IPRO 314

THE FIRST ARTIFICIAL KIDNEY:

BUILDING A WORKING REPLICA OF KOLFF'S ROTATING DRUM

Kidney

- Excretory organ
- Urinary System
- Nephron
- Function
  - Water excretion
  - Waste excretion
  - Regulation of ion concentrations
  - Acid/Base balance (blood pH)
  - Secretion of hormones
    - Blood pressure regulation (renin)
    - Production of RBC (erythropoietin)

Kidney Failure

- Insufficient number of functional nephrons (< 20%)
- Causes:
  - Severe Trauma
  - Nephrotoxins (heavy metals, CCl_4)
  - Infections
  - Vascular Disorders
- Treatment
  - Organ transplantation
  - Dialysis

Dialysis

- Extra-corporeal device
  - Water and salt transport
  - pH balance
  - Nitrogen (urea) excretion
- Capable of sustaining life
  - Bridge to recovery (acute) or transplantation (chronic)
- Characteristics:
  - Semi-permeable membrane
  - Dialysate fluid
  - Diffusion based

Evolution of Dialysis

- Vivi-diffusion
- Kolff rotating drum artificial kidney
- Twin coil artificial kidney
- Flat plate artificial kidney
- Hollow fiber dialyzer

Project Description

This IPRO team has the unique opportunity to recreate, from the original plans, a working replica of the first clinically successful artificial kidney. Designed, built, and implemented in 1942, Willem Kolff's rotating drum was the first successful extra-corporeal medical technological device. It provided a successful technological reference point for subsequent development of dialysis devices. This device literally established the field of artificial organs. There are no working models in the Western Hemisphere. Two exist in Europe both in the Netherlands.

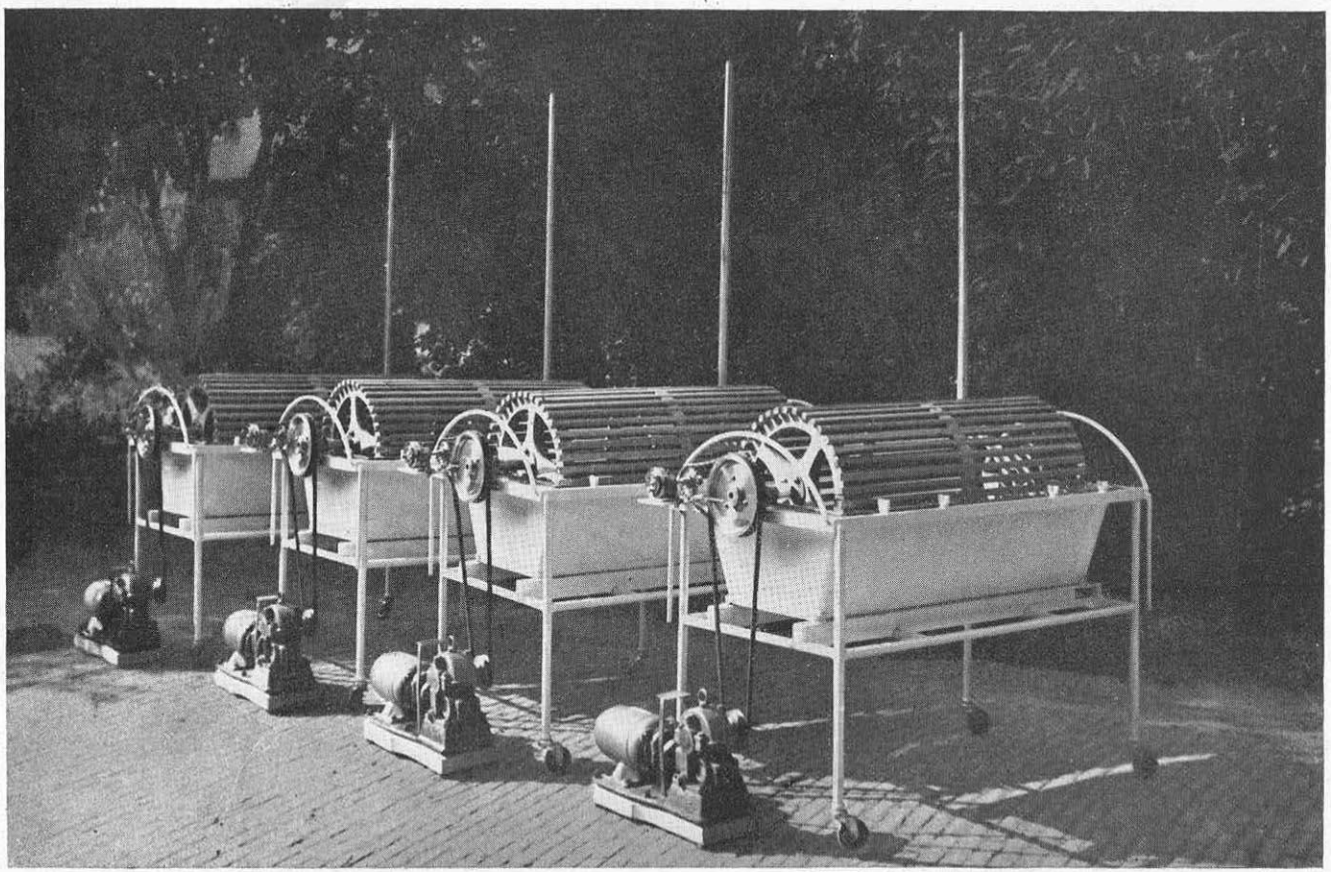


Fig. 1.
The first series of artificial kidneys ready September 1944.

