JAERI-M
6330

PRELIMINARY RESULTS ON DYNAMIC MAGNETIC LIMITER IN JFT-2a TOKAMAK

December 1975

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Experimental Study on Dynamic Magnetic Limiter in JFT-2a Tokamak

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(Received November 19, 1975)

Experimental study has been performed on a dynamic magnetic limiter in JFT-2a (DIVA) Tokamak. The magnetic configuration can be changed with in 1 ms by increasing or decreasing a divertor hoop current. The time variation of heat flux to the divertor region is measured with a conventional thermocouple by using the dynamic magnetic limiter; decreasing the divertor hoop current to zero at any given time.

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JFT－2a トカマクにおける動的磁気リミタの初期実験結果

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（1975年11月19日受理）

JFT－2aにおいて，動的磁気リミタに関する実験を行なった。ダイバータ・フープ電流を増加または減少することによって，1ms 以内にプラズマの平衡価位を変えることができた。動的磁気リミタを使用することによって，すなわち，任意の時間にダイバータ・フープ電流を零にすることによって，ダイバータへの熱流束の時間変化を通常のサーモカップルによって測定することができた。

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目 次 な し

1. Introduction

Effects of impurity, and skin current profile during current raising phase become serious in a future large Tokamak device. A static magnetic limiter provides a possibility of lowering impurity content, while a dynamic magnetic limiter can control a plasma diameter and current profile. Basic characteristics of static and dynamic magnetic limiters are studied in JFT-2a (DIVA) device.

The cross-sectional view of JFT-2a is shown in Fig. 1. Detailed description of the device is given in ref. (1). A plasma equilibrium with a separatorix magnetic surface of magnetic limiter is obtained in a shell with an opening toward a divertor hoop which carries a current parallel to the plasma current. Various configurations with and without a separatorix magnetic surface are obtained by changing the ratio of the divertor hoop current to the plasma current. Configurations with a static magnetic limiter were stably obtained in JFT-2a, and their properties were investigated in detail[2)3)4)]. In this note, preliminary experimental results concerning a dynamic magnetic limiter is described, where the ratio of the divertor hoop current to the plasma current is increased or decreased within a few hundred microseconds during the discharge.

2. Experimental Results

In Fig. 2, typical oscillograms of discharge parameters are shown. Dotted lines correspond to the case of increasing the ratio of the divertor hoop current I_D to the plasma current I_P at 5 ms, while solid lines represent the case of keeping the ratio, I_D/I_P constant. The ratio I_D/I_P increases from 0.9 to 1.8 within 0.4 ms (Fig. 2-a), and Ip decreases 20%, which is due to the incomplete decoupling of Ip-circuit from I_D-circuit (Figs. 2-b and 2-c). Electron line density $\bar{n}_e\ell$ of a main plasma column begins to decrease at 0.7 ms after increasing I_D/I_P and continues decreasing as is shown in Fig. 2-d. The total number of electrons in the main plasma column decreases about 30% during first 2 ms. The ion saturation current I_S at R=40 cm and Z=-6 cm in the divertor region increases immediatly after increasing I_P/I_D and reaches a quasi-stationary value after 1 ms as is shown in Fig. 2-e. The electron line density profile of the main plasma column and the ion saturation current profile at R=40 cm are shown in Figs. 3-a and 3-b, respectively. After increasing I_D/I_P the $\bar{n}_e\ell$-profile shrinks and its half width at 9 ms becomes about 60% of that with keeping I_D/I_P constant as is shown in Fig. 3-b. It can be concluded that the separatrix magnetic surface near the main plasma column shrinks after increasing I_D/I_P. The peak of I_S-profile shifts about 1.5 cm outward and it can be said that the separatrix magnetic surface expands into the divertor region.

It is shown that the configuration can be changed by increasing I_D/I_P from 0.9 to 1.8. When the ratio I_D/I_P exceeds 2, the plasma column collapses, which may be due to the loss of equilibrium or stability with a large value of I_D/I_P.

In the case of decreasing I_P/I_D down to zero, the separatrix magnetic surface is expected to disappear. The ion saturation current considerably decreases after decreasing I_P/I_D to zero. The path of runaway electrons is also investigated by measuring X-ray from a target (4 mmϕ) placed in the divertor region[2]. It is shown that runaway electrons to the divertor immediatly disappear after decreasing I_P/I_D. These results show that the separatrix magnetic surface disappears after decreasing I_P/I_D to zero and a plasma does not expand to the divertor region as expected.

