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1.0 Introduction

In this assignment I will evaluate the options and make appropriate recommendations for the design and construction of the HVAC technologies and the installation challenges that will occur for at least 2 of the different design uses that the multi storey building will be divided into.

Following this, I will evaluate energy provision and the principles and installation of natural, artificial, emergency lighting and power systems within the building.

Finally, I will appraise the building fabric and potential equipment choices for the design and installation practice within the context of sustainable futures, low carbon/low energy cost savings.

2.0 Recommendations for HVAC Technologies and Possible Challenges Facing the Building Uses.

After careful analysis of HVAC technologies suitable for a large commercial building it is recommended that a VRF system is used. A VRF system can run multiple indoor units which are connected to one main unit fitted in the plant room. This makes the system suitable for medium to large buildings which have a high demand for performance and optimum efficiency. The VRF system will offer a heat pump and heat recovery technology as a hybrid unit. The heat pump systems will deliver cooling or heating to a space as required, whereas the heat recovery system can provide heating and cooling at the same time by separate indoor units, this will move energy around the building for maximum efficiency. This VRF system offers a simple and flexible solution where there will be demand for a changeover capability between the heating and cooling for all the indoor units, this will help ensure a constant and comfortable indoor climate is achieved. The main benefits of using the VRF system are quiet operation, consistent comfort levels, installation is easy and good for tight spaces, heat and cool at the same time, zoned air control for hot and cold, limited breakdowns/down time as well as having state of the art technology controls. The heat recovery system will use two pipes rather than the conventional three used in most heat recovery systems, this will reduce installation time and material costs but will not effect the performance. This recovered energy can be moved around rooms and be upgraded to heat water for sanitary use. Using this system and transferring wasted energy will result in substantial savings made on annual running costs and Co2 emissions. The indoor units can be installed as floor standing, ducted, ceiling cassettes, ceiling suspended, and wall mounted. (Ferguson Enterprises, 2021) (Daikin, n.d.) (Easy Air Conditioning, 2020) (LG electronics, 2020) (Porges, 2020) (Brumbaugh, 2004) (Bhatia, 2014)

Due to the multi-use zones of the building the VRF system will suit the buildings need. Retail shops will need to be kept at a moderate temperature and made comfortable for all people entering the shops. The accommodation however will be different as the needs of each individual will vary, one room may be very warm and want to cool the space whereas another room may be too cold and want to warm the space. Using the VRF system the retail floor can be kept at a moderate temperature whilst individually meeting each room's need in the accommodation floors. The VRF system works by varying the amount of refrigerant that flows to a series of evaporation coils in a refrigeration piping system, this allows for some evaporators to be in cooling mode whilst others are in heating mode simultaneously. Although on average a VRF system will cost 5-20% more than a chilled water system, the VRF system is typically 30% more efficient than comparable HVAC systems. The initial cost for equipment will tend to be higher for the VRF 3 pipe system, but the installation cost is generally lower in a 2-pipe distribution unit. (Mitsubishi Electric Corporation, 2021) (Mitsubishi Electric, 2015) (MFM Group, 2021) (Bhatia, 2014)

As the HVAC main unit will be installed in a plant room which is below ground floor, this presents an issue. The HVAC unit needs sufficient ventilation circulating the room to be able to function properly and reach maximum efficiency. Additional ventilation inlets will be constructed down to the plant room, this will allow for sufficient ventilation and a good climate for the HVAC system to be in, please see figure 2.4 for technical drawing for typical natural ventilation inlet for the basement. A further issue is how all the pipe work and ducts will be able to reach each room to distribute the heating, ventilation and air conditioning. These pipes will run up one side of the building to every floor through a channel that is designed specifically for the building services. Once they reach each floor they will be distributed just above the suspended ceiling for the shops and offices. This will be different for the apartments, which will have plastered ceilings with a smooth skim finish. The services have many options on how to distribute to the apartment rooms. The chosen method is again through the ceiling as well as having some wall mounted systems implemented as well. To make the interior look as aesthetic as possible the units will be connected to the electrics/pipes running through the partition walls. Trunking will be used if any wires are exposed.