Four rotating drums ready to be sent out to the US, the UK, Canada, and Poland when WW II was over.

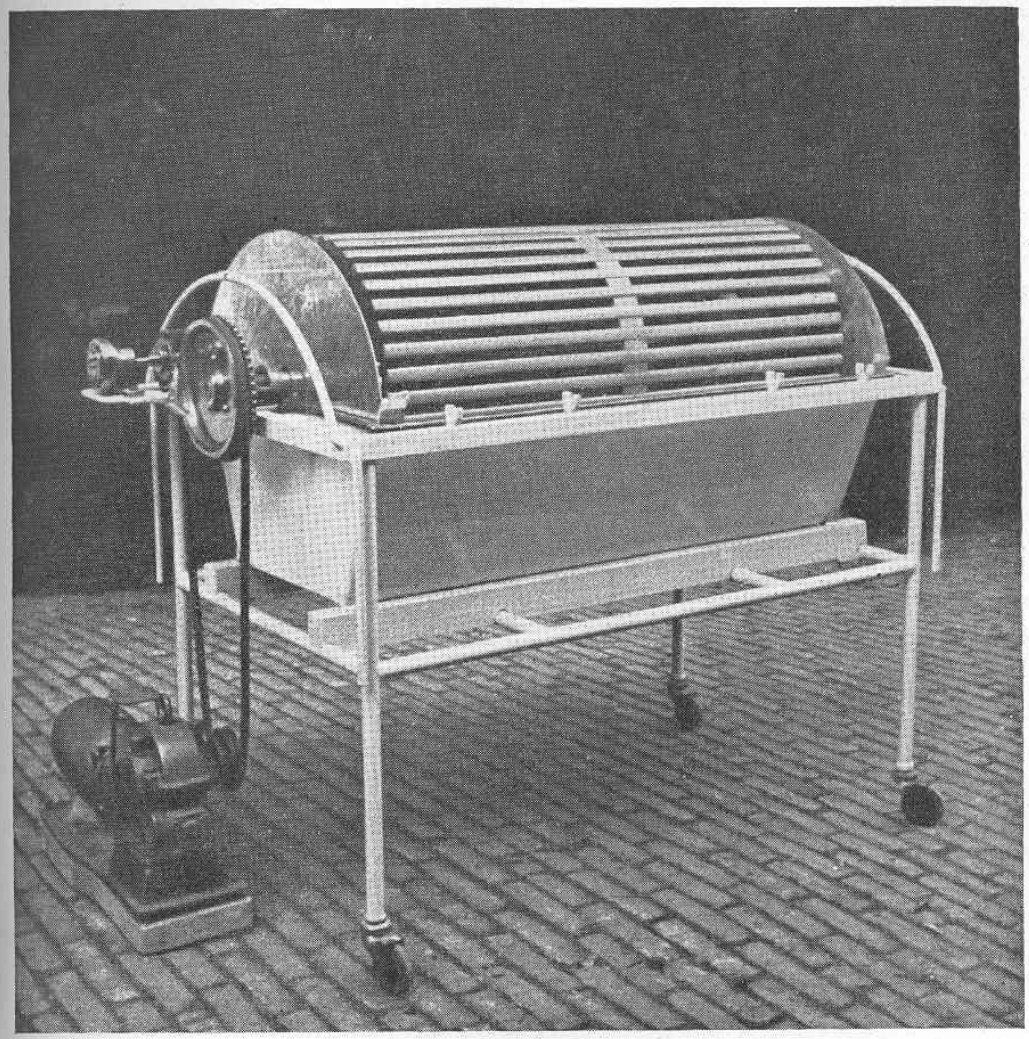
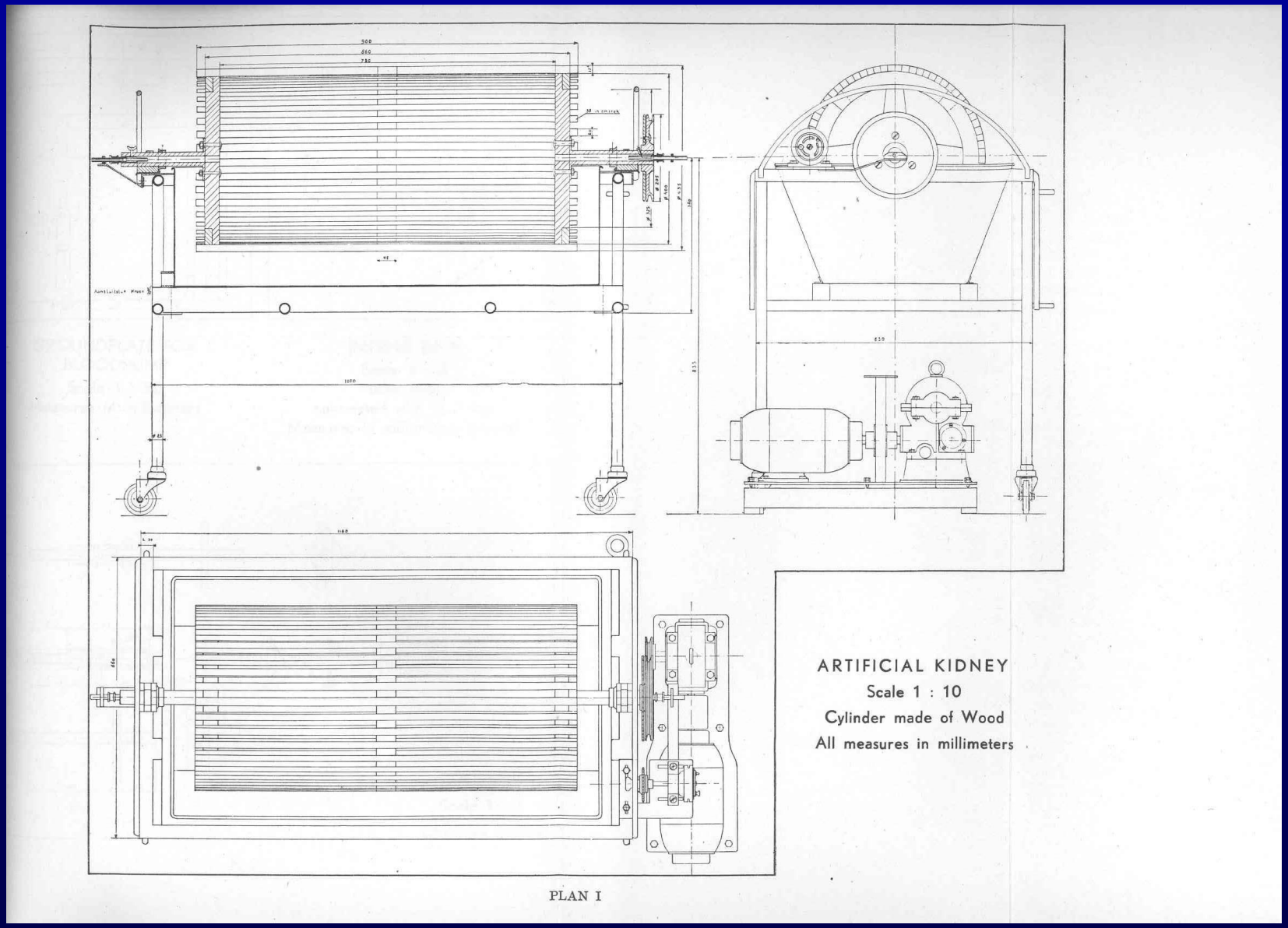


