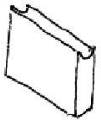
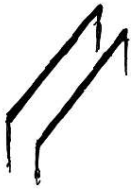
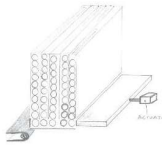
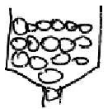
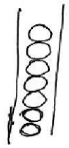
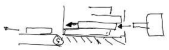
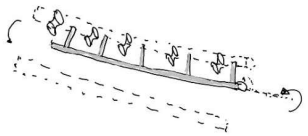
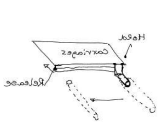
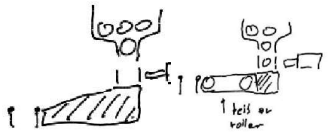
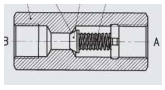
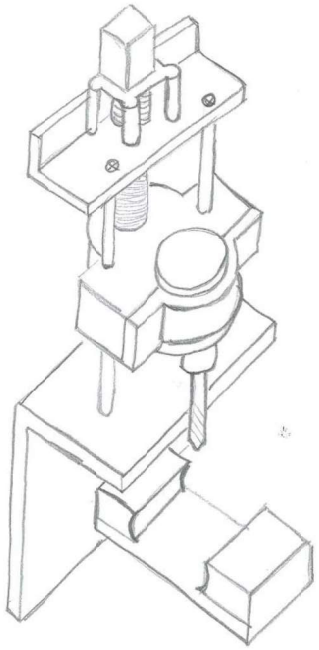
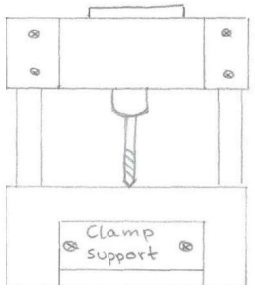
APPENDIX A: Morphological Chart

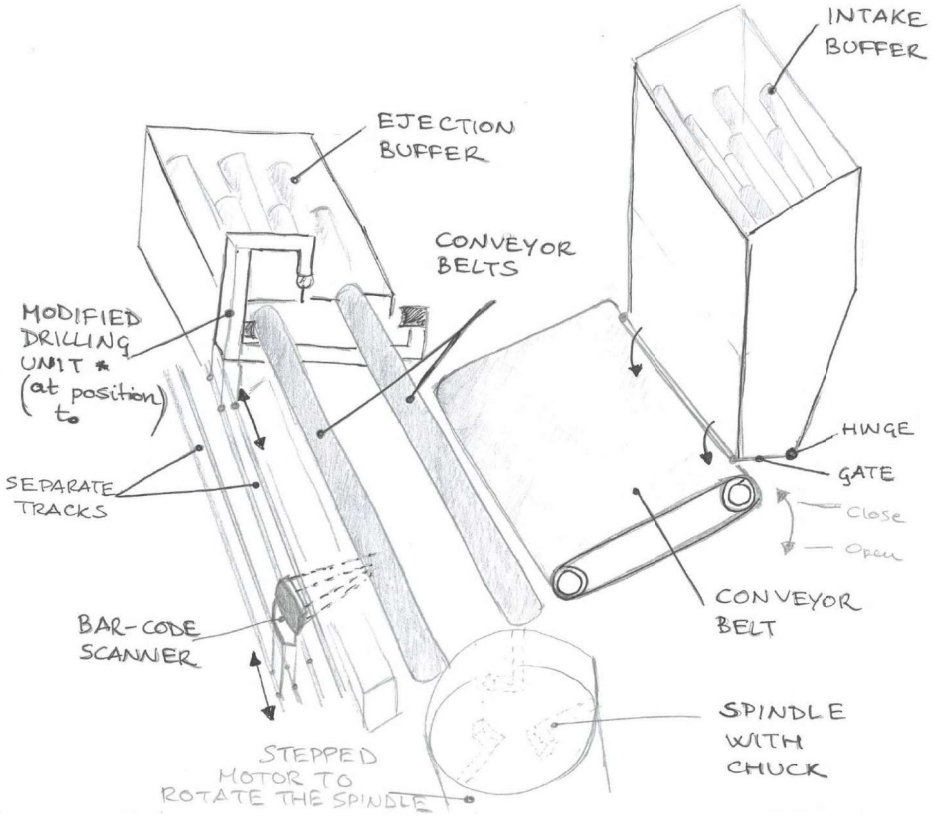
FUNCTION	CONCEPT					FUNCTION	CONCEPT				
Linear Actuator						**Clamping**					
Description	Pneumatic	Hydraulic	Electric	Ball Spline		Description	Pneumatic Schunk PZH-SF	3 jaw gripper electric	Spindle with chuck	2 finger	Magnetic gripper
Support						**Angular Position**					
Description	Concave	Bearings	Conveyor belts	Rollers	Longitudinal simple supports	Description	Stepped DC servomotor	Electric Servo	Hydraulic rotary actuator	Ball spline actuator	Low torque servo- hinges
Chip Removal						**Sliding (either drill or tube)**					
Description	Air Blow Gun, 6 bar	Sprain Gun, 6 bar	Pneumatic Cold Air Gun			Description	Linear carriage (drill)	Conveyor belt (tube)	Linear actuator (tube/drill)	Linear Motion Roller(tube)	Ball spline actuator (tube/drill)
Buffer Storage						**Ejection**					
Description	Separated sections	Tubes vertically stored	Tubes horizontally stored longitudinally	Tubes horizontally stored one on top of the other	Fennel + actuator to align tube before exit	Description	Conveyor belt(s)	Linear actuator	Transverse ejection through turning lever arm		
Intake						**Valve System/Air management**					

