IPRO 314

THE FIRST ARTIFICIAL KIDNEY:

BUILDING A WORKING REPLICA OF KOLFF'S ROTATING DRUM

IPRO 314: FACULTY AND STUDENT MEMBERS

Project Advisor:

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Project Sponsor:

Museum of Science and Industry
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Student Members:

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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.

TEAM PURPOSE AND GOALS:

Overall, to build a working model of the rotating drum to present to the Museum of Science and Industry.

To enable students interested in healthcare, BME, MBB, etc., to understand the relationship between basic mechanical forces and device design.

To enable students to work as cross disciplinary team members and contribute to solving design and construction issues for an artificial organ.

To enable students to understand the development of the design of an artificial organ from an historic example.

To understand the interplay of knowledge bases from chemistry, materials, physiology, etc., required to develop an artificial organ.

To understand the relationship between clinical needs and requirements and design of an artificial organ.

MAJOR ACTIVITIES AND TASKS:

Project teams follow the 4 major component parts: hollow axle, wooden drum, blood pump, and stand and basin. The first major effort involved translating 2 dimensional plans into 3-D CAD. The adjustable blood pump is the most challenging and requires the most time. Each team will have to derive a working model from 2-D plans designed in 1947 with very basic materials. Semester goals are to have digital plans for each major component, a stand and basin assembly, a finished wooden drum, and machined preliminary prototypes for the axle and blood pump components.