To measure the time evolution of heat flux to the divertor region by a conventional thermocouple, I_D/I_P is suddenly decreased at a prescribed time[5]. Fig. 4(a) shows the output of the thermocouple V_T and Fig. 4(b) V_T-profiles obtained by scanning the thermocouple at R=40 cm in the divertor region. Time response of the thermocouple probe is about 5 ms[4]. The solid line in Fig. 4(a) shows the output V_T with keeping I_D/I_P constant and the broken line shows V_T with decreasing I_D/I_P to zero at 15 ms. The time integrated heat flux to the divertor is determined from V_T at 40 ms when V_T saturates. The time integrated heat flux with decreasing I_D/I_P is smaller than that with keeping I_D/I_P constant as is shown in Fig. 4-a. The profile of the time integrated heat flux V_0 with decreasing I_D/I_P shown by broken line in Fig. 4-b almost coincides with that of the output at 20 ms as expected because I_D/I_P decreases at 15 ms and the time response of the thermocouple is 5 ms. The time evolution of the heat flux to the divertor region can be measured with a time resolution of 1 ms with decreasing I_D/I_P to zero at a prescribed time, because the configuration can be changed within 1 ms.

3. Conclusions

The main results are: 1) magnetic configuration can be changed within 1 ms by increasing or decreasing the divertor hoop current, 2) the time evolution of the heat flux to the divertor region can be measured with a conventional thermocouple by decreasing the divertor hoop current to zero at a prescribed time.

Characteristics of a dynamic magnetic limiter is now under intensive investigation.

4. Acknowledgments

Our particular thanks are due to the Diagnostic Group and the JFT-2a Operation Group for their helps. Many thank are also due to Drs. M. Tanaka and M. Yoshikawa for their fruitful discussions.

Reference

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2) Shimomura Y.; Seventh European Conference on Controlled Fusion and Plasma Physics (Lausanne), September, 1975.
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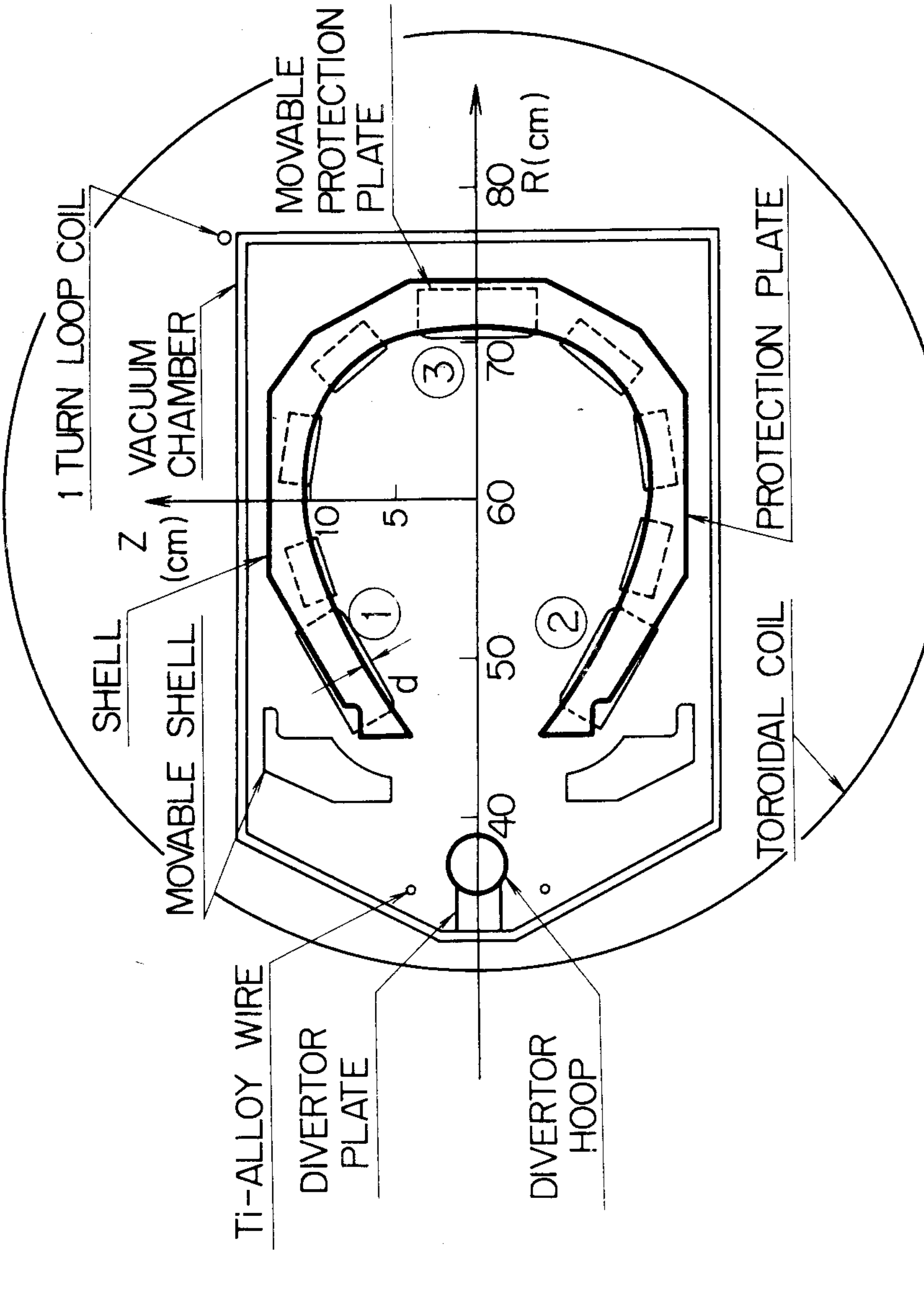