DRILL CONFIGURATION N 1

Additional clamp support

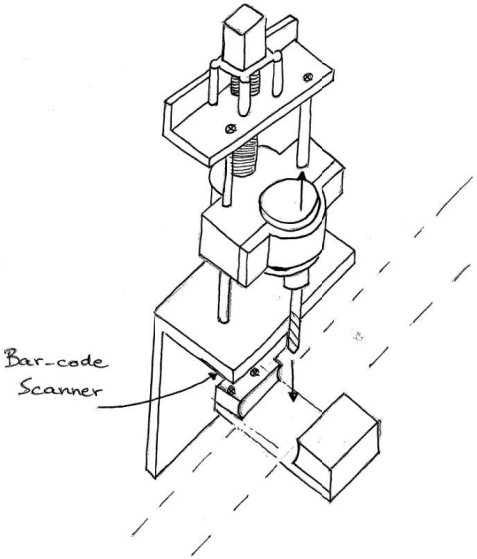


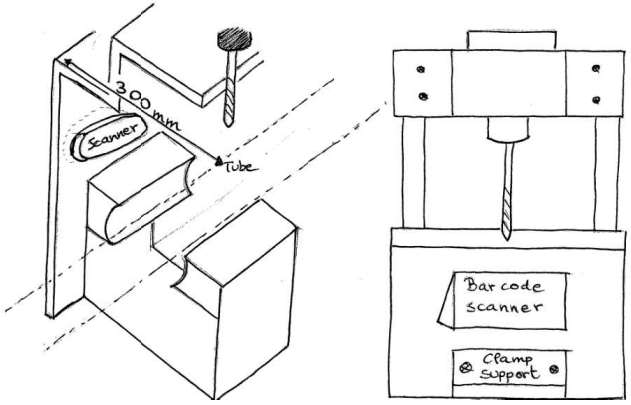




