Instruction Manual

for FT - 100A

CONTENTS

SECTION I — INTRODUCTION

The Plug-In Unit can be used with all kinds of conventonal oscilloscopes, directly displying the variation of f_T for the dynamic points of a transistor on cathode ray tube. G.B

The measurable range of f_T covers 25 Mc/CM to 400 Mc/CM in five steps and the emitter current is measured in the range between 0.1 mA and 500 mA. Model TF-100A is adapted for Tektronix Type 530 Series, Type 540 Series and 550 Series oscilloscopes.

SECTION II — SPECIFICATION

Measurable Frequency : 100 Mc

f_T measurable range : 25, 50, 100, 200, 400 Mc/CM in five steps
(0 to 1,600Mc)

Collector Voltage range : $\pm$ 2 to 30V, continuously variable

Emittor Current range : 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10, 20.0,
50.0, mA/CM in nine steps (0 to 500 mA)

Polarity : NPN, PNP Exchangeable

Calibration : Horizontal axis 0$\pm$10 division (CM)
vertical axis 4division (CM) in [illegible] 25MC/CM

Dimention : 147 wide X 174 high X 232 deep mm

Weight : 3.8 Kg.

Power supply : A.C 6.3V 50 to 60 c/s
D.C +225V, below 20mA
+100V, below 3 mA
+ 75V, 150mA
−150V, below 15mA

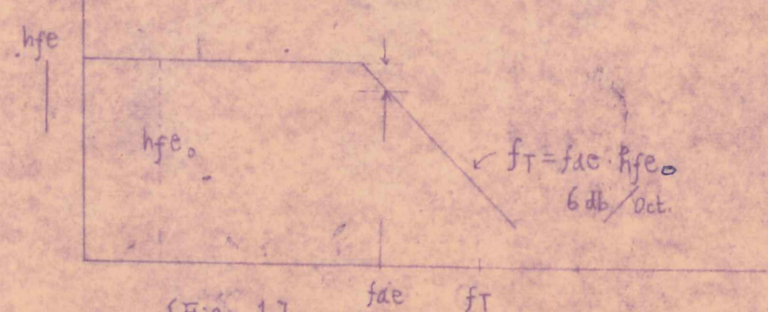
SECTION I I I — PRINCIPLE

As shown in Fig.1, the frequency characterstic of hfe is approximated to the undermentioned equotion as one of paramater showing the higf frequency characharacteristic of a transistor.

$hfe = hfe_0 \; 1/1+j(\, f/fae \,)$

hfe : Common emitter,forward transfer ratio

fae : Common emitter,current transfer ratio



(Fig. 1)

The above multiplication characteristic falls down at the curve of 6 db/Oct. and the descending curve gives GB product of hfe. This curve is an important one which determines the high range characterisTic of common emmitter transistor and is called f_T. Since common emitter multiplication circuit is most available in the practical circuits,it is convenient to use the inherent GB product in place of the cut-off frequency fα of αb of common base,forward current transfer ratio.

Cut-off freq

As indicated in Fig.1,f_T being the frequency to be hfe =1, therelation between fαe and fαb is therefore given by

$$f_T = f\alpha e \times hfe_0 \qquad (2)$$
$$= K \times \alpha b \times f\alpha b \cong K \times f\alpha b \qquad (3)$$
$$\text{where } K = f\alpha e(\, 1+hfe_0)/f\alpha b \qquad (4)$$

← can not be true

$f_{hfe} = \dfrac{f_{hfb}}{1+hfe_0}$

K is a coefficient to be determined by the electric potential gradient of the base region and its ordinary value is 0.5 to 0.8.