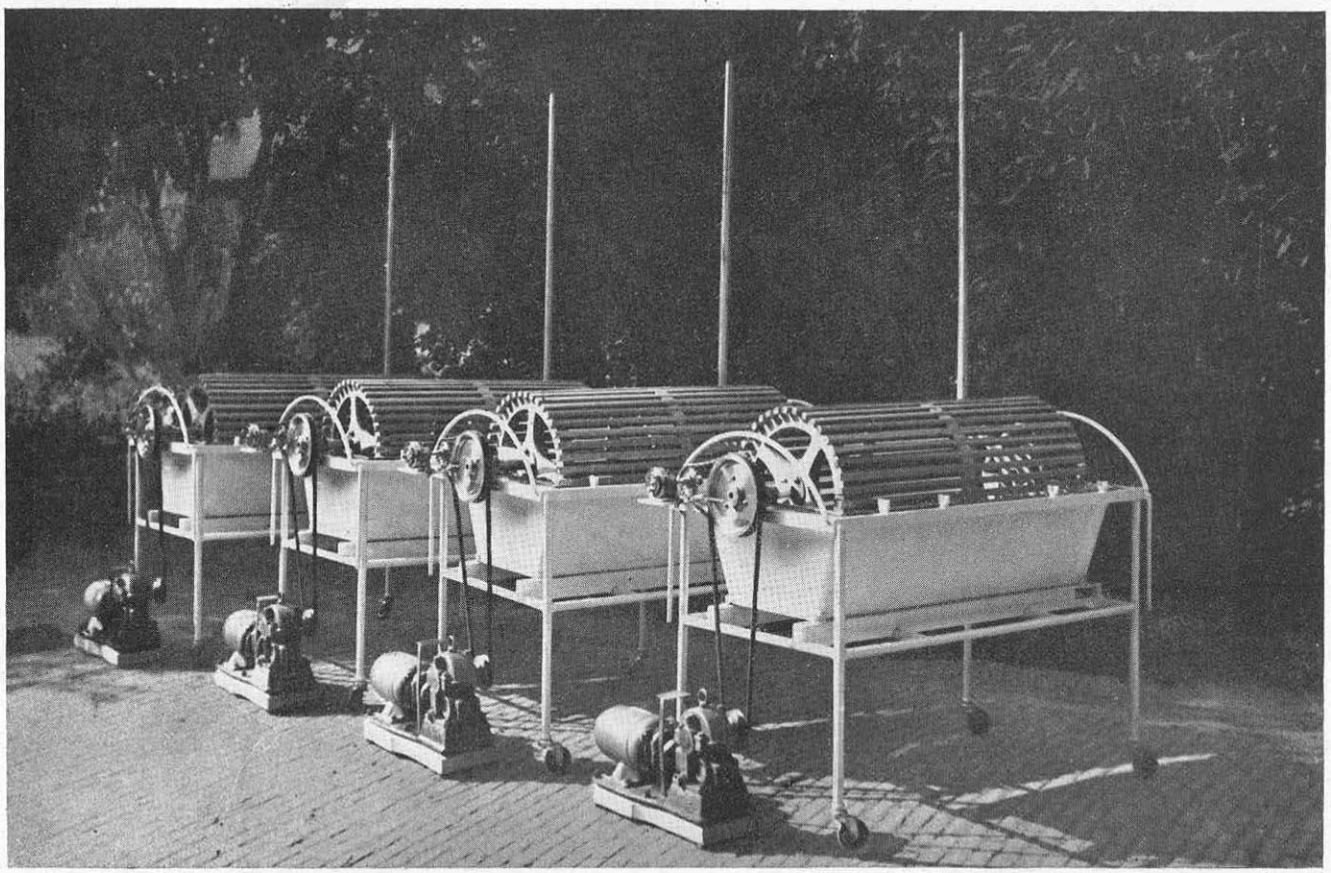


Fig. 1.
The first series of artificial kidneys ready September 1944.