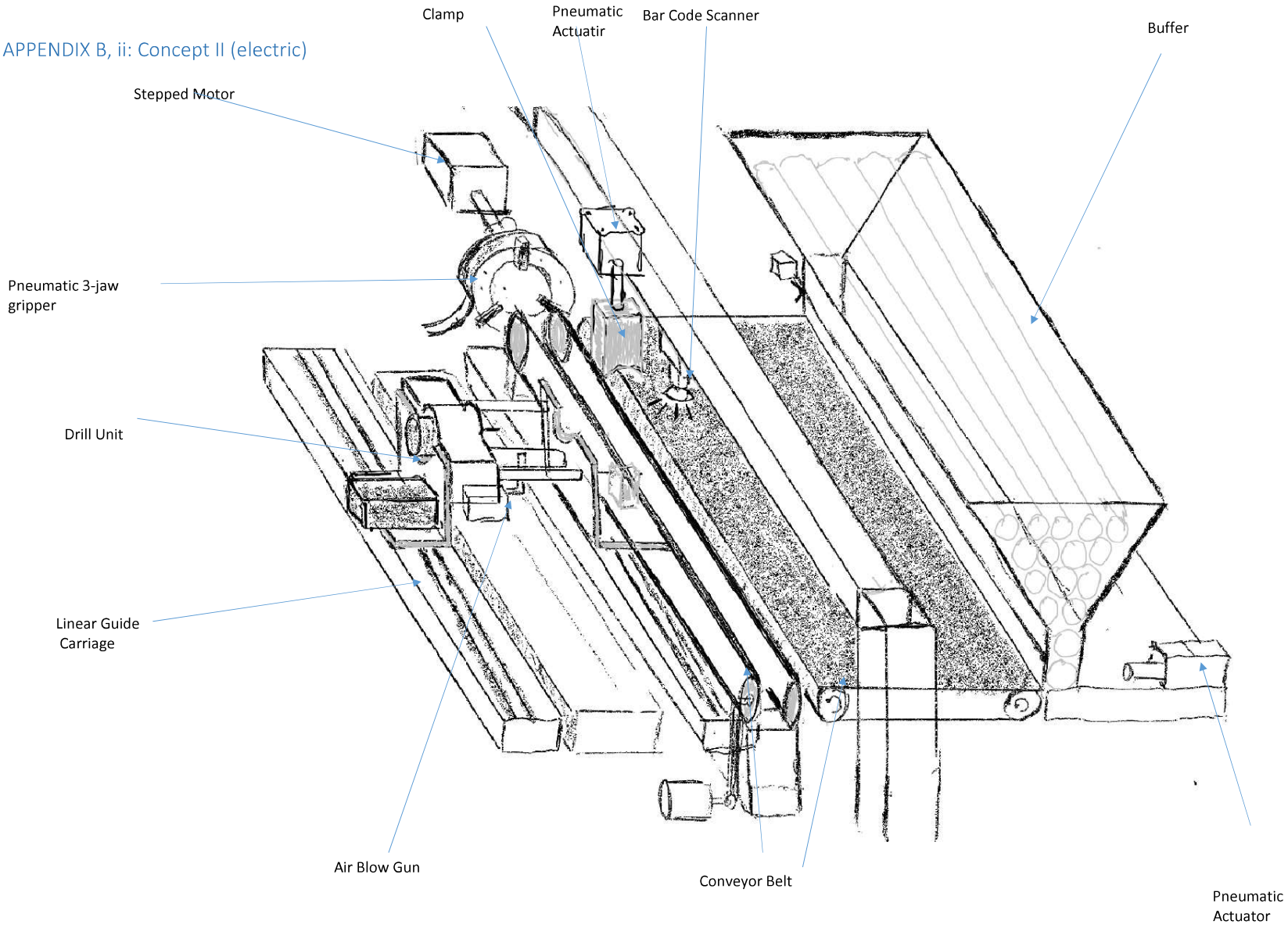
DRILL CONFIGURATION N 2

Additional clamp support and bar code scanner separate tracks to move bar code are not required)





