BIFOCAL DEMAND PACING

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Ventricular demand pacemakers are now commonly used to correct symptomatic bradycardia with satisfactory rehabilitation in most instances. However, in some patients with borderline cardiac function, ventricular pacing alone fails to restore adequate cardiac output. It has been shown that atrial contribution with A–V synchrony may, in patients with failing heart, increase cardiac output up to 30%. Dr. Abelmann and his group at Harvard Medical School have reported that with identical heart rates and cardiac output atrial pacing against ventricular pacing will reduce myocardial oxygen consumption by approximately 15%. This and other benefits obtained by A-V synchrony are tabulated in the following slide (Fig. 1). Thus, in patients with atrial bradycardia, sinus arrest or atrial brady-tachyarrythmias, atrial pacing would be preferred. Both the advantages and shortcomings of atrial pacing are shown on Fig. 2. To provide A-V synchrony and protection also in A-V block and thus overcome the shortcomings of atrial pacing, a Bifocal demand pacemaker has been developed. Its characteristics are shown in Fig. 3. This pacemaker facilitates the natural depolarization sequence without competing with spontaneous ventricular activity. Controlled by the ventricular depolarizations it automatically adapts its stimulation according to the patient's needs. It may remain dormant, it may stimulate only the atria or it may stimulate both the atria and ventricles with a preset sequential interval.

Fig. 4 shows the Bifocal demand pacemaker facilitating the natural depolarization sequence without competing with spontaneous ventricular activity. Bifocal pacing corrects both the atrial and ventricular rate, overdrives certain superventricular arrythmias by atrial stimulation and improves cardiac efficiency by A-V synchrony. Patients without A-V block also benefit from the more effective non-ectopic ventricular beat originating from the Purkinje fibers.

Fig. 5—Illustrates the basic construction. Technically, the Bifocal demand pacemaker consists of two demand units: A conventional QRS inhibited ventricular demand pacer and a QRS inhibited atrial demand pacemaker. The escape interval of the atrial pacemaker is always shorter than the escape interval of the ventricular pacemaker. The difference between the two escape intervals defines the A-V sequential interval. Both of these units are in a single package sharing batteries and the QRS detecting circuit. They act in synchrony and provide QRS inhibited A-V sequential stimulation. This pacemaker is QRS controlled and thus the atrial depolarizations or P waves are not monitored. Therefore, P waves have no direct effect on the pacemaker function. The implantable Bifocal demand pacemaker, when continually pacing both the atria and ventricles in sequence, consumes 37 microamperes. When stimulating only the atria it consumes 19 microamperes and when it is dormant the consumption is less than 6 microamperes. The life of the batteries as seen in units returned with depleted batteries was an average of 19 months.

Fig. 6—Illustrates the picture of an external Bifocal A-V sequential demand unit. The rate, the A-V interval and the ventricular stimulating current are adjustable by individual controls. This unit can also be used as a conventional demand pacemaker by using only the electrodes connected to the ventricular terminals.

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Fig. 7—Shows a special USCI catheter that provides 4 proximal 'atrial' and 2 distal 'ventricular' electrodes for Bifocal pacing.

Fig. 8—Illustrates an X-ray showing the placement of temporary Bifocal pacing catheter in the heart. The distal pair of the electrodes is placed in the right ventricular apex. This is the same way as used for conventional ventricular demand pacing. Then the proximal electrodes are tested for atrial stimulation threshold and one pair with the lowest threshold is selected and connected to the atrial terminals of the pacemaker.

Fig. 9—Illustrates the picture of a permanent implantable unit, with both atrial and ventricular electrodes attached. The silastic sleeve of the atrial electrode is preshaped similar to the letter J to provide a stable mechanical and electrical contact with the atrial wall.

Figs. 10-11—Show chest X-rays showing the permanently implanted atrial and ventricular electrodes. One electrode placed in the ventricle both monitors the endocardial electrogram and provides stimulation to the ventricles when such stimulation is needed. The J-shaped second electrode connected to the atrium provides the atrial stimulation when needed.