Moreover,upon representing the phase characteristic of common base forward current transfer ratio αb fαb as $-(\pi/4+m\,)$.

it follow that

$$K \doteqdot 1 / 1 + m$$

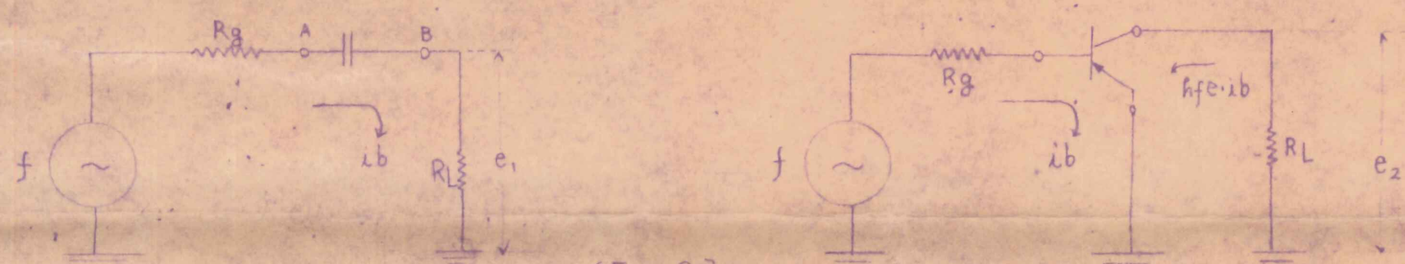
m is called the surplus phase and in case of an alloy junction type transistor, it becomes $m = 0.22$ rad ($k = 0.822$)

In another case of a drift type and other types transistors, it becomes much larger.

Since f_T shows GB product of common emitter at frequency of $f > f_{\alpha e}$, if hfe at 100 Mc is measured, f_T is given by the following relation

$$f_T = hfe_{\,100Mc} \times 100\ \text{Mc}$$

practically, as shown in Fig.2 (a), the output voltage from an oscillator [redacted] is impressed on R_L through R_G



(Fig. 2)

In case of $R_G \gg R_L$, the electric current in which flow into R_L is almost stationary electric current and voltage e_1 to be produced in R_L is