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

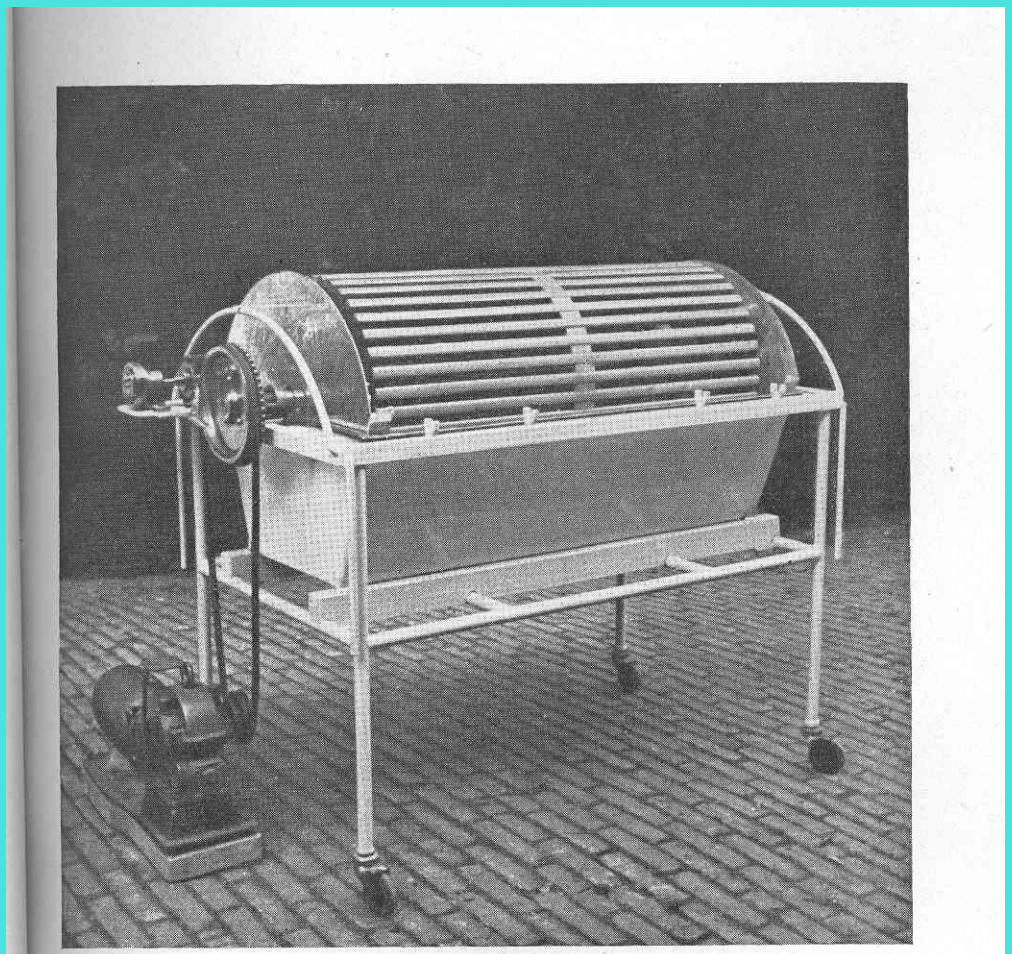
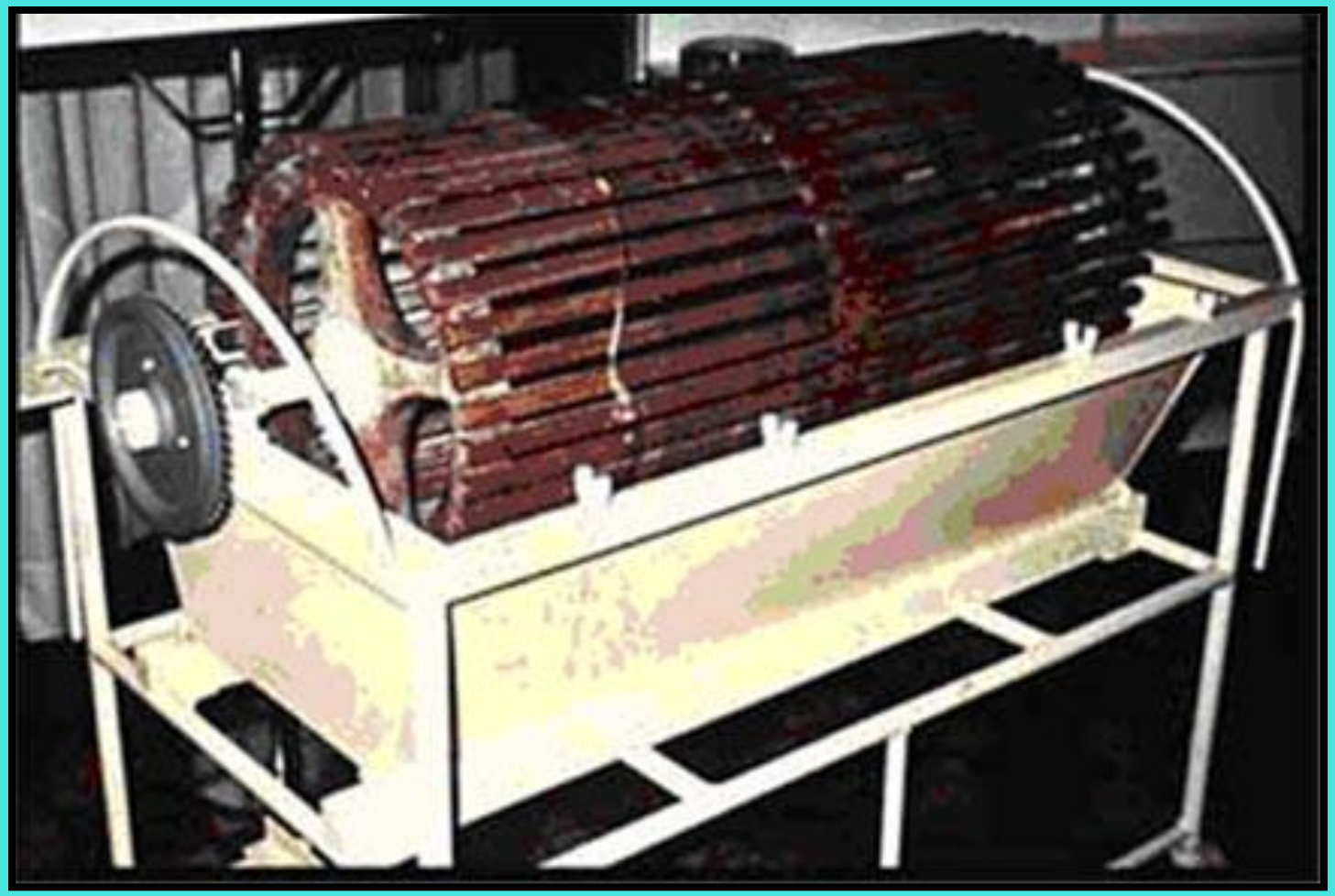
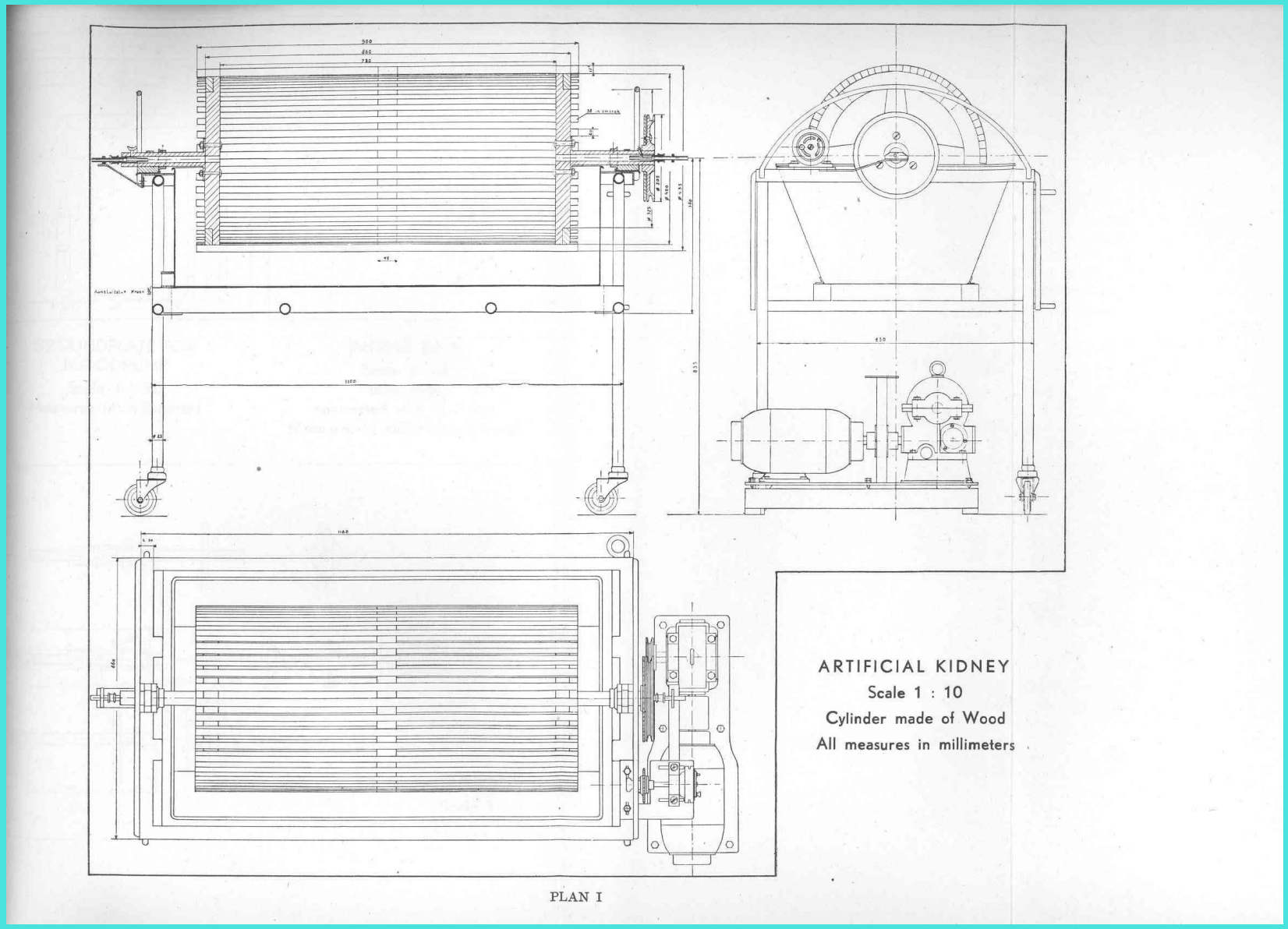


