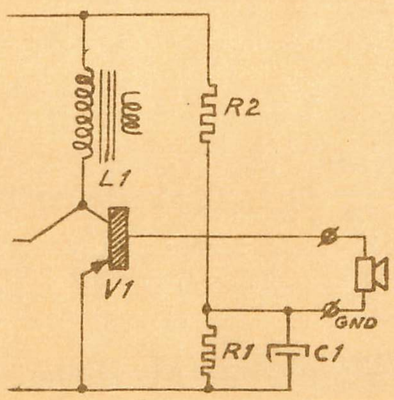


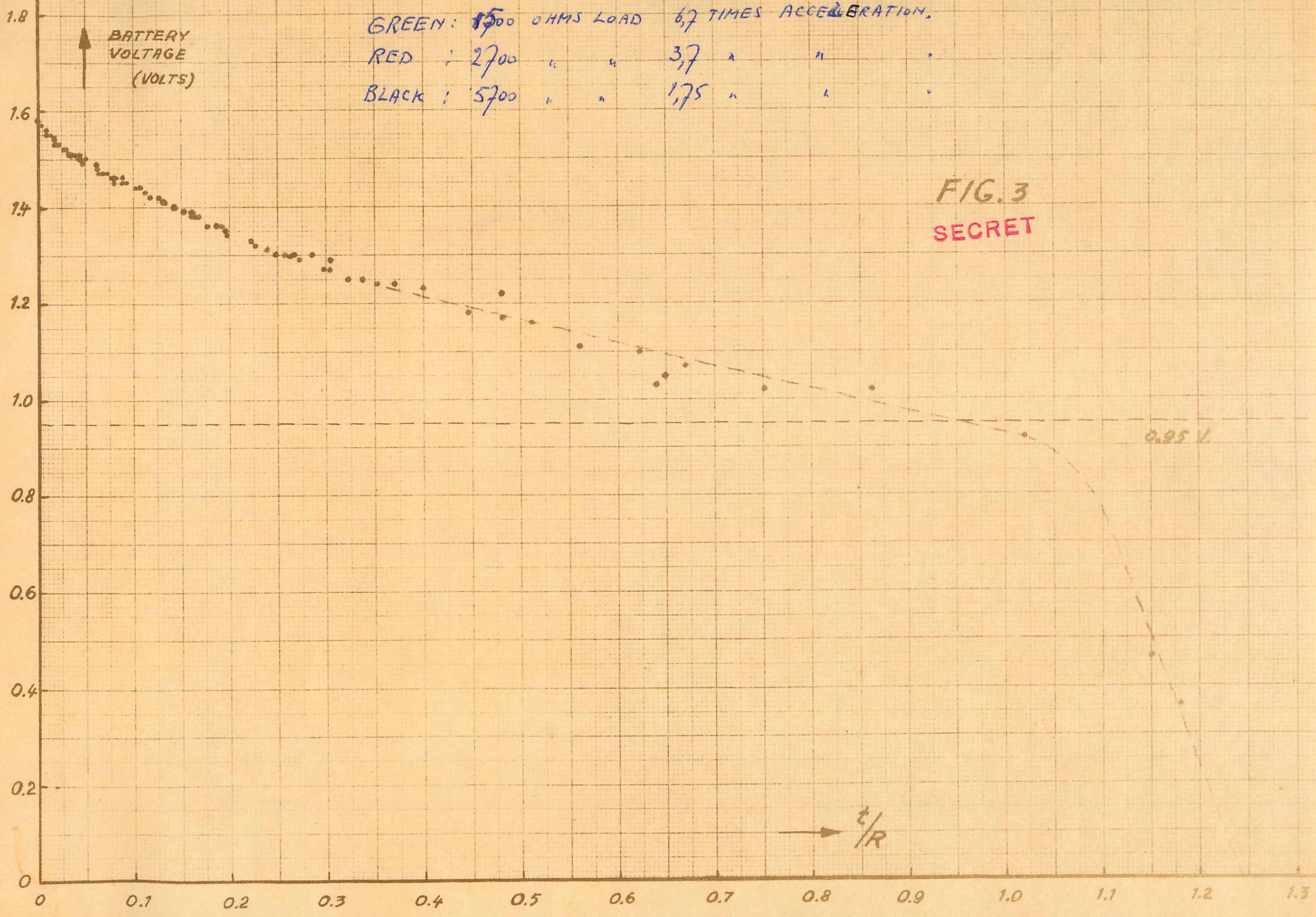
FIG. 2



ALTERNATIVE INPUT ARRANGEMENT (SEE TEXT)