Fig. 12—Demonstrates schematically the different modalities of pacing. Although atrial triggered pacing is not a modality of atrial stimulation, it is represented in this figure to indicate that the P-waves trigger the spikes, which in turn stimulate the ventricles. During continuous atrial pacing, the spikes precede the P-waves which, thereafter, activate the ventricles via the A-V junction. Continuous sequential A-V pacing is characterized by spikes which stimulate both atria and ventricles persistently with a preselected (Artificial) A-V V sequence. Bifocal (sequential atrioventricular) demand pacemaker may stimulate both atria and ventricles in sequence, stimulate only the atria or remain totally dormant, thus automatically adapting to the patient's needs.

Fig. 13—Shows a Bifocal pacemaker in a patient with sinus bradycardia and premature ventricular contractions. It can be observed that the atrial pacemaker compensates for the premature ventricular beats.

Fig. 14—Shows a Bifocal pacemaker in a patient with first-degree A-V block. The sequential interval of the pacemaker was similar to the patient's own conducted A-V interval. Therefore, the different degrees of fusion and changes in morphology can be observed.

Fig. 15—Shows an interesting EKG tracing with Bifocal pacer. A magnetic switch is incorporated in these pacers for evaluation of pacemaker function by preventing inhibition and thus converting the unit to a fixed-rate mode. When testing the pacemaker the rate produced by the magnetic switch is independent of the patient's physiological condition and should be used to determine the condition of the batteries. It is important that during each outpatient visit the demand pacemaker be checked by applying a magnet and this rate recorded for control. Fig. 16 depicts the testing of a Bifocal pacemaker with a magnet. The measurement of the interval during a magnet-induced fixed-rate mode should be recorded in order to follow the pacemaker function and determine battery condition. A change greater than 10 percent indicates battery failure.

During the past three years we have implanted 125 Bifocal pacers with encouraging results. In the early stages, the basic indication for implantation of Bifocal pacers was to improve cardiac output. Recently. Bifocal pacemakers have also been used for patients with sick sinus syndrome—atrial brady-tachycardias. In

BENEFITS OF A-V SYNCHRONY

1. INCREASED CARDIAC OUTPUT
2. REDUCED OXYGEN NEED
3. REGULAR VENTRICULAR FILLING
4. PROTECTION AGAINST CERTAIN ARRYTHMIAS AND RETROGRADE CONDUCTION

Fig. 1.

ATRIAL PACING

ADVANTAGES:

1. A-V SYNCHRONY
2. NORMAL VENTRICULAR DEPOLARIZATION
3. SUPPRESSION OF ATRIAL ECTOPIC RHYTHMS

DISADVANTAGES:

LOSS OF PROTECTION IN A-V BLOCK OR WHEN ATRIAL THRESHOLD IS INCREASED.

Fig. 2.

BIFOCAL PACING

1. AUTOMATICALLY ADAPTS THE MODALITY OF STIMULATION TO THE PATIENT'S NEED
2. COMBINES THE ADVANTAGES OF ATRIAL, A-V SEQUENTIAL AND DEMAND STIMULATION
3. DOES NOT COMPETE WITH THE SPONTANEOUS VENTRICULAR ACTIVITY

Fig. 3.

Fig 4.

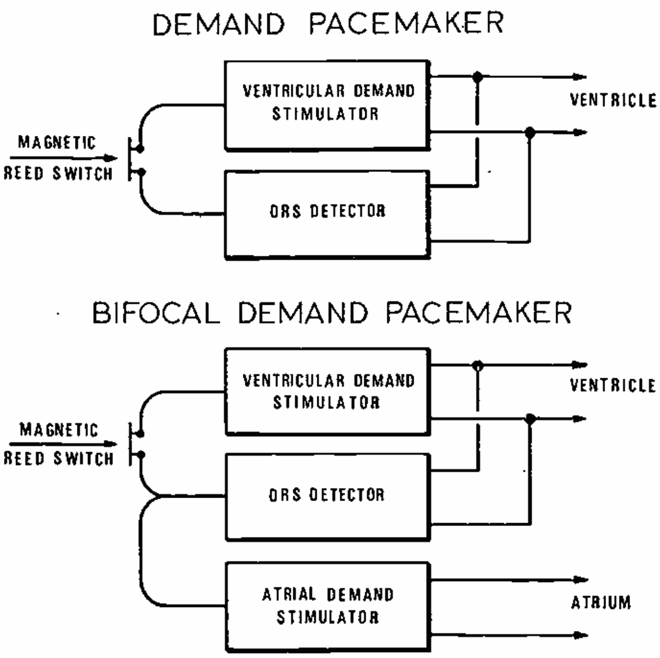


Fig. 5.