Fig. 15.
The latest model of an artificial kidney. The cylinder is made of varnished lathwork, and rotates with its lower segment through a tank with rinsing-liquid. The splashboards are seen on either side of the cylinder.

Kolff rotating drum artificial kidney

Dr Jacob van Noordwijk



PLAN I

Overall schematic of the device from the Kolff 1946 book

Major Components

1. Stand and Basin
2. Wooden Drum
3. Hollow Axles and Rotating Couplings
4. Blood Pump
5. Glass and Tubing
6. Heater and Motor

Stand and Basin

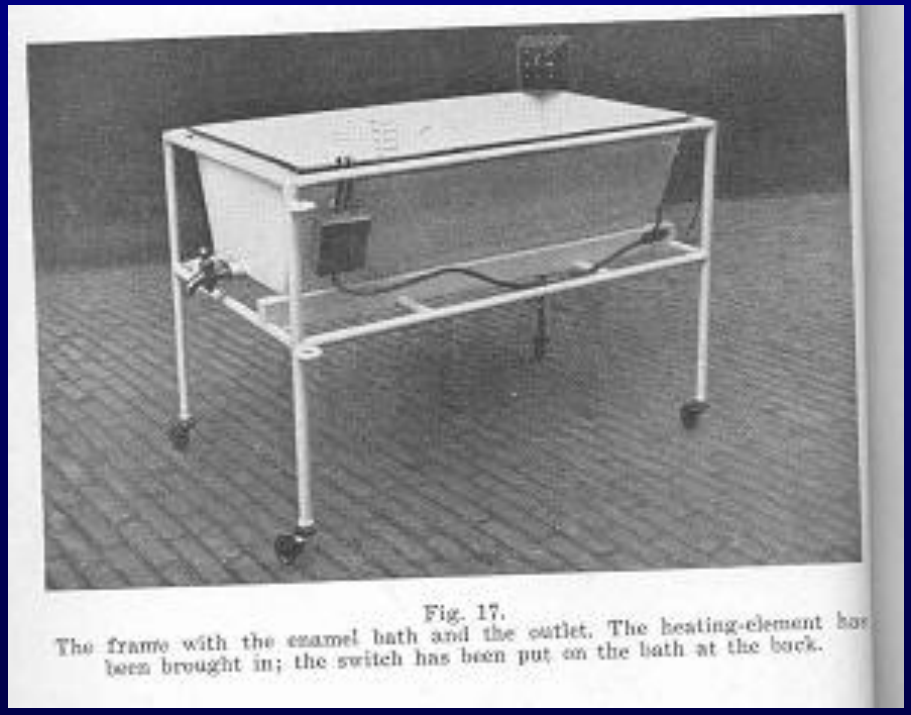
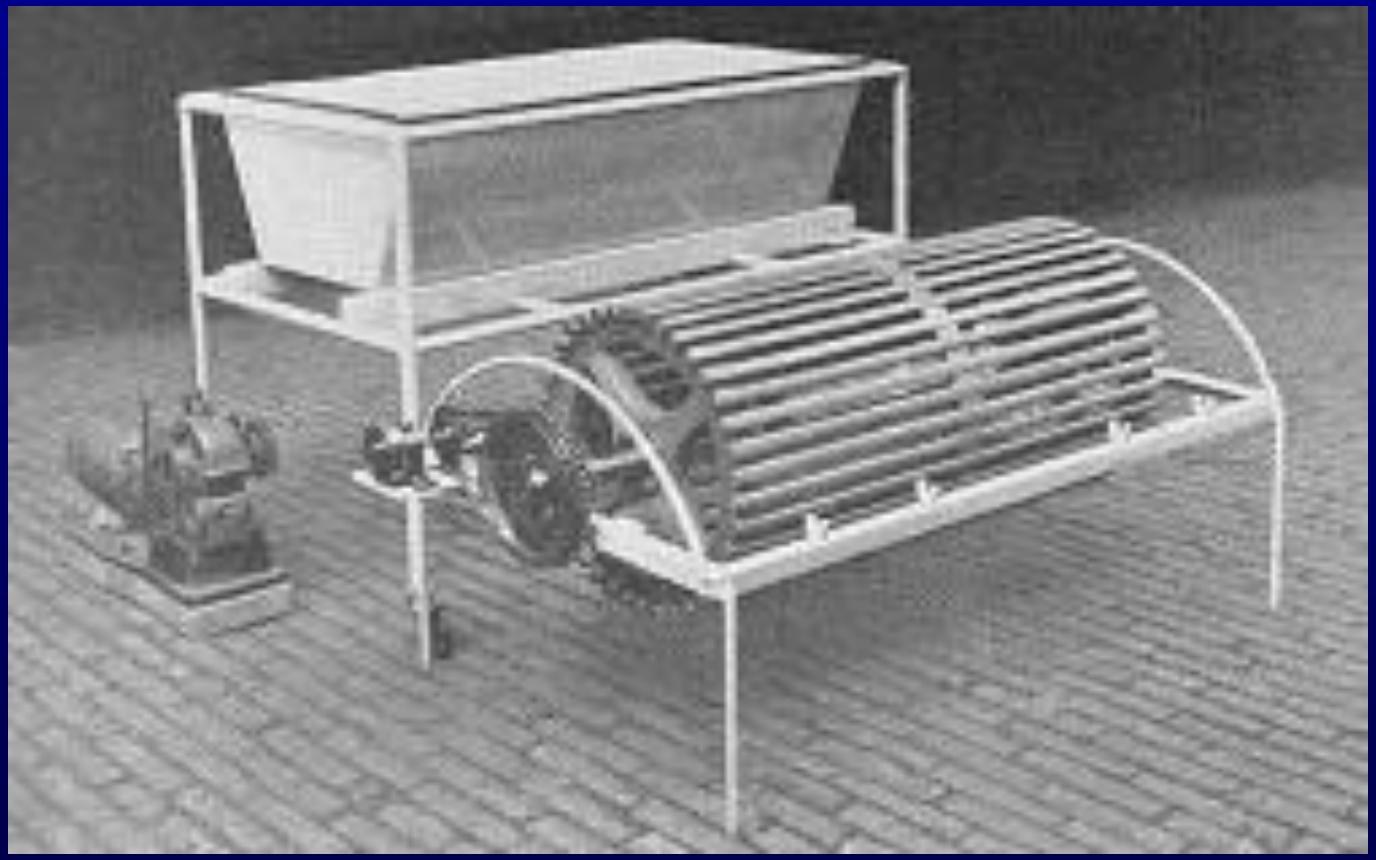


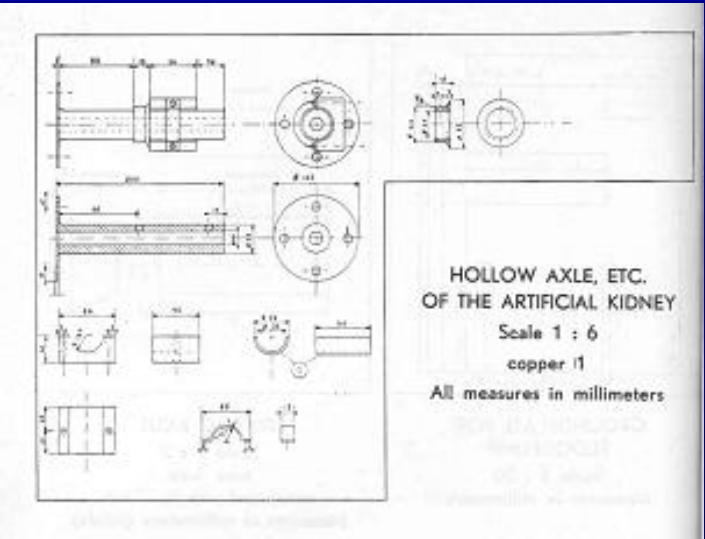
Fig. 17.
The frame with the enamel bath and the outlet. The heating-element has been brought in; the switch has been put on the bath at the back.