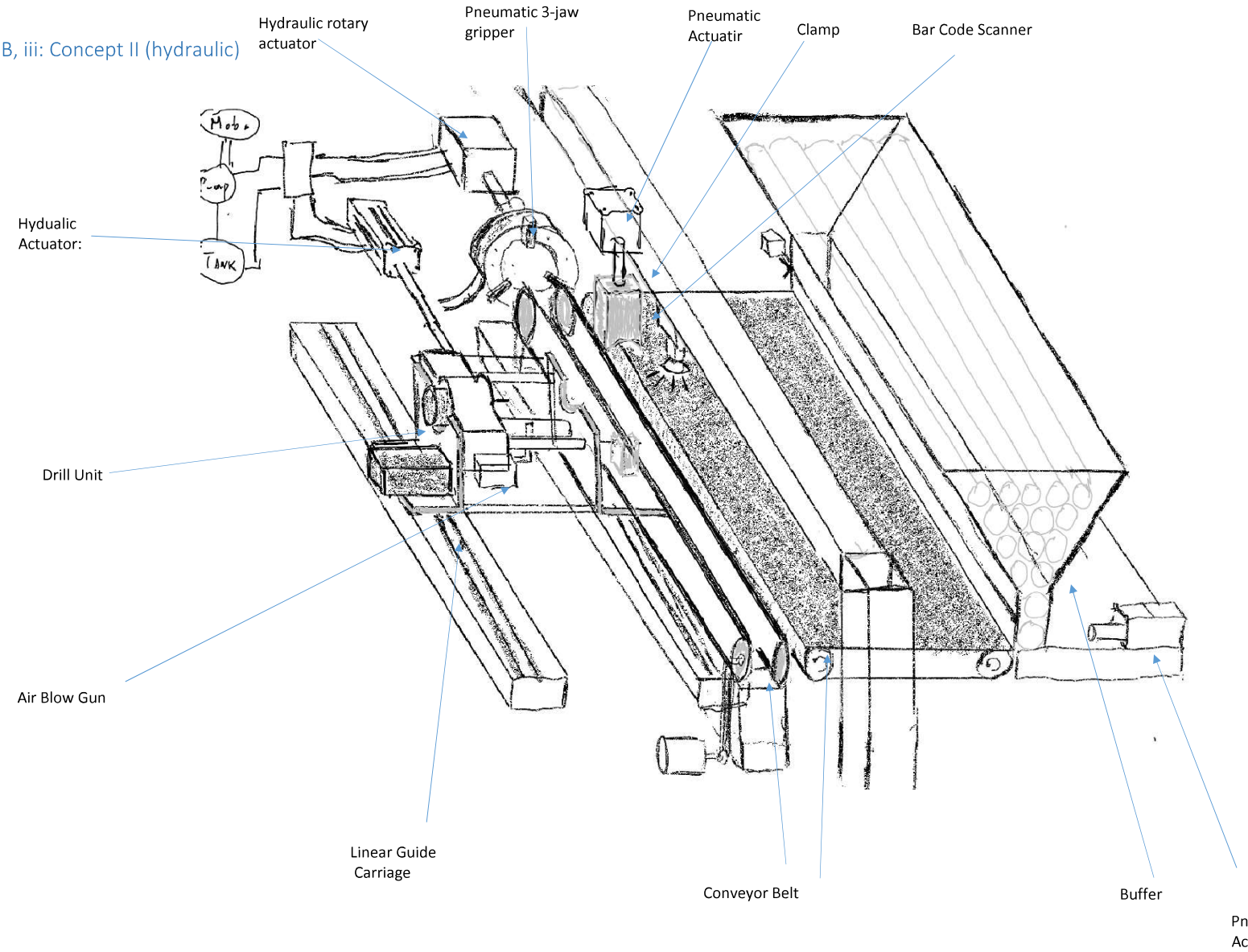
APPENDIX B, ii: Concept II (electric)



In this concept, the tube exits the **buffer** through the funnel shaped end. A servo motor turns the hinge connected to the gate opening a passage and the **pneumatic actuator** pushes the tube to the first conveyor belt. Here, the tube is transported to the edge where it falls into the second **stranded conveyor belt** which acts as a support. The conveyor slides the tube into the pneumatic **3 jaw gripper** which clamps the object firmly. At this stage, the tube is rotated through the **stepped motor** at fixed angular changes. At each angular rotation, the **bar code scanner** moves along the vertical top frame scanning for the code. The process is repeated until the code is found. Next, the **drilling unit** is actuated in synchrony with the **clamp** on the vertical frame through a **linear guide carriage**. The clamp is moved down using a pneumatic actuator and holes are drilled at different positions along the length of the tube.

Finally, the tube is ejected at the end in the end into a secondary buffer.