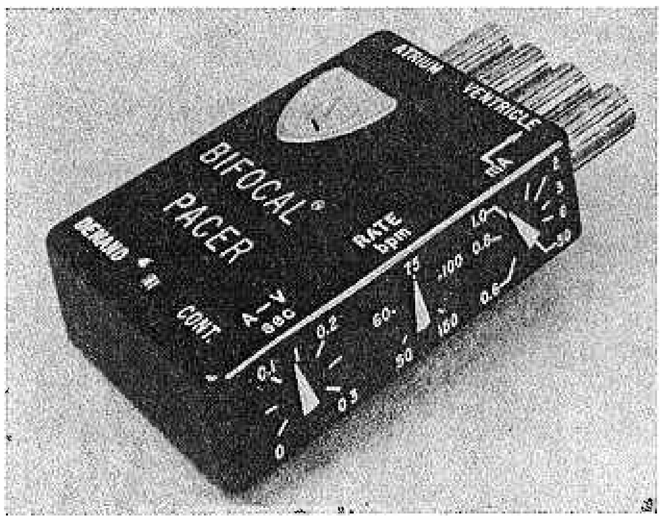
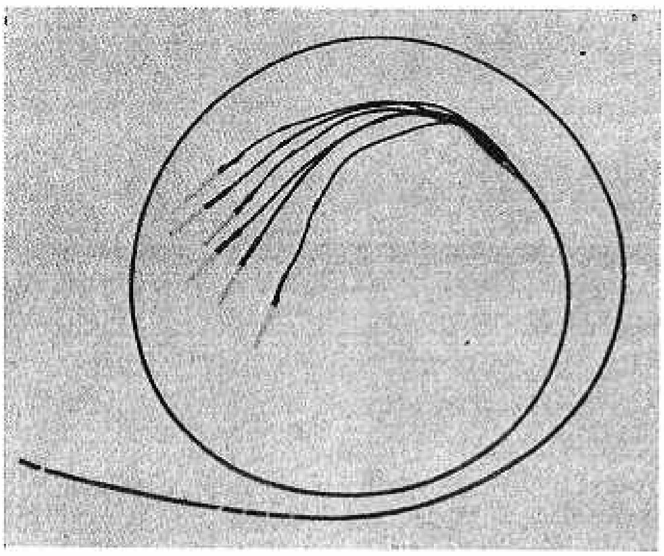


Fig. 6.



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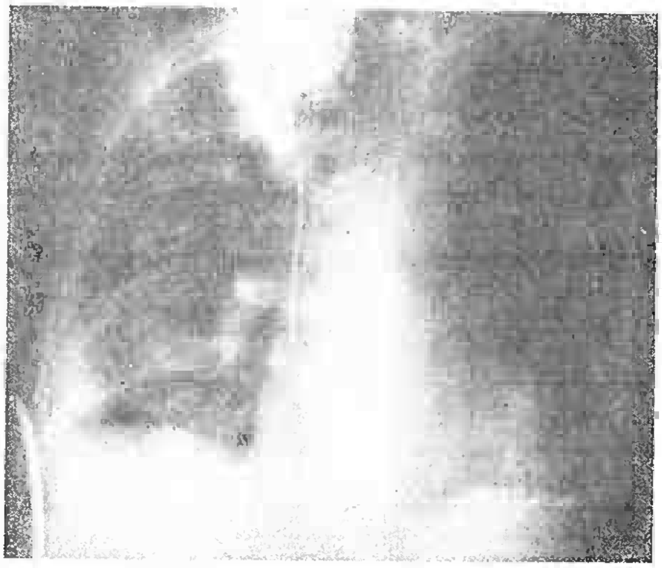