The HVAC unit chosen is designed and installed by Mitsubishi Electric. The City Multi VRF R2 (Variable Refrigerant Flow) is claimed as the only 2-pipe system in the world by using cutting edge technologies. When compared to other devices the 2-pipe technology is cheaper to install, durable, reliable and provides energy efficiency as well as extremely good levels of control. After several conversations with professionals, technical advisors and companies, this system will fit the high rise multi zoned building and meet all challenges faced by the multi zone use. Some of the main benefits for using the VRF two pipe system is that less pipe connections are needed when installing. When compared with similar systems from other manufacturers, the Mitsubishi Electric Multi City VRF will use around 20 connection sites for 4 indoor units, whereas other manufacturers will use around 58 connection sites for 4 indoor units. Having less connections in the pipe work will reduce labour costs and materials needed. As copper prices have risen, the less copper used means much less capital cost when compared to other systems. This system has proven to be cheaper to install and provide less potential for leak sites with fewer connections. The 2-pipe system allows for alterations and more flexibility for servicing, reducing the through-life costing. If alterations or any additions are to be made, individual branches can have a branch ball valve installed, allowing individual branches to be worked on while the other branches are still running, this allows the majority of the system to still be functional whilst maintenance works or alterations are made. Unlike a normal 3-pipe system, the 2-pipe system does not require regular oil recovery cycles, as there are less refrigerant volumes and velocities during mode changeover, the oil recovery is kept to a minimum. This helps to stop zone-temperature drift during recovery cycles, as well as improving the control accuracy and energy efficiency. The heat recovery between indoor units is done through the branch control boxes, this allows heat integration/energy recovered to be diverted, which will result in reducing pipe transmission loss. Heat will be redirected in the valve blocks to the branch that requires it. Multi City VRF R2 can be fitted outdoors or indoors. As the plant room is in the basement it is under the assumption the unit will be installed indoors but it also has the option to be installed outdoors. The VRF will need a lot of duct work and volume dampers will be installed at each floor to distribute the heating ventilation and air conditioning to each floor/room. (Mitsubishi Electric Corporation, 2021) (Mitsubishi Electric, 2015) (Realnet, n.d.)

Case studies have shows the Multi City VRF systems work. An installation in a Co-Op shop in Dagenham showed a decrease in usage of energy by 39,312kW/h and savings of £7,825 from previous bills. Another case study for the Logic Group based in Hampshire showed the total estate saved 120,225kWh over a one-year period saving £15,630 and reducing their CO2 output by 65.5 tonnes. Many other case studies are available and are built into a variety of commercial buildings. (Mitsubishi Electric, 2015) (Mitsubishi Electric Corporation, 2021)

The system chosen falls in line with the BS EN 15004 F-Gas Statutory Inspection requirements and the EC Regulation 842/2006.

Figure 2.1 – Table of comparison between 3 HVAC systems.

Table key for compatibility with building and high energy efficiency demands.

1-2 poor compatibility with building use and needs - Red

3 Medium compatibility with building use and needs - Yellow

4-5 Good compatibility with building use and needs - Green

HVAC Unit	Unit capabilities	Efficiency	Materials Cost	Installation Cost	Alterations	Maintenance	Score
Multi City VRF R2-pipe	Large Buildings - 5	Good - 5	Low/Medium - 3	Medium - 4	Easy - 4	Easy - 4	25
Common VRF 3-pipe	Large Buildings - 5	Good - 5	Medium - 2	High/medium - 3	Medium - 3	Medium - 3	21
Common Multi Split	Small/Medium buildings - 1	Good - 5	Low - 4	Low - 5	Easy - 4	Easy - 4	23

The table represents comparisons only between the systems stated. All views are of my own from the specific units I have researched and been informed of from companies and professionals. As you can see the VRF 2-pipe system comes out on top with 25 points. The multi split system comes in second, but as you can see it is not very compatible with large buildings that are multi use. Multiple units would have to be installed, as a multi split can only connect to 8 branch control units which makes it not so compatible and could actually increase the cost by having to have multiple main systems running, spacing could also be an issue. Also, maintenance costs would be increased due to more units. The VRF 3-pipe system comes in third but is compatible with the building's uses so would be considered. An AHU (Air Handling Unit) was considered for the building. This has similar benefits to

the VRF system, but after various conversations with M & E professionals it was highlighted the VRF has superior control functions which will make the VRF more compatible with the multi-use building. (Porges, 2020) (Mitsubishi Electric Corporation, 2021) (Mitsubishi Electric, 2015) (Brumbaugh, 2004) (BPC Ventilation, 2019)

Please see Figures 2.1, 2.2 and 2.3 for typical Unit layout and Multi zoned control technical drawings. As well as figure 2.5 for electrical and HVAC services distribution to each floor.

3.0 Energy use Provisions, Natural and Artificial Lighting, Emergency Lighting and Power Systems Implemented within the Building.