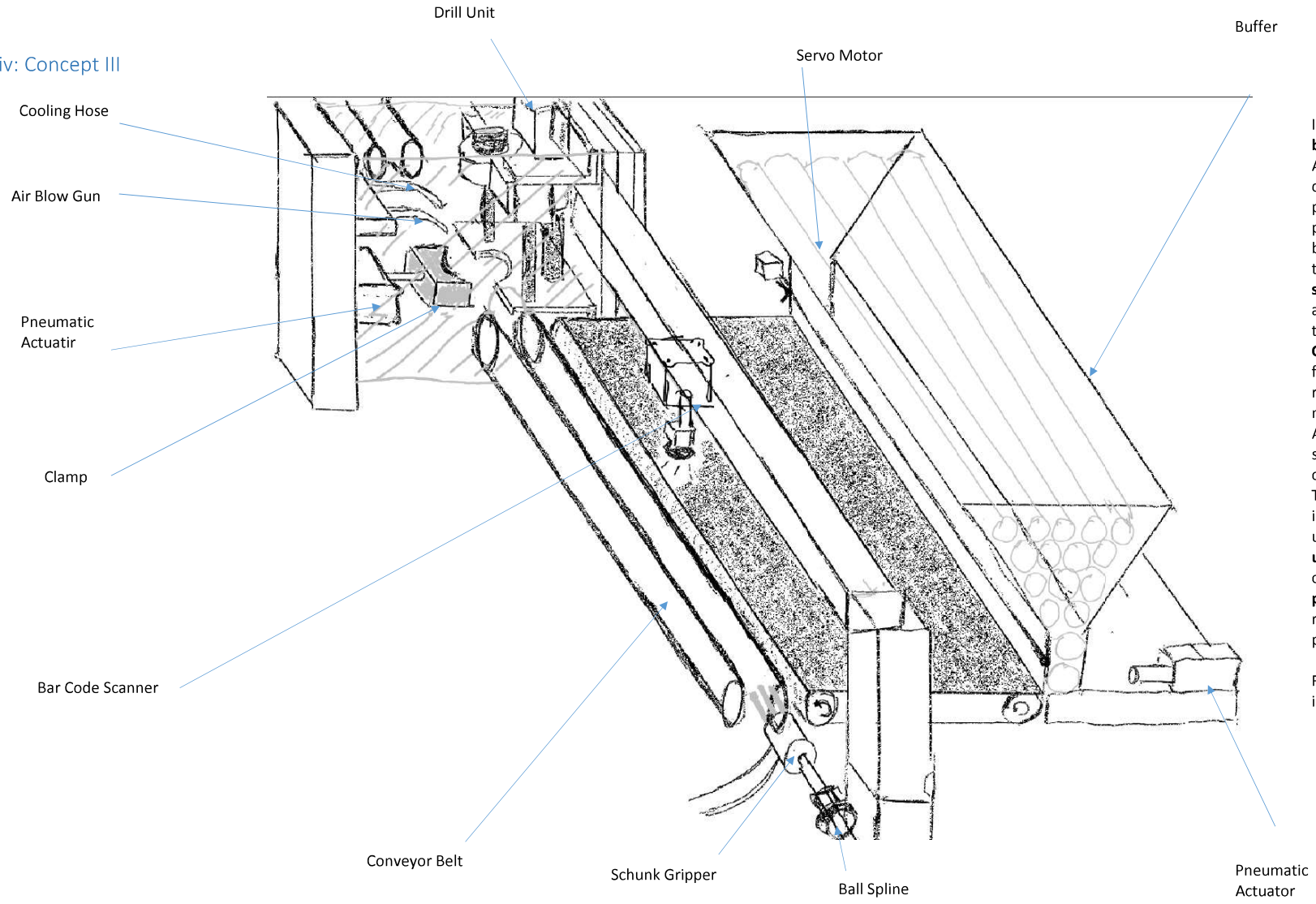
APPENDIX B, iii: Concept II (hydraulic)



In this concept, the tube exits the **buffer** through the funnel shaped end. A servo motor turns the hinge connected to the gate opening a passage and the **pneumatic actuator** pushes the tube to the first conveyor belt. Here, the tube is transported to the edge where it falls into the second **stranded conveyor belt** which acts as a support. The conveyor slides the tube into the pneumatic **3 jaw gripper** which clamps the object firmly. At this stage, the tube is rotated through the **angular actuator** at fixed angular changes. At each angular rotation, the **bar code scanner** moves along the vertical top frame scanning for the code. The process is repeated until the code is found. Next, the **drilling unit** is actuated in synchrony with the **clamp** on the vertical frame through **hydraulic linear actuator**. The clamp is moved down using a pneumatic actuator and holes are drilled at different positions along the length of the tube.