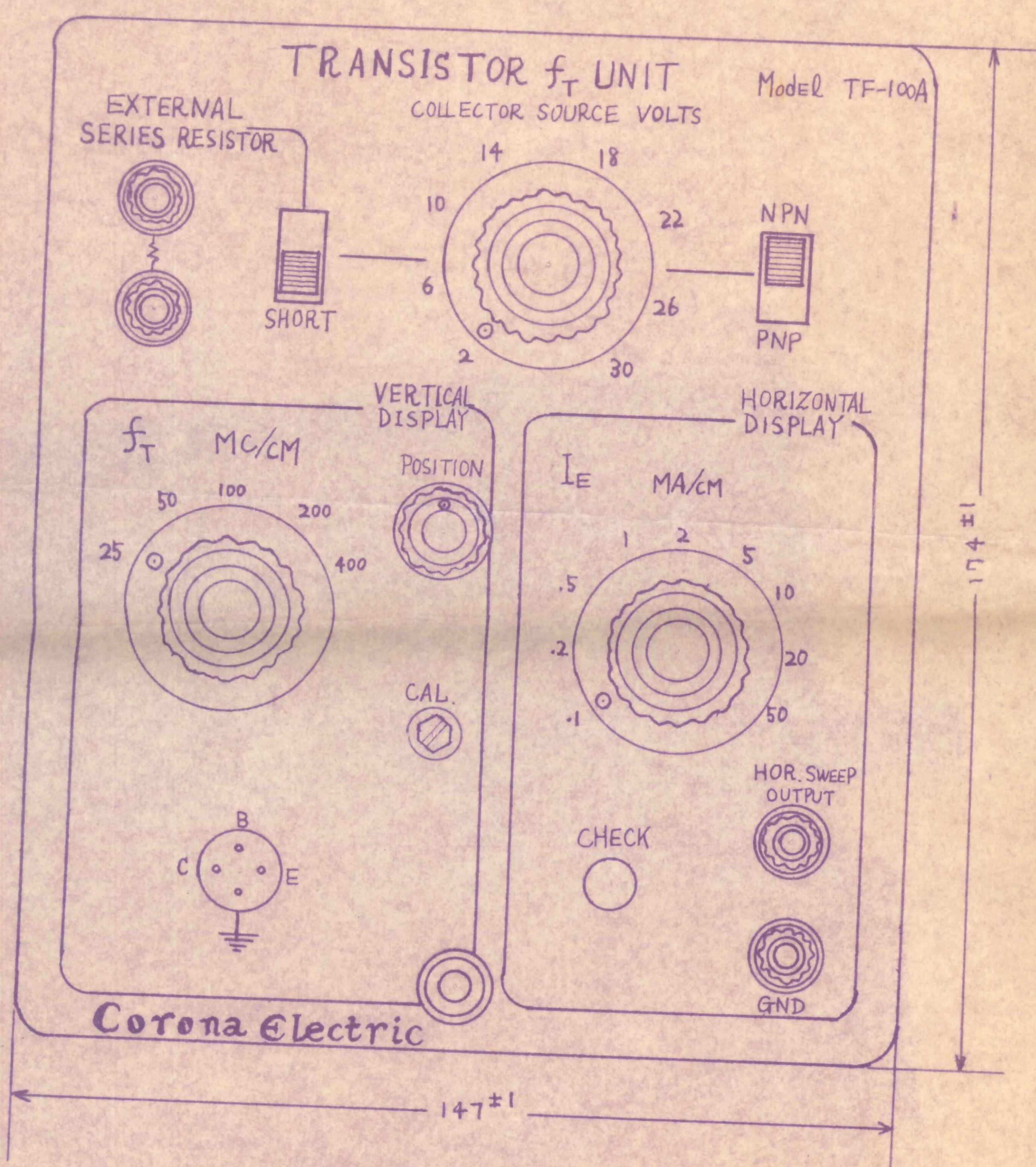
$$e_1 = ib \times R_L$$

In the next place, as shown in Fig.2 (b), in putting a transistor under test into the separation between A and B, the output volsage from an oscillator is impressed like the previos way on the base of the transistor through R_G.

Since R_G is considerably large in this case, the current to be flown into the base is nearly equal to the above mentioned ib.

Meanwhile, the current multiplied by hfe of ib flows into the collector of the transistor

FRONT PANEL


TRANSISTOR f_T UNIT
Model TF-100A
EXTERNAL SERIES RESISTOR
SHORT
COLLECTOR SOURCE VOLTS
2
6
10
14
18
22
26
30
NPN
PNP
VERTICAL DISPLAY
f_T MC/CM
25
50
100
200
400
POSITION
CAL.
B
C
E
HORIZONTAL DISPLAY
I_E MA/CM
.1
.2
.5
1
2
5
10
20
50
HOR. SWEEP OUTPUT
CHECK
GND
Corona Electric
174±1
147±1