Commercial buildings today are increasingly airtight and have more heat generated office appliances and lighting, this creates a problem when trying to maintain a stable and comfortable internal environment. Buildings account for around half of the UK greenhouse emissions and the government and legislation are demanding higher standards of air quality and an increase in energy efficiency. Part L of the Building Regulations aims to reduce CO2 emissions from new builds by an average of 9% when compared with the 2010 standards. Part F of the Building Regulations is primarily focused on mechanical ventilation systems and indoor air quality. In this document the minimum ventilation rates are advised to be an air supply rate of 10 litres/second/per person which is the minimum for commercial offices. This is easily achieved just by the implementation of the HVAC system, but we must also look at natural ventilation which can reduce the use of artificial ventilation, some money and energy throughout the building's life. The BS 5925: code of practice for ventilation principles and designing for natural ventilation

Following an updated minimum energy efficiency standard which was introduced in April 2018, for a landlord to grant a new lease agreement the property must have an Energy Performance Certificate rating E or above unless an exception applies. From April 2023 a landlord will not be able to let their commercial property if it does not have an Energy Performance Certificate E or above. (Energy Efficiency and Commercial Leases, 2017) (Thomson & bancks LLP, 2021) (Crown, 2014)

LED bulbs will be the primary source of illumination used throughout the building. The LED lighting will help in achieving a reduction in carbon footprint and achieving a more energy efficient building. LED lighting is estimated to be 80% more efficient and last up to 10 times longer than fluorescent lighting. This has multiple benefits for the building owner and tenants with a reduction in overheads as well as actively achieving a sustainable and energy efficient lighting solution being two of the many benefits. Lighting approximately accounts for 50% of a commercial building's electrical usage. This is a very large portion and needs to be controlled and as efficient as possible. Efficient lighting controls will be implemented throughout the building, this will allow each individual office, shop, corridor and apartment to control their own lighting to suit their required needs. A BMS system will have control over the lighting and adjust the lighting throughout the day to counteract the lighting outside and create a comfortable environment for all users inside the building. Although the lighting will be controlled through an automatic system, each individual room, office or shop will be able to override the system and adjust the lighting in their premises to suit their needs. These controls will be installed on the walls as touch pads that will need a login and password to gain access. Within the BMS lighting system you can easily access the performance of your lights, your energy usage per section of the building and see if there are any faults. As a building owner this is a very useful system not just for the control and monitoring benefits but the energy bills can be easily split into each individual room/usage at the end of the week/month. Each store, office or apartment will be able to have their own bill and can monitor their energy usage, leaving no work for the owner or tenants to do other than pay their bills. The artificial lighting will be installed via linear systems, ceiling recessed, surface mounted, projected and free standing. (Remark Group, 2021) (Commercial lighting, 2021) (Lighting Styles, 2021) (Phillips, 2000)

Natural lighting will be maximised within the buildings from the design of the windows. The South facing façade will have larger/more windows as the sun rises to the South as this is where most of the light throughout the day will shine. By doing this more natural lighting will be on the building, so the use of artificial lighting during the daytime is reduced significantly. The design of the floor plan will have the office spaces and retail shops near to the South facing windows with store cupboards and other less used rooms to the back, this will prioritise where the natural light is to be distributed and overall reduce artificial usage. As well as maximising the window size other methods will be used internally such as including using shiny surfaces and light-coloured floors and walls which will take advantage of the sunlight and make the offices/retail areas appear more brighter than they actually are. The office spaces will use mainly glass partition walls or have an open space plan, this will help the natural light shine throughout the office floors and maximise the range in which the lighting can reach as the glass

partitions take up less space within the office and are easily installed and demounted. (Dillmeier Glass Company, 2021) (Phillips, 2000)

Emergency lighting will be essential for the multi-use building as if there was to be a power cut or loss of electricity, it would be important to be able to direct people safely out of the building via emergency lighting. Under the BS 5266-1:2016 Emergency lighting – Part 1: Code of practice for the emergency lighting of premises, this part of the British Standards gives recommendations and appropriate guidance on the provision and operation of emergency lighting in most commercial premises. The other standards followed within the design of the building are the BS EN 1838: 2013 lighting applications – emergency lighting, the BS EN 60598-2-22: 2014 luminaires for emergency lighting and the BS EN 62034: 2012 Automatic test systems for battery-powered emergency escape lighting. Emergency lighting should be provided at all common escape routes and fire exits to enable a person to see and be able to escape the premises. Emergency lighting will need to be provided for every floor of the building including the basement. In the retail section of the building considerations should be made to install the lighting luminaires below the design base of the smoke layer. There are two main types of emergency lighting, these are maintained and non-maintained. The maintained system incorporates a battery that is charged directly from the mains lighting supply. In a non-maintained system, a back-up power supply is incorporated which is completely independent from the mains supply. The maintained system will typically last for 1 hour whilst the non-maintained system will last for 3 hours. The maintained system will mainly be used above fire exit doors whilst the non-maintained will be used in corridors, shops, offices and common areas. To comply with the BS 5266: Part 1 a horizontal illuminance installed at floor level at an escape route should not be less than 0.2 lux. Escape routes of up to 2m wide require 50% of the route to be lit to a minimum of 0.1 lux. Each car park, plant room, shop, common area, office and apartment will have sufficient emergency lighting installed to comply with the BS 5266 to ensure a safe exit is provided if an emergency was to happen within the building. Once the emergency lighting is fitted a completion certificate from the supplier will be obtained. (Eden Council, 2021) (CIBSE Journal, 2021) (Chappell-Smith, 2021) (Watts, 2006)

4.0 The building fabric and potential equipment choices for the design and installation practice within the context of sustainable futures, low carbon/low energy cost savings.