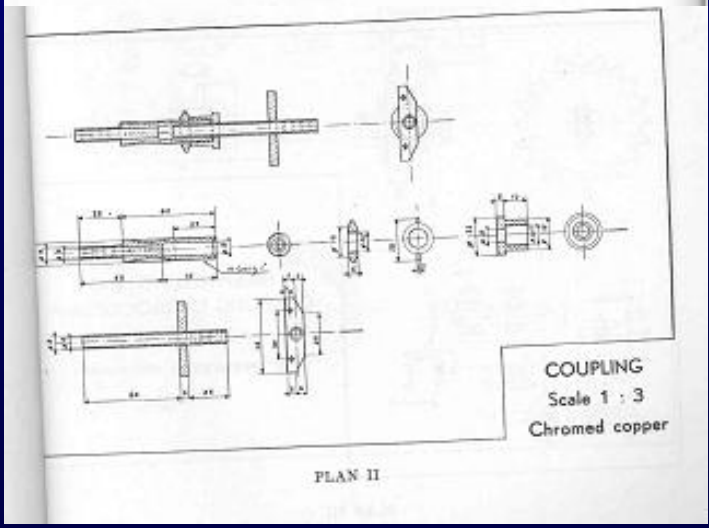
Wooden Drum



Wooden Drum (Cont.)

Hollow Axles and Couplings





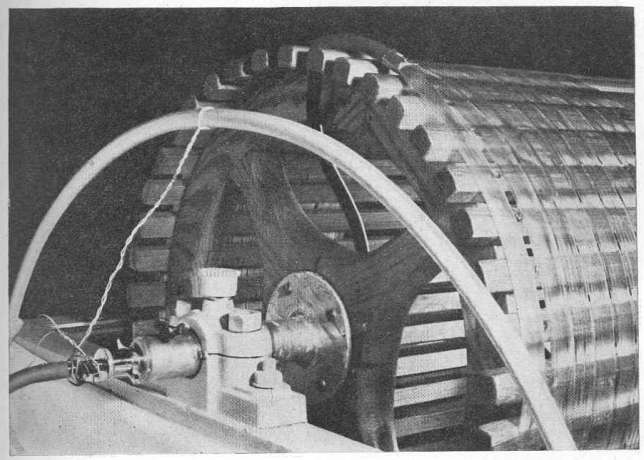


Fig. 25.
The supply-end of the dialyser, half-lateral.
The blood, coming on through the rubber tube to the left, flows into the rotation coupling, mounted in the hollow axle and from there into a second rubbertube which passes into the cellophanetube on the outside of the drum. (This is not a photo of the latest type of kidney, but of the second kidney which was constructed.)