Consequently, the voltage e_2 given by

$$e_2 = nfe \cdot i_b \cdot R_L$$

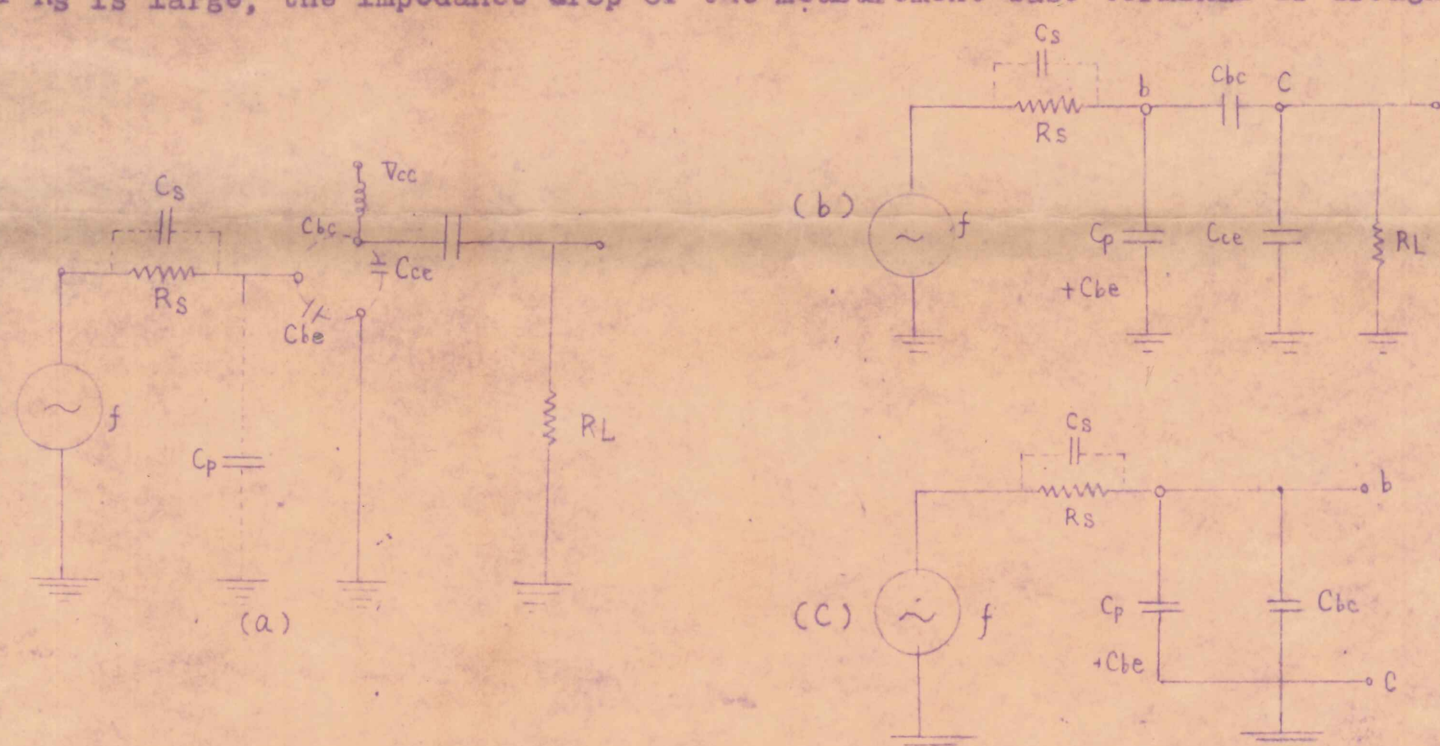
$$\text{where } nfe = e_2 / e_1$$

Moreover f_T being equal to $f \cdot nfe$, f_T is given by measureing e_2 with taking some values for f and e_1.

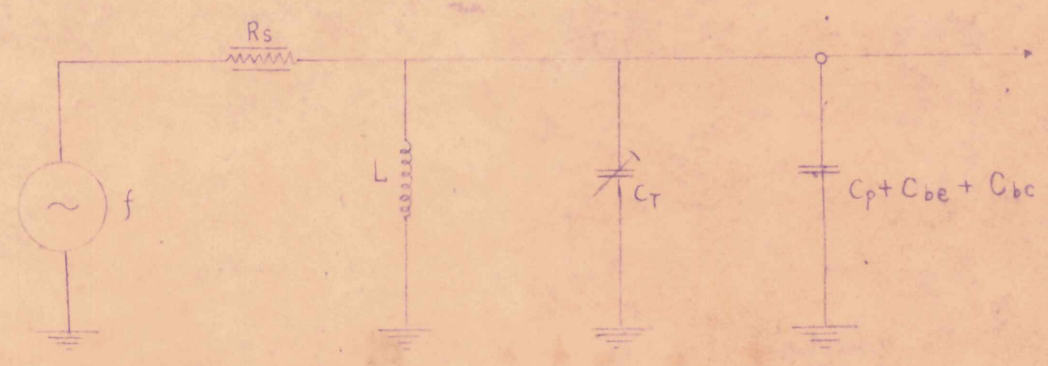
In the long run, it is necessary for the measurement to make the impedance high which is seen the oscilloscope section from the measurement base terminal. However, the floating capacity of the cut-of and socket to put a transistor as the practical apparatus exist and behaviour is shown in Fig. 3 (a).