Fig. 15.
The latest model of an artificial kidney. The cylinder is made of varnished lathwork, and rotates with its lower segment through a tank with rinsing-liquid. The splashboards are seen on either side of the cylinder.

The primary example of a rotating drum upon which the current project is based



A photograph of one of the original Kolff Rotating Drums



Overall schematic of the device from the Kolff 1946 book

Close up photos of the separate components

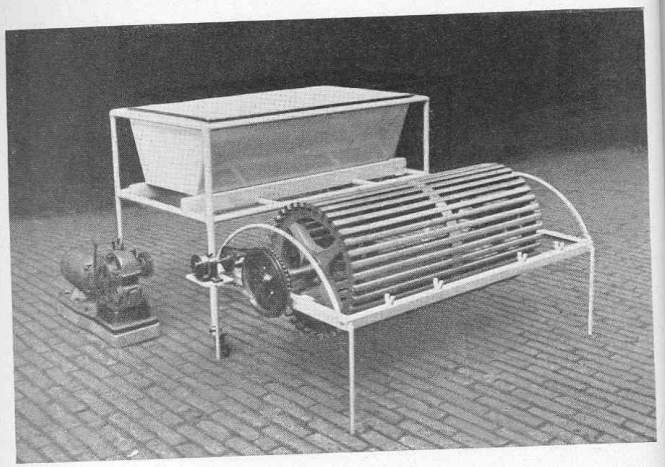


Fig. 16.
The angle-iron frame is provided with legs, and can be lifted with the cylinder from the frame.