Fig. 1 Cross-section of JFT-2a

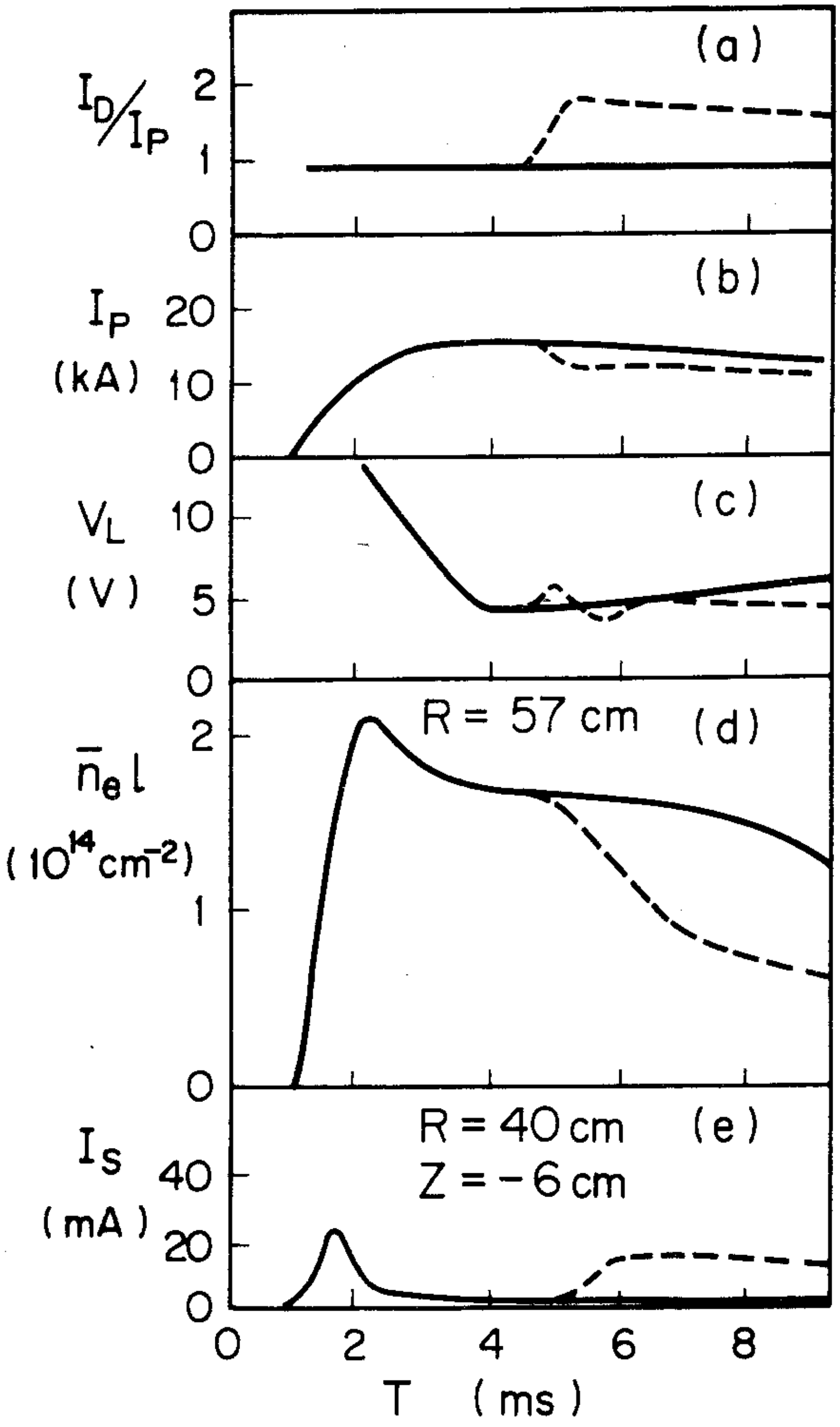
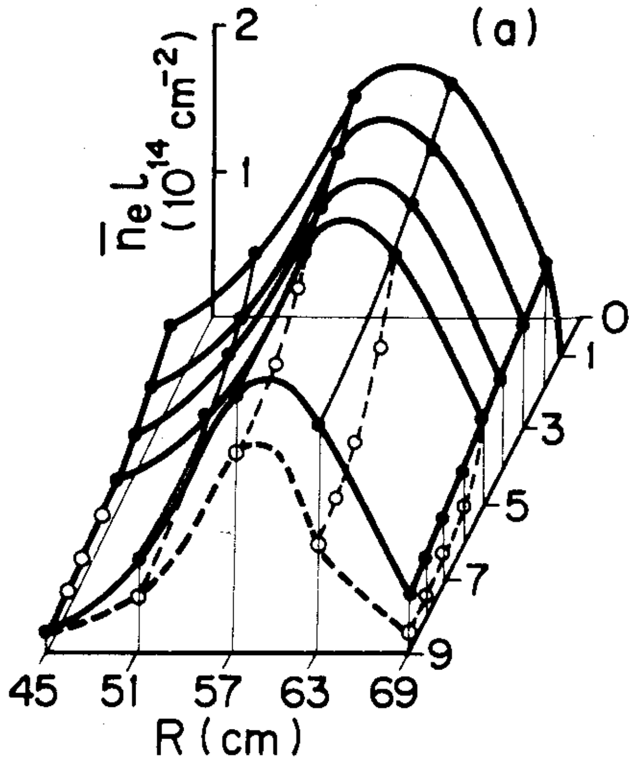


Fig. 2 Oscillograms of discharge parameters. (a) ratio of a divertor hoop current I_D to a plasma current I_P, (b) I_P, (c) loop voltage V_L, (d) electron line density $\bar{n}_e \ell$ of a main plasma column and (e) ion saturation current I_S in the divertor region. Solid