Furthermore, it is the same as Fig. 3 (c) from the viewpoint of equivalent. In case of a small R_L it is shown in Fig. 3 (c).

In 100 Mc, the effect of $C_p + C_{be} + C_{bc}$ cannot be negligible and, even if R_s is large, the impedance drop of the measurement base terminal is brought.



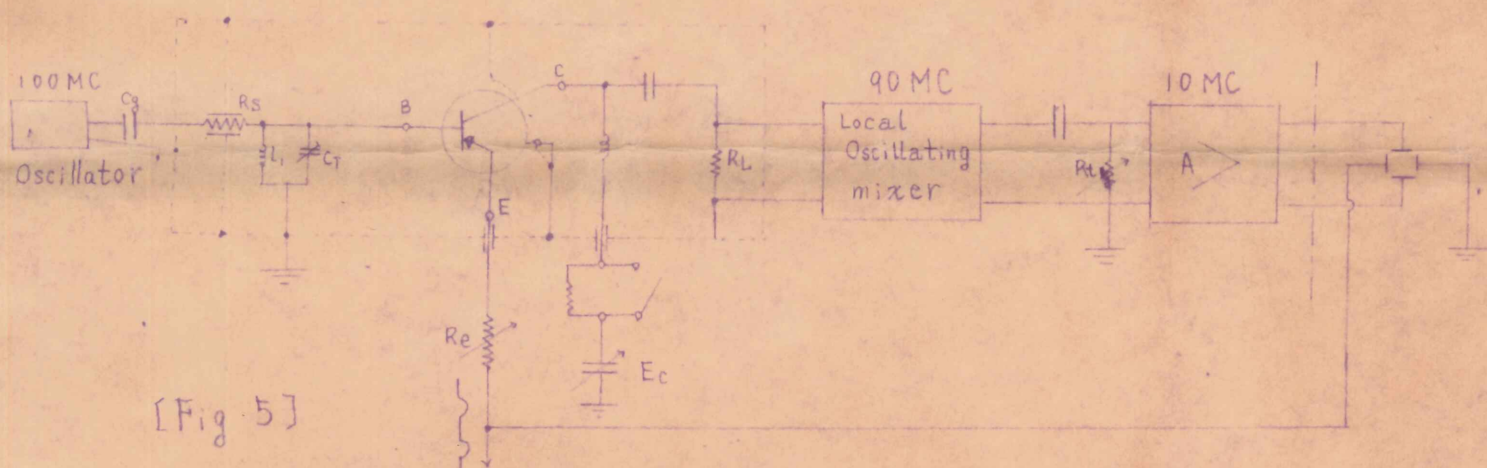
For the purpose, as shown in Fig.4, the practical apparatus is designed to make the impedance at the measurement base terminal high with tuning oscillator frequency through the use of compensated ind ctance.



[Fig 4]

SECTION IV—THE SCHEMATIC DIAGRAM

The plug-in Unit mainly consists of the oscillating parts, measurement parts, local oscillating mixer parts, multipljcation parts and power supply, and its main schematic circuit is shown in Fig.5.