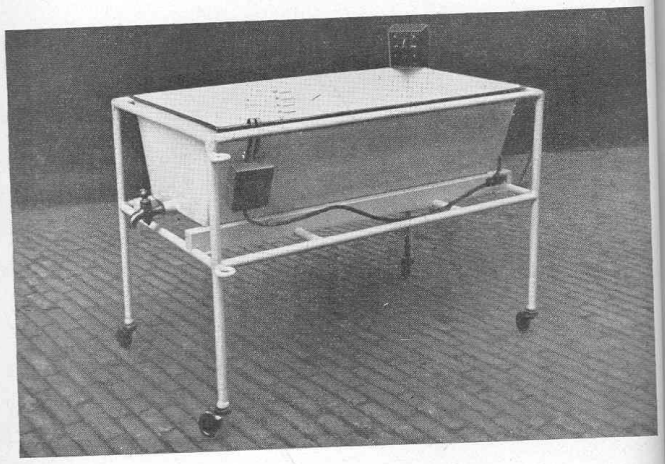


Fig. 17.
The frame with the enamel bath and the outlet. The heating-element has been brought in; the switch has been put on the bath at the back.

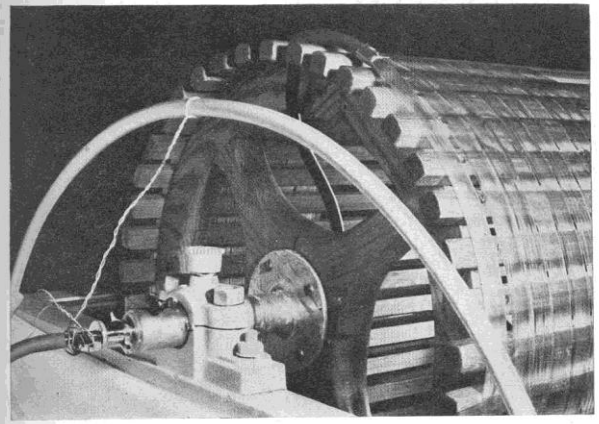


Fig. 25.
The supply-end of the dialyser, half-lateral.
The blood, coming on through the rubber tube to the left, flows into the rotation coupling, mounted in the hollow axle and from there into a second rubbertube which passes into the cellophanetube on the outside of the drum. (This is not a photo of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

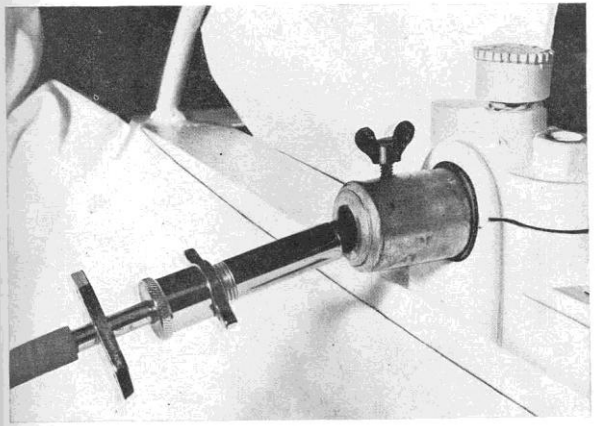


Fig. 26.
A rotationcoupling, half drawn out of the hollow axle. The winged nut is seen with which the coupling is fixed in the axle. A counternut has been screwed against the screwcap.