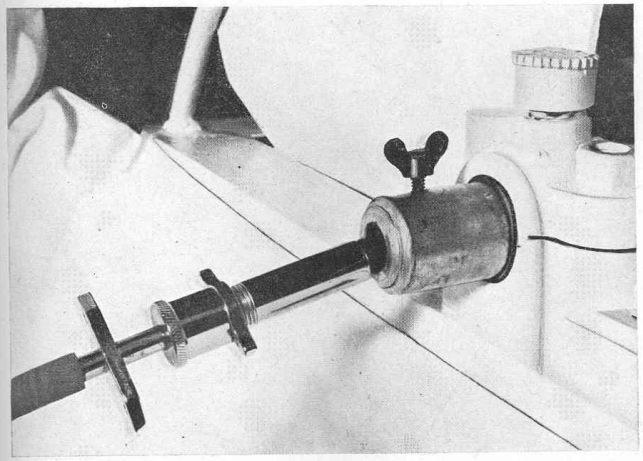
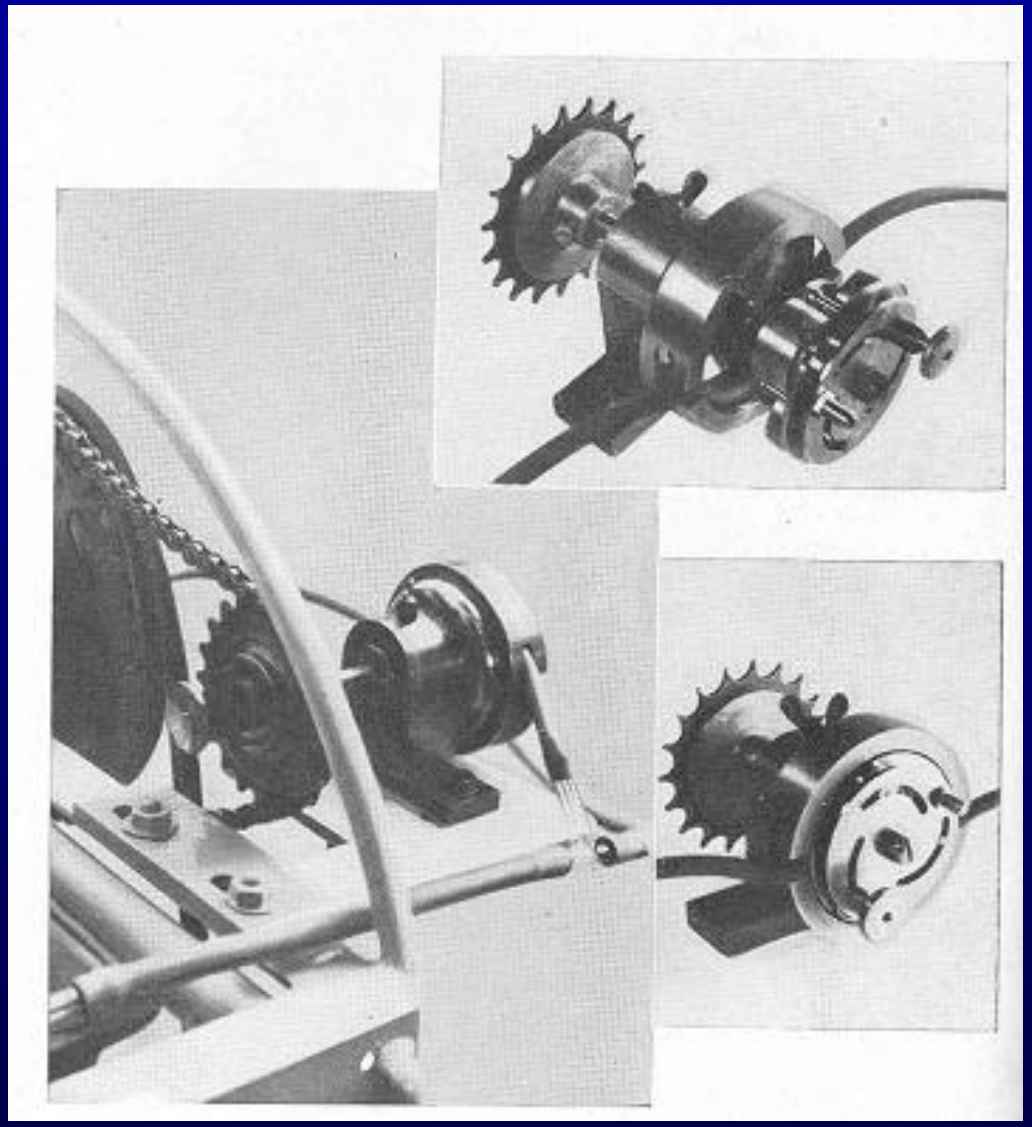