[Fig 5]

The output of oscillating frequency 100 Mc is impressed on The base of a transistnr under test througH C_g and R_s. When the output of R_L to the collector is impressed on the local oscillating mixer parts of oscillating frequency 90 Mc, it becomes 10 Mc output, which is amplfied through a resistor attenuator R_t and is put into the inPut of the vertical axis amplification parts of the scope. Meanwhile, in using the half-wave rectified voLtage to the emitter powr supply, the voltage is impressed on the horizontal axis of the scope as well as the emitter of a transistor under tEst is provided the common base to the power supply And f_T is measured by changing the emitter current aNd the collector voltage optionally. Since the horizontal axis is swept with the repetition 50 c / s half-wave rectified voltage, I_E can be read directly by calibrating the voltage sensitivity. The collector source voltage is provided with the transistorised and stabilized power supply and its voltage is continuously variable.

SECTION V - OPERATION

V. 1. The explanation of the Front Panel

(1) (COLLECTOR SOURCE VOLTS)............a.. Adjust the voltage to supply the collector of a transistor under test with the Control Dial.

(2) (NPN - PNP EXCHANGE SW)................ This is subject to the transistor type to be measured.

(3) (EXTERNAL SERIES RESISTOR)............. The terminal is provided for the insertion of terminal resistor is series with the collector of atransistor under test.

(4) (MC / CM) ....aThe Control Dial is to exchange f_T range which has up to 400 MC /CM in five steps. The calibration shuld be done at 25 MC / CM.

(5) (BOSITION) .... Adjust the position of the beam line on the screen with this.

(6) (CAL.)............................. Screw with a driver for the calibration of amplitude on the screen.

(7) (C.E.B.) .... Insert a transistor under test into this socket.

(8) (Ie MA / CM) .... The Control Dial is to exchange the emitter current of a transistor under test and is divided into nine steps between 0.1 and 50 MC / CM.

(9) (CHECK) .... Adust the sensitivity of the horizontal axis on the screen with the push-button.

(10) (HOR.SWEEP OUTPUT) ... this is provided for the output of the sweep signal on the horizontal axis.

V.II. Measurement

(1) Insert the Plug - In Unit into the oscilloscope which is acceptable the Unit.

(2) Set ut the Front Panel as follow.

(COLLECTOR SOURCE VOLT) ...	Approximately 2 V.
(NPN - PNP Exchange SW.)...	Subject to the type of a transistor to be measured.
(EXTERNAL SERIES RESISTER)..	when the external load resistor is in use, set SHORT SWitch up.
(f_T MC / CM)	25 MC / CM
(POSITION)	Approxima medium position
(CAL.)	- ditto -
(I_e MA / CM)	0.1 MA / CM

(3) As to the operation of Tektronix Oscilloscope, it is subject to the instruction manual pertaining to the scope.

(4) Exchange the o cill scope so that the sweep signal from external may be put into the horizontal axis of the scope.

Connect two terminals between EXT. SWEEP INPUT of the oscilloscope and HOR. SWEEP OUTPUT of the Plug - In Unit, in use with attached cord.

(5) Turn On the power supplyswitdh of the scope. Then, adjust properly the beam intensity, the horizontal position and sensivity only after the scope is working normally.

The sweep signal from the Unit is about 30V P - P

(6) When the beam line of the horizontal axis appears on the screen, adjust POSITION Control of the Unit until the beam line appears approximately at the medium level of the graticule. Push CHECK push-button and adjust the holizontal sensivity so that the just 10 divisions(100mm) may be obtained. The horizontal current sensitivity for I_e is calibrated through these procedures. However, every time NPN-PNP SW is exchanged in accordance with the polarity of a transistor under test, adjusthe position of the beam line because the sweep polarity of the horizontal axi s becomes reverse.

(7) Insert the condenser 1000 PF into the holes B-C of the socket for a transistor under test. Since each scope has alittle different input capacitty, readjust L8 under working in some cases. But,even if the tuning loss may appear, there is no error in the measurement value,when itis possible to adjust CAL.Control.