PE - Mk III A

SECRET



GREEN: 1500 OHMS LOAD 6,7 TIMES ACCELERATION.
RED : 2700 " " 3,7 " " "
BLACK : 5700 " " 1,75 " " "
BATTERY VOLTAGE (VOLTS)
t/R
0.95 V.
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3

FIG. 3

SECRET

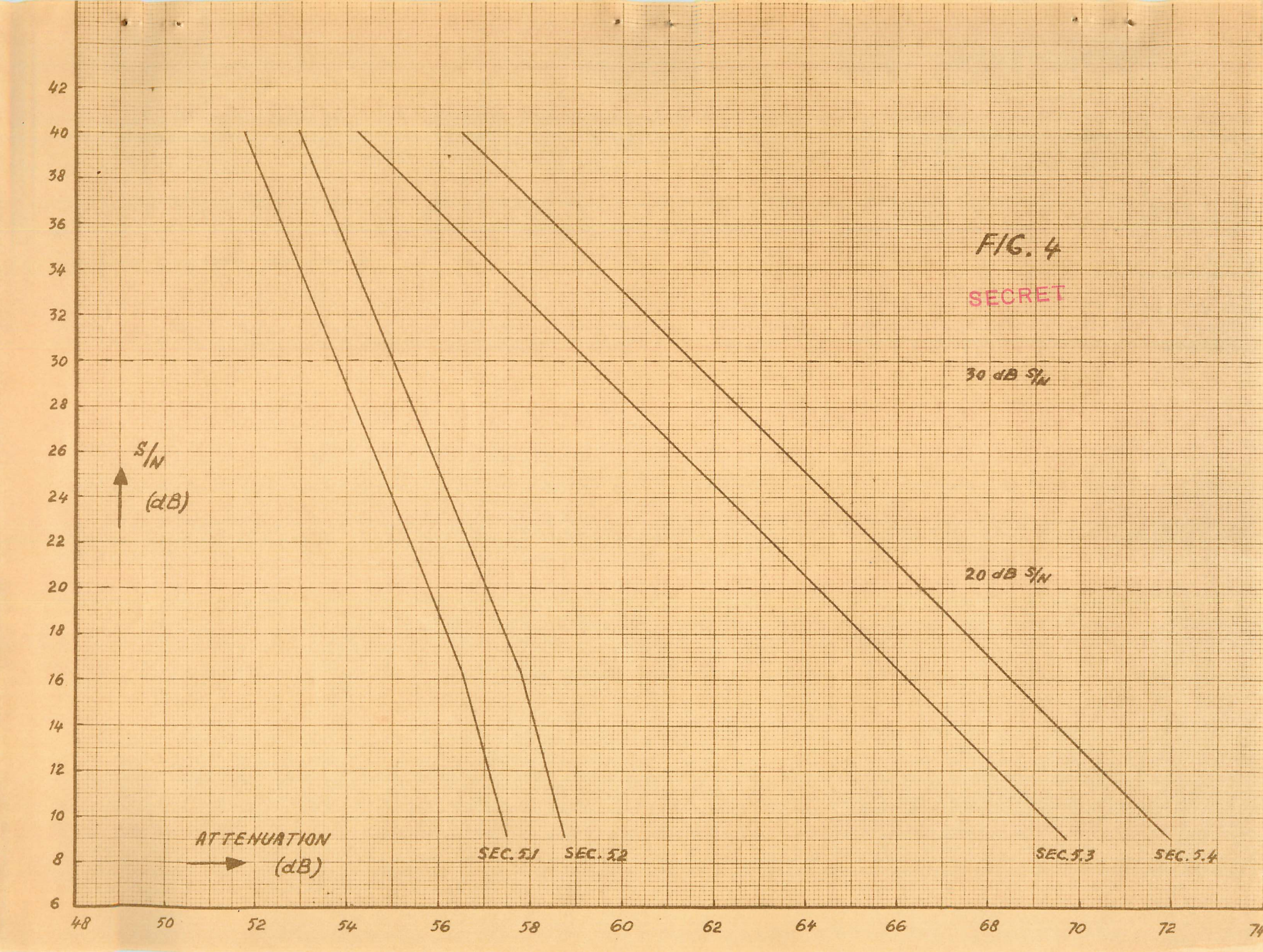


FIG. 4
SECRET
30 dB S/N
20 dB S/N
S/N (dB)
ATTENUATION (dB)
SEC. 5.1
SEC. 5.2
SEC. 5.3
SEC. 5.4
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
48
50
52
54
56
58
60
62
64
66
68
70
72
74