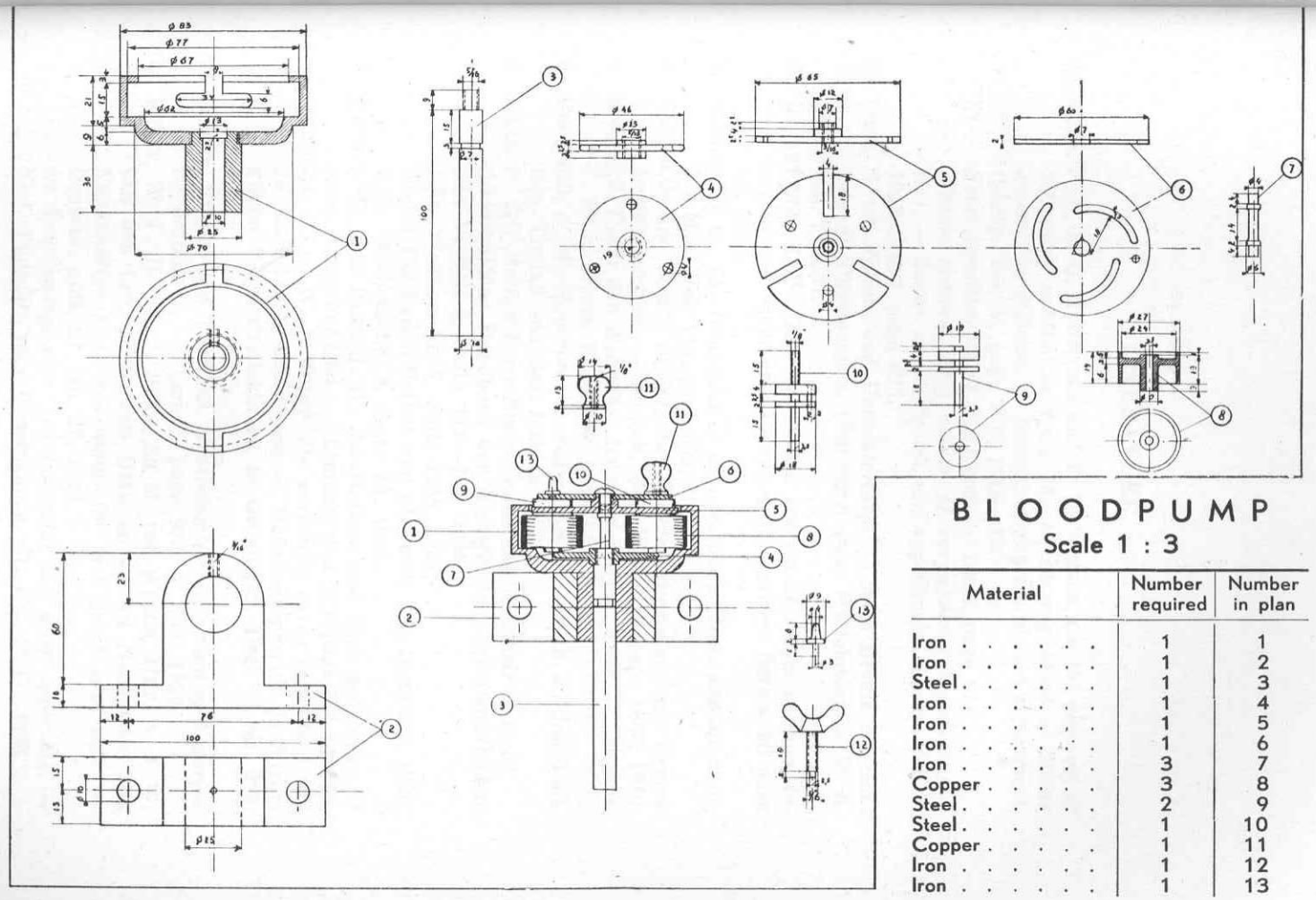