After confirming that the [redacted]control dial is set up at the position of 25 MC / CM, turn CAL. with a driver and adjust so that the vertical axis amplitude on the screen may be 4 divisions (40 mm).

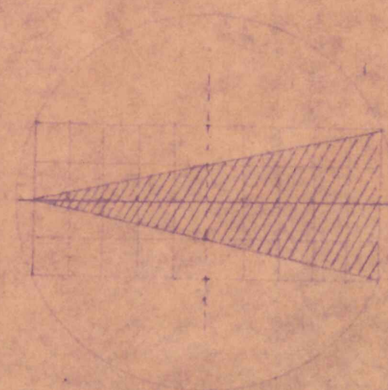
Remove the condenser after adjusting. The measurement is prepared [redacted] through the above-mentioned procedures.

V. III. OPERATION

(1) Insert a transistor to be measured into the socket.

(2) Set up the range which is to be measured with COLLECTOR SOURCE VOLTS Control and Ie Control.

When the proper amplitude is made by exchanging f_T MC / CMcontrol, the wave-form like an envelope is displayed on the C. R. T. screen. f_T is obtained with the position of the amplitude and MC / CM Control. For example, if f_T MC / CM Control set up at 100, Ie MA / CM Control 0.2 MA / CM and collector [redacted] Source voltage 10V, as shown in Fig.6, f_T is read as 200 MC at the emitter [redacted] current 1mA and Collector Voltage 10 V.



[Fig 6]

V. IV. DIRECTION FOR USE OF EXTERNAL SERIES RESISTOR

Although SHORT SW is ordinarily settled at SHORT and Vc is constant, if the SW is switched to another side, the variations of f_T along the actual dynamic ~~pe~~ points are observed by determining the values of power supply and load resistor.

For example, if the variations of f_T are required for Vc = 6 V, R_L = 100 ohms and Ie = 200 mA, set up MA / CM Control Dial at 5 as COLLECTOR SOURCE VOLTS = 6(V) + 100(ohm) X 20(mA) = 8 V, $E_{xt}R$ = 100 ohms.

Besides, when SHORT SW is opened, it is possible to use the external collector power supply (0 to 250 V) between the underside of FRONT PAEL and ground terminal.

Since the horizontal axis sweep signal is produced in the position of the connector terminals at the rear of the Unit, it is unnecessary to connect the terminals in the oscilloscope's interior at every use, only when the said terminal and EXT. SWEEP INPUT terminal are connected before operation.

SECTION VI — SUPPLEMENT

The principle of the measurement uses the descent of $f_{\alpha e}$ at 6 db / Oct., as said ahead. Accordingly, f_T cannot be displayed unless the measurable frequency 100 MC is on the descending curve of 6 db / Oct. of a transistor under test. A transistor which has $f_{\alpha e}$ of below 30 MC is measured with the Unit. When a transistor having $f_{\alpha e}$ of over 30 MC is measured with this, hfe is simply measured [redacted] at the frequency 100 MC. Although it is necessary to examine the rough $f_{\alpha e}$ of a transistor to be measured, $f_{\alpha e}$ is induced from the relation $f_{\alpha e} = f_{\alpha b}/hfe$, if $f_{\alpha b}$ and hfe are given beforehand. Furthermore, a transistor which is low f_T and has, for example, below 25 MC is observed a small amplitude on the C. R. T. [redacted] screen, so it is recommended to use the Unit of the measurable frequency 10 MC.

Since the measurable frequency of the Unit is 100 MC, the output appears a little with the connections of the socket terminal without inserting a transistor into the socket. That is why the impedance at the terminals is multiplied with the resonance circuit. But, as the connection output hardly appears with the impedance between the base and the emitter of a transistor to be inserted at the time of its measurement, it has no influence on the indication amplitude of f_T.

The appearance of the abovementioned output can be confirmed with inserting a resistor valued a few hundred ohms into the base and the emitter holes (equivalent to the impedance betwee the base and the emitter of a transistor).