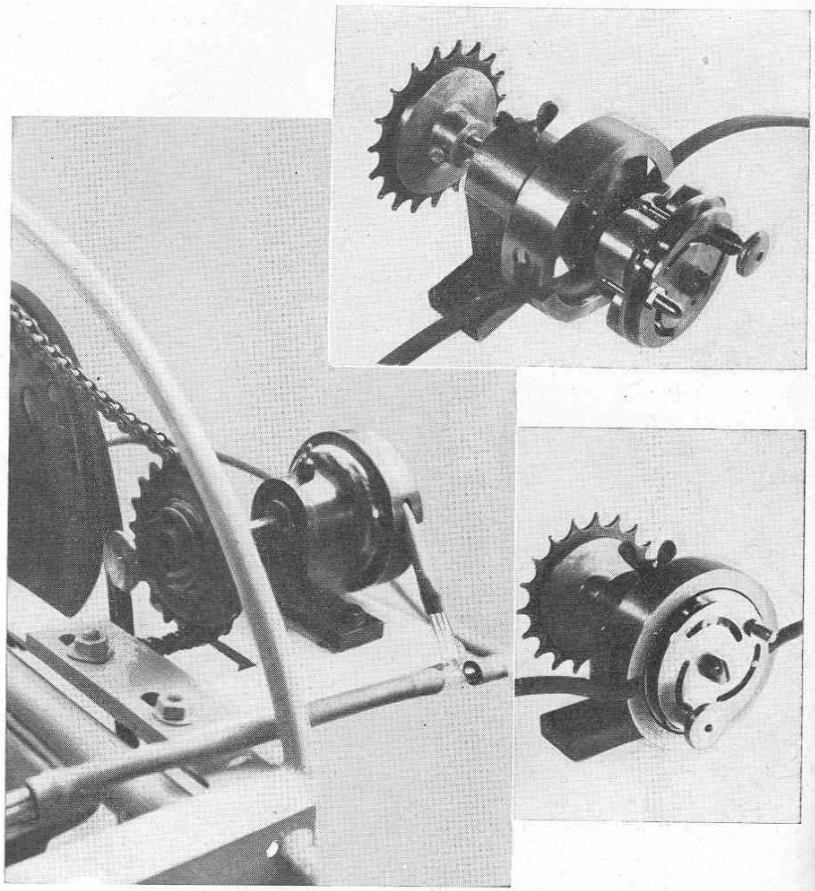
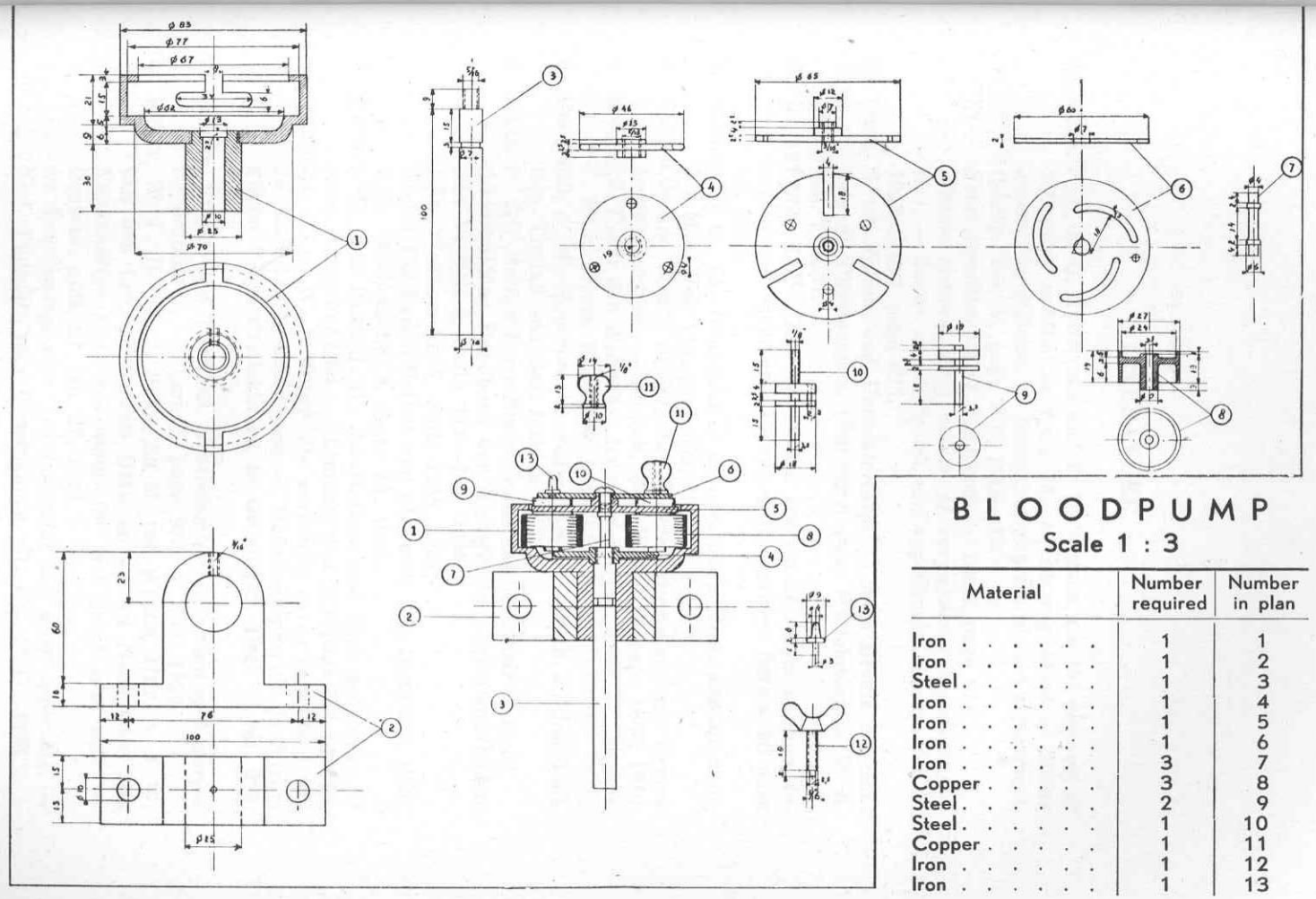