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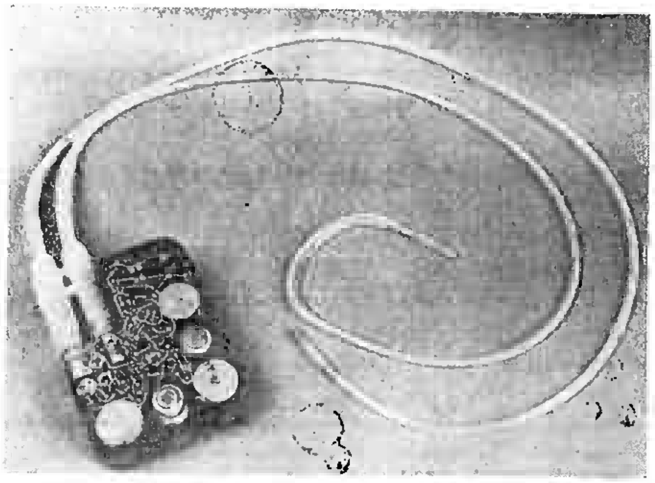

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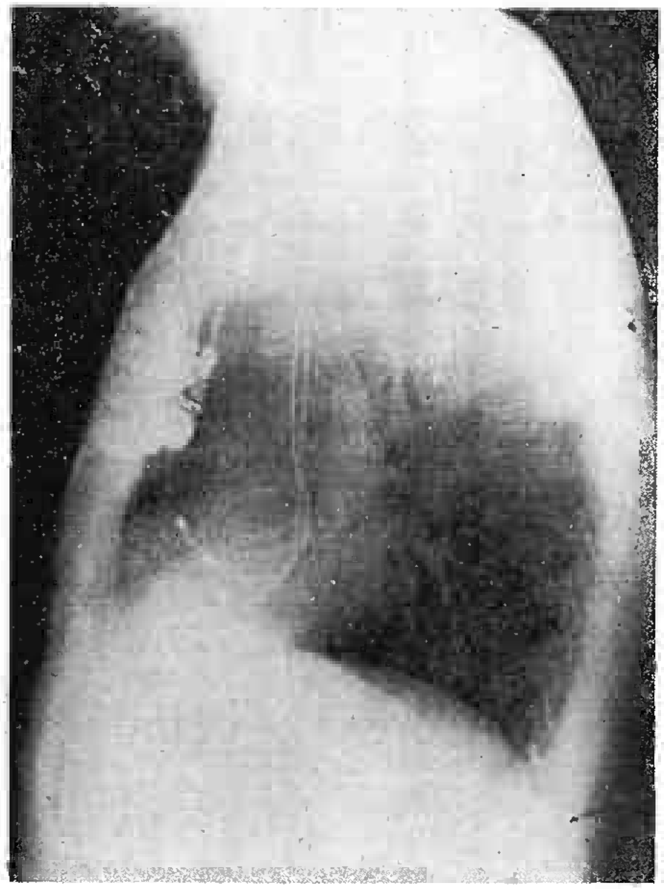

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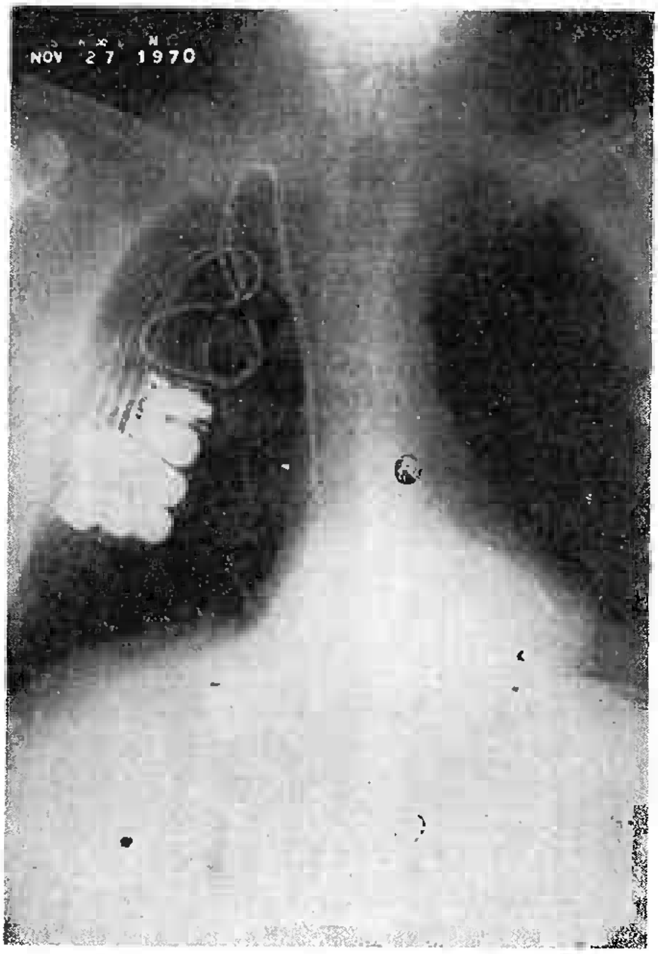