Fig. 26.
A rotationcoupling, half drawn out of the hollow axle. The winged nut is seen with which the coupling is fixed in the axle. A counternut has been screwed against the screwcap.

Hollow Axle and Rotating Coupling (Cont.)



Blood Pump



BLOODPUMP

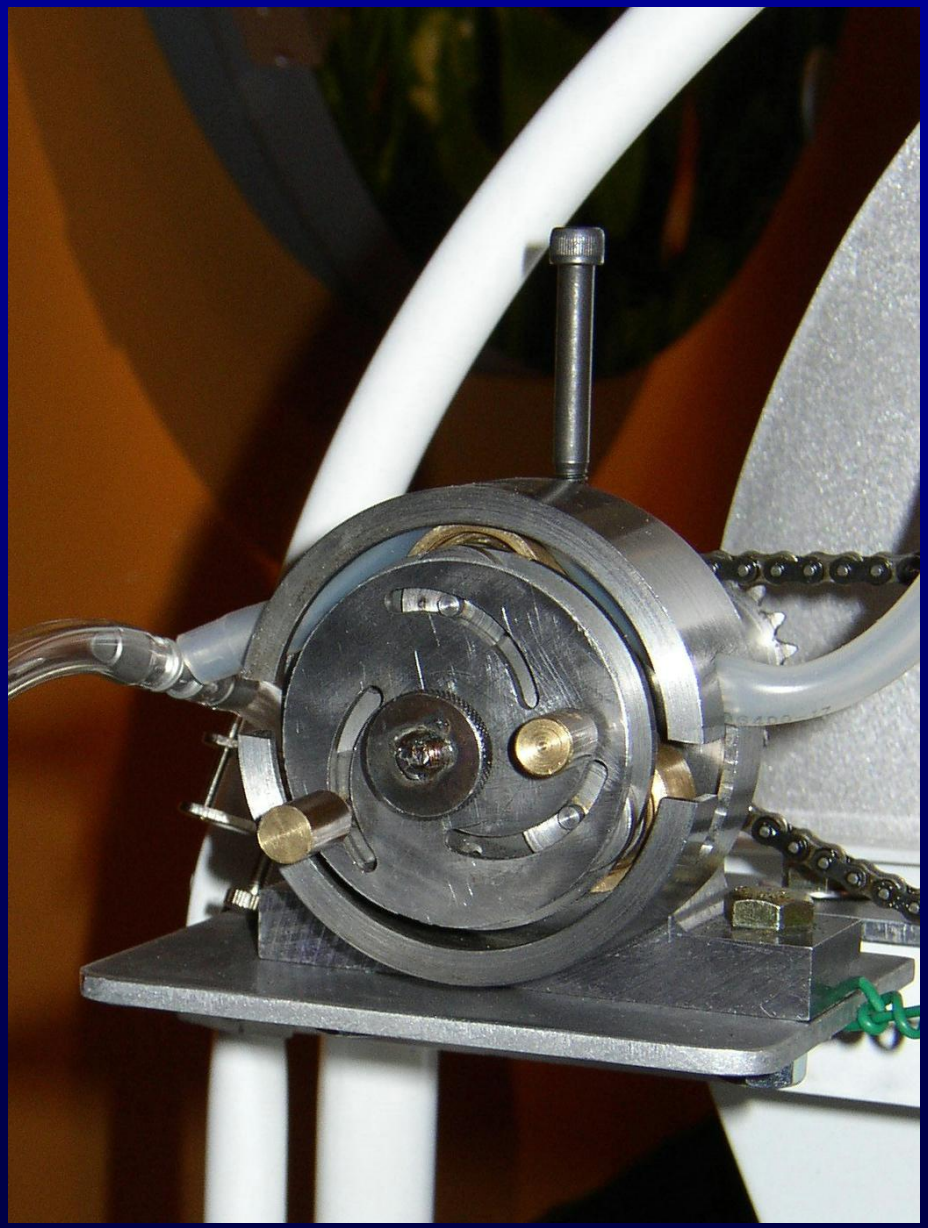
Scale 1 : 3

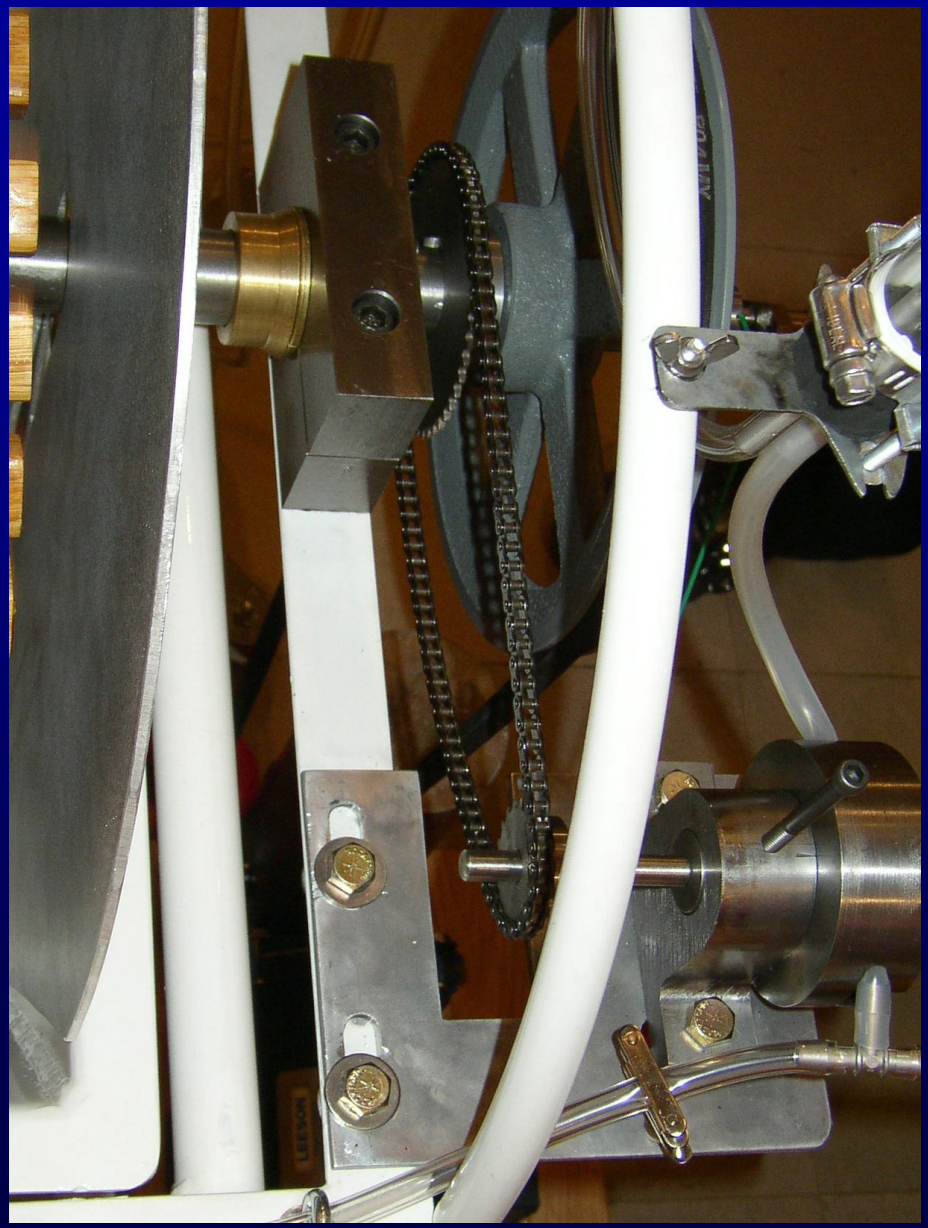
Material	Number required	Number in plan
Iron	1	1
Iron	1	2
Steel	1	3
Iron	1	4
Iron	1	5
Iron	1	6
Iron	3	7
Copper	3	8
Steel	2	9
Steel	1	10
Copper	1	11
Iron	1	12
Iron	1	13

PLAN IV

Blood Pump Schematic

Blood Pump (cont.)





Glass and Tubing

Heater and Motor

What's Next?

- Complete second device
- ASAIO Conference (Chicago)
  - June, 2006
- BMES (Chicago)
  - October, 2006

IPRO 314: FACULTY AND STUDENT MEMBERS

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