Fig. 27.
At the right bottom: the tubepump, seen aslant in front.
At the right top: the tubepump opened for putting in the tube. One sees very clearly one of the three cylinders which must mangle the tube till it is empty.
To the left: the tubepump mounted on its footplate. At the back of the chainwheel is the button with which the freewheel is switched on and off.

Close up photo of the mechanical blood pump which takes the blood from the drum and continues the flow up to a device which separates clots and bubbles from blood and returns it to patient.



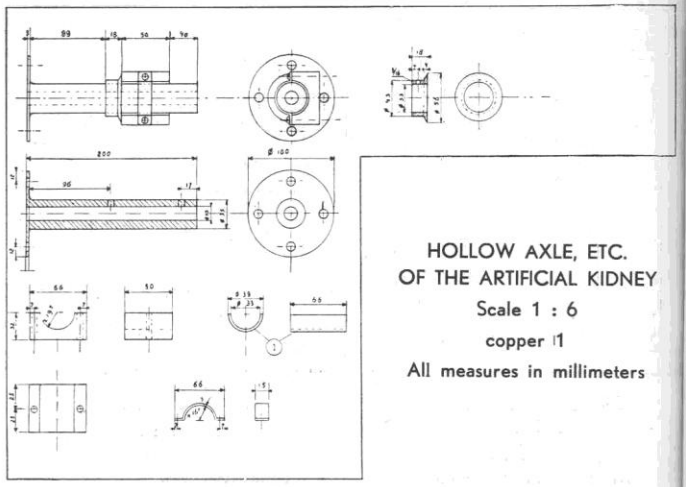
BLOODPUMP

Scale 1 : 3

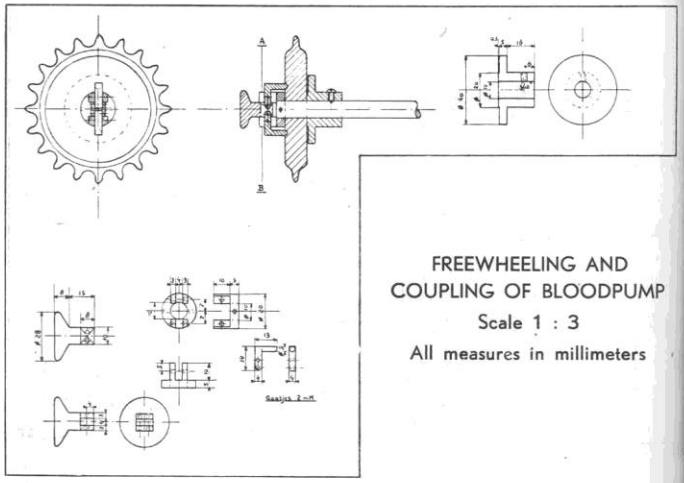
Material	Number required	Number in plan
Iron	1	1
Iron	1	2
Steel	1	3
Iron	1	4
Iron	1	5
Iron	1	6
Iron	3	7
Copper	3	8
Steel	2	9
Steel	1	10
Copper	1	11
Iron	1	12
Iron	1	13