FInally, the tube is ejected at the end in the end into a secondary buffer.

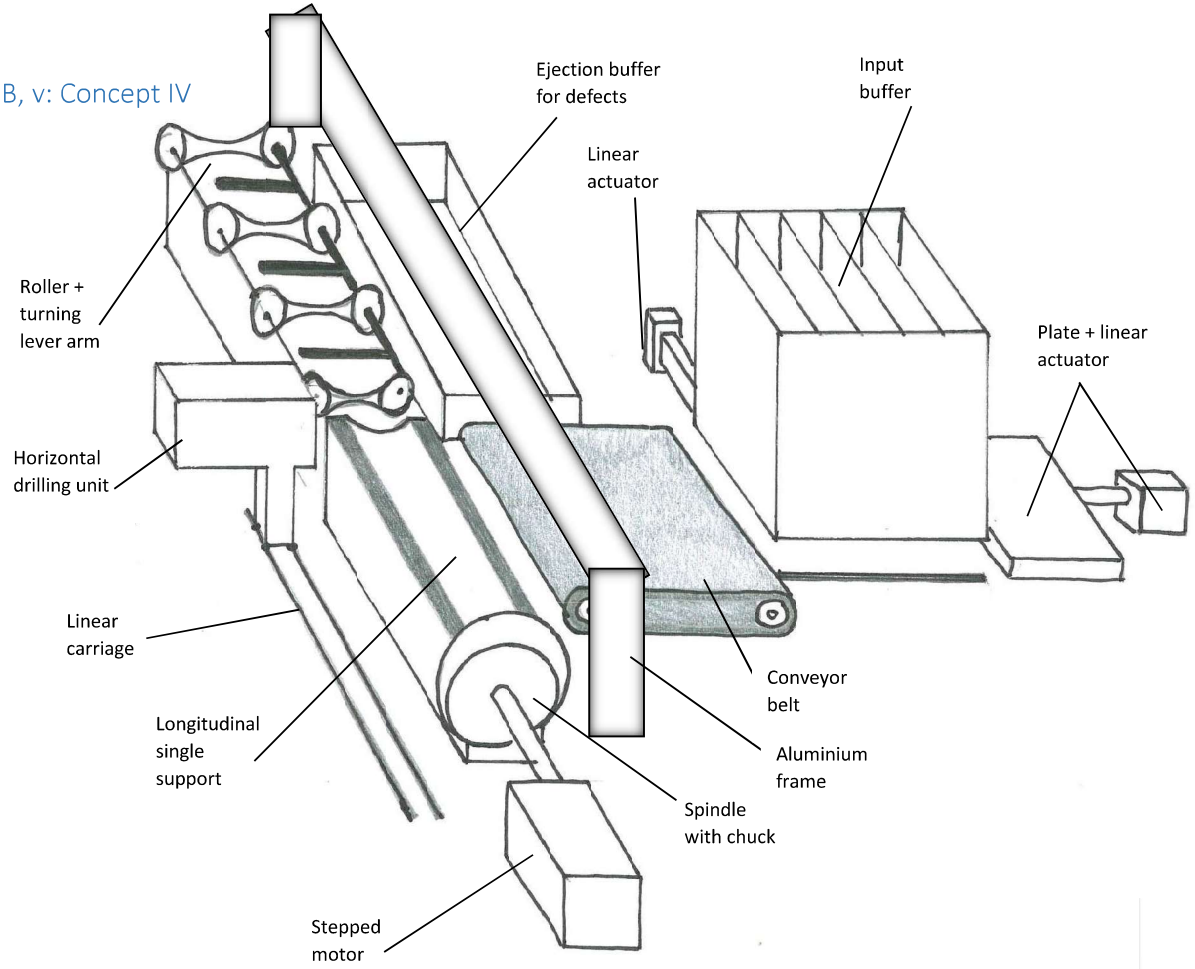
APPENDIX B, iv: Concept III



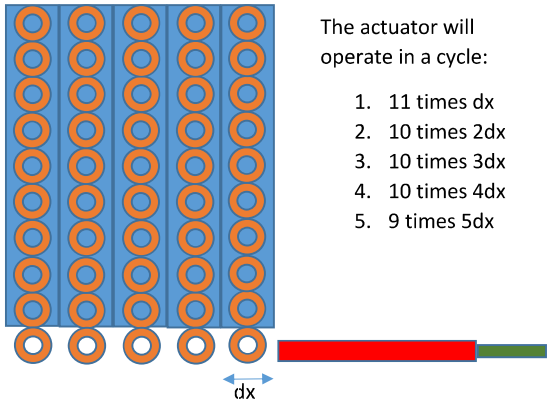
In this concept, the tube exits the **buffer** through the funnel shaped end. A servo motor turns the hinge connected to the gate opening a passage and the **pneumatic actuator** pushes the tube to the first conveyor belt. Here, the tube is transported to the edge where it falls into the second **stranded conveyor belt** which acts as a support. The conveyor slides the tube into the pneumatic **Schunk Gripper** which clamps the object firmly. At this stage, the tube is rotated at fixed angular changes and moved axially through the **ball spline**. As the tube is moved through the ball spline the **bar code scanner** is fixed in one position