lines correspond to the case of keeping I_D/I_P constant and dotted lines increasing I_D/I_P at 5 ms.



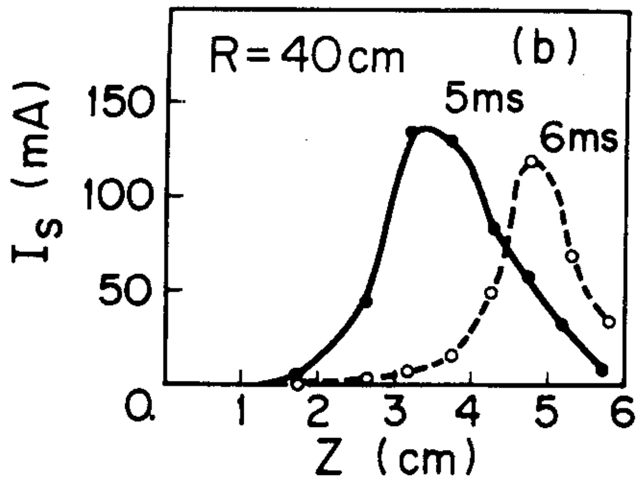


Fig. 3 Profiles of electron line density $\bar{n}_e \ell$ of a main plasma column and ion saturation current in the divertor region. Solid lines correspond to the case of keeping I_D/I_P constant and dotted lines increasing I_D/I_P at 5 ms.