PLAN IV

Blood pump schematic

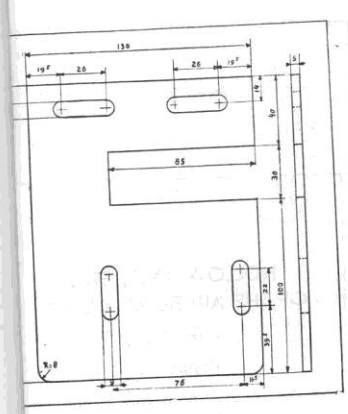


HOLLOW AXLE, ETC.
OF THE ARTIFICIAL KIDNEY
Scale 1 : 6
copper !1
All measures in millimeters

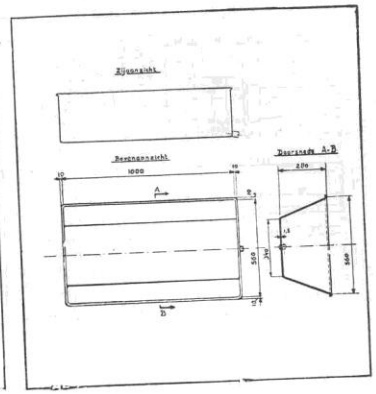


FREEWHEELING AND
COUPLING OF BLOODPUMP
Scale 1 : 3
All measures in millimeters

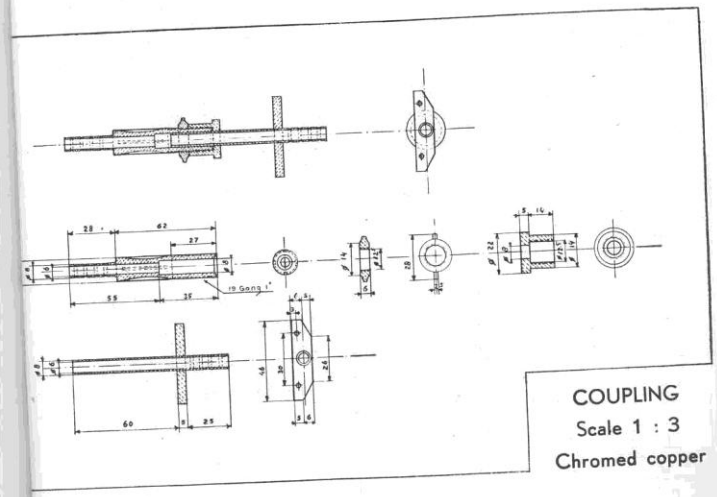
PLAN III



GROUNDPLATE FOR
BLOODPUMP
Scale 1 : 30
Measures in millimeters



RINSING BATH
Scale 1 : 3
tube hole
connected with $^{3}/_{4}$ '' tap
Measures in millimeters (inside)



COUPLING
Scale 1 : 3
Chromed copper

PLAN II

Further schematics of axle and blood pump

Stand (with casters) and drum support frame developed this semester

First iteration of hollow axle from this semester

SPRING SEMESTER 2006 OBJECTIVES:

Stand: Fill, sand, prime, and paint, drill and tap in eye bolts, drill holes for pump and pinch block, wood supports.

Basin: Fill, sand, prime and send out for enamel coating.

Drum: Finish assembly, sand, and varnish.

Blood Pump: Continue machining, fitting, and testing to finished product, base plate, and chain.

Axles and Couplings: Continue machining, fitting, and testing to finished product.

New Items:

- Design and fabricate drum drive gear and pulley, and fit.
- Acquire electric motor and control, construct wooden base, with belt.
- Clot and bubble catcher: fabricate components including glass chamber.
- Splash shield: design and fabricate.
- Wooden reel for cellophane: design, construct, and varnish.
- Heparin glass burette: design and fabricate.
- Glass canulae.
- Heater assembly and regulator: design and fabricate.

Additional Museum Objectives:

Print out 2D schematics on 36" poster paper.

Develop animation for each component and total package.