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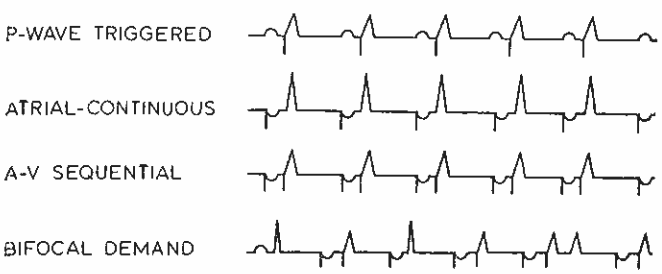

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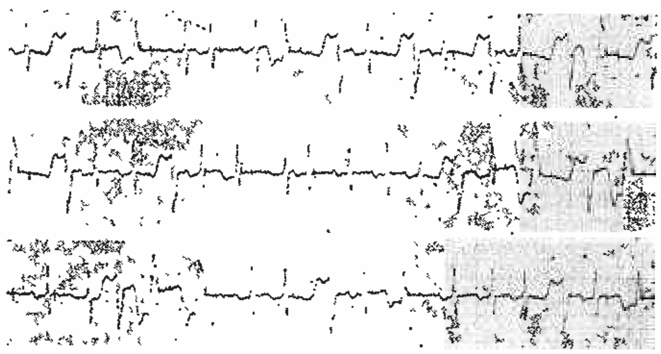

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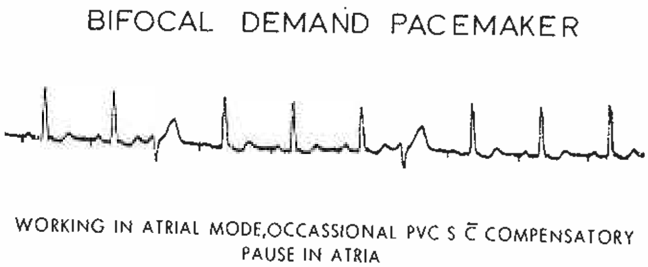
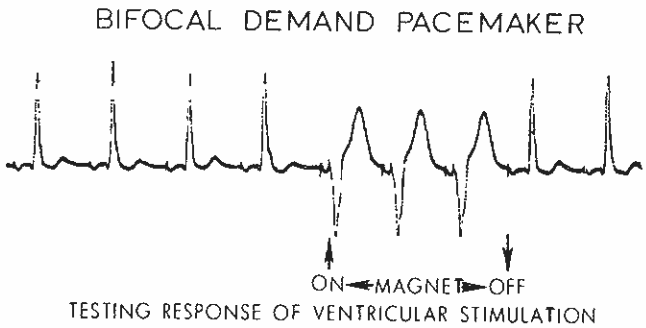


Fig. 13.



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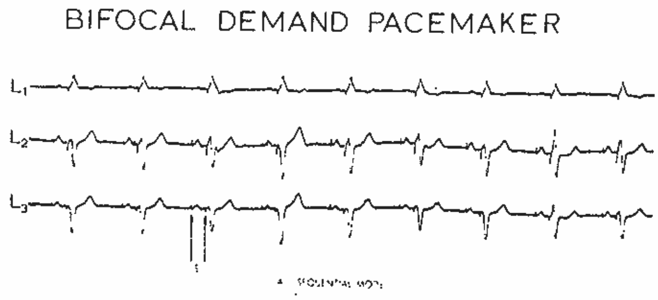

Fig. 14.

a number of these patients, we have found that 2 to 3 months after implantation, drugs could be progressively discontinued, and that the atrial stimulation not only protected against the bradycardia but also suppressed the episodes of tachycardia.

Pacing therapy has undergone marked evolution during its relatively brief existence. Further developments in concept, clinical applicability and technical areas are forthcoming. The physician has the obligation to understand the various pacing modalities and to select the most suitable concept of pacing for each particular disorder.