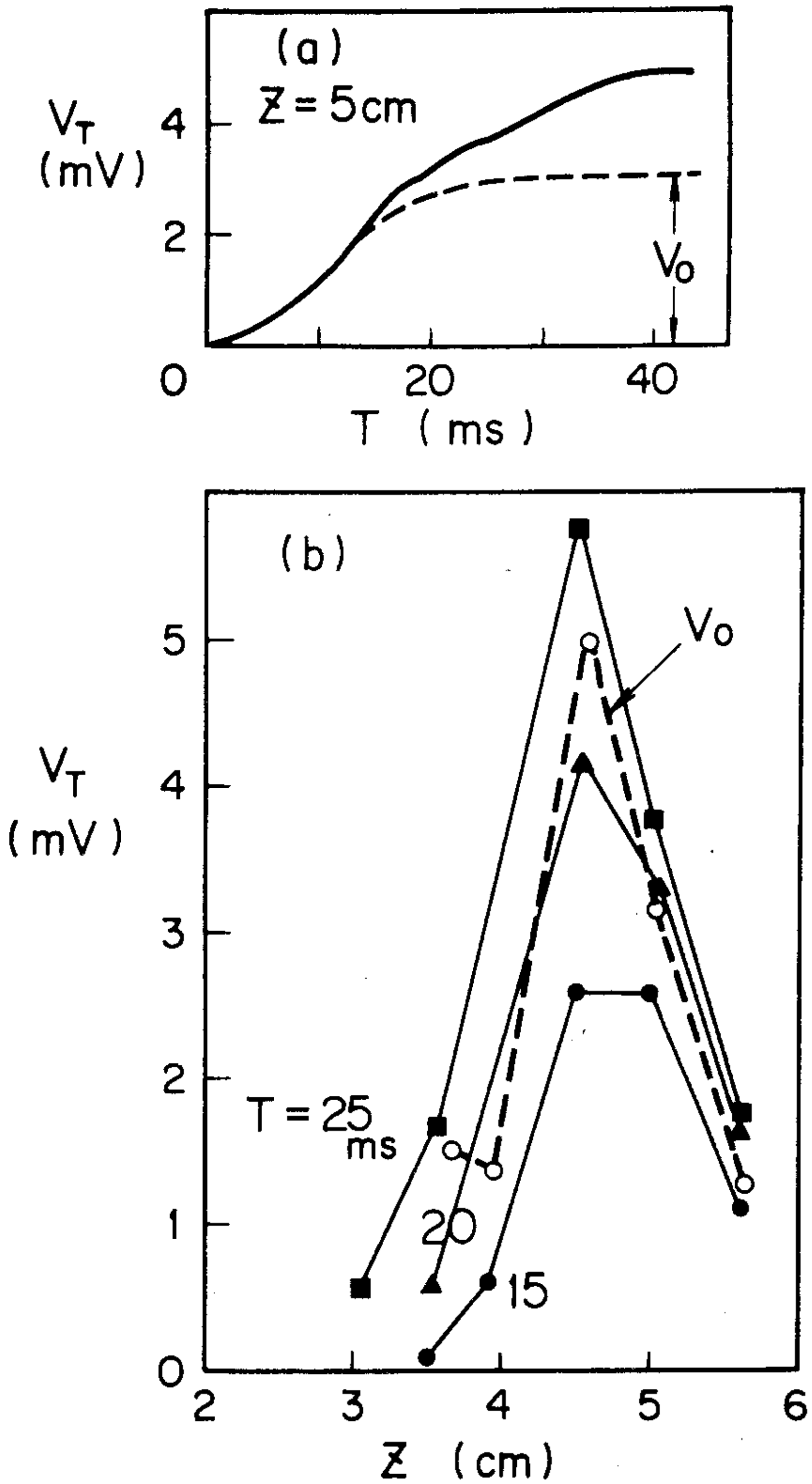


Fig. 4 Oscillograms of output of a thermocouple and profiles of the output in the divertor region. Solid lines correspond to the case of keeping I_D/I_P constant and dotted lines decreasing I_D/I_P down to zero at 15 ms.