on the top vertical frame. The process is repeated until the code is found. Next, the tube is moved also using the ball spline into the **drilling unit** area and fixed using the **clamps** on the vertical frame through **a pneumatic actuator**. The process is repeated to drill holes at different positions along the length of the tube.

Finally, the tube is ejected at the end into a secondary buffer.

APPENDIX B, v: Concept IV



INPUT BUFFER SECTION

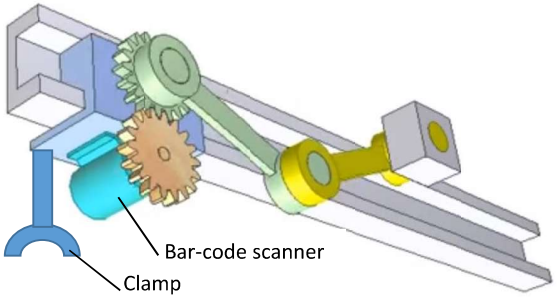


The actuator will operate in a cycle:

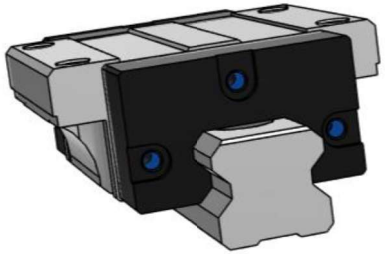
1. 11 times dx
2. 10 times 2dx
3. 10 times 3dx
4. 10 times 4dx
5. 9 times 5dx

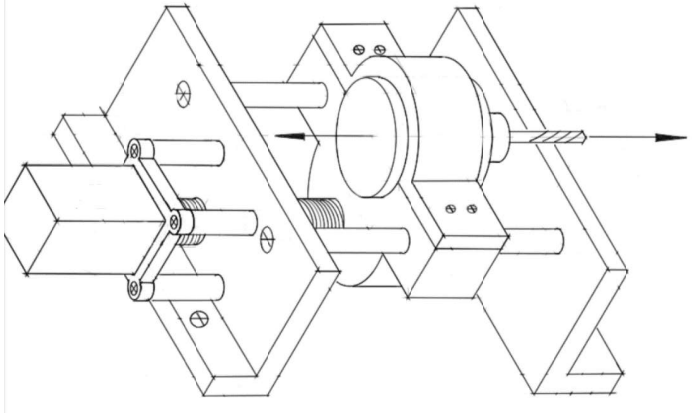
HORIZONTALLY LOCATED DRILLING UNIT WITH COOLING SYSTEM

ALUMINIUM FRAME and SLIDER MECHANISM



LINEAR CARRIAGE





APPENDIX B, vi: Concept V