4.1 Natural ventilation – Natural ventilation can be implemented through smart windows which can be run through a building management system. This system has a pc-server installed where all the information is gathered from the windows. This monitors all windows and any adjustments can be made from this server. A climate control touch screen pad can be fitted on the wall to give tenants access to the data, indoor and outdoor climate as well as energy savings and usage can be displayed on the screen. A main weather station installed outside of the building will collect data regarding the climate, humidity, temperature, wind speed and direction. Actuators are installed to each window and can be controlled individually or sectioned for the different uses of the building, for example one office floor will have complete control of their own windows, the retail stores will also have this benefit and be able to control the windows within their own store. Each room office/shop will have a sensor which measures the temperature, CO₂ and humidity levels to ensure regular data is collected and monitored. A control system is installed to override the preset climate controls in each separate office, store or apartment, this is in the form of a keypad which can be installed on a wall. The override system will allow the user to open and close windows if they feel the preset climate controls are not comfortable for them. As well as smart window technologies other inlets such as louvres, air bricks, canopies and inlet channels will be utilised.

The ventilation opening will predominantly be faced towards West Gate Street, this is where the most predominate winds will come from, and where the most uses of natural ventilation can be sourced from.

4.2 Sun screening is a feature which comes with the smart windows, these provide cost effective shading. These windows are suitable for large scale commercial buildings. The sun screening will direct the sun to the windows in the winter when heat is needed and reflect the sun away in the summer to avoid overheating and glare. This creates a good option for natural ventilation, as each separate section of the building can control their own windows and set different controls/settings depending on their own needs, as well as providing a good solution for dealing with when to use natural sun light and when not to. A contract with Window Master has been agreed for them to install all windows, controls and monitors with a lifetime guarantee.

(AtomicMedia, 2019) (Window Master, 2021) (WindowMaster, 2021) (Contrasol Ltd, n.d.) (Reynaers, 2021) (Ventive, 2020) (Hall, 2008)

4.3 Passive Design - Passive systems can be implemented into the building, this will help reduce the massive energy use the HVAC system will need to operate the large multi-use building. From the design stage air tightness, balanced energy ventilation as well as energy recovery ventilation, smart construction around key abutment areas to stop as much thermal bridging as possible, high performance insulation installed all around the buildings envelop for continuous insulation, high performance triple glazed windows and doors that will provide the building with thermal comfort as well as being durable and solar shading to maximise the heat from the sun when needed and deflect the sun when not need. All these passive options will contribute in reducing, CO2 emissions and energy use within the building helping create a more sustainable and energy efficient building. Some other key passive systems implemented will be additional ventilation inlets to maximise the natural air outside and reduce the use of artificial, these can be openings in the building, air bricks or through louvres and windows. The large south facing windows will take advantage of the natural sun light and provide heating to the building. (Auros Group, 2020) (Climate Colab, 2014) (Bere, 2013) (Hall, 2008)

4.4 Energy Saving Controls – These controls will have a big impact in reducing energy use, they will be able to monitor each rooms use and turn off automatically if the room or area is not in use. They will also be able to control separate areas, if one person at a desk wants their lights brighter, they can do so whilst not tampering with anyone else's controls. This allows each individual to have control over their own lighting needs, this system will also be pre-set to turn off lights at a set time in the offices and shops as relying on people to switch off all the lights at the end of a day does not always work. This will maximise energy efficiency within the building as well as enhance comfort levels and boost productivity, many studies have shown sufficient and effective lighting has boosted productivity within the workspace. The control systems can also be used for the heating, ventilating and air conditioning, this will provide a consistent climate and not use more energy than need, when manually controlled people tend to increase the heating to much then have to use the air con to cool down. The controls can be scheduled to pre heat and area before use or even turn off all heating at a certain time once everyone has left. The energy control can be integrated with other systems easily which gives a very flexible option of a system was to be changed or new additional smart technologies are installed within the building. Furthermore the controls can prevent down time of the systems within the building, alerts will be sent to the main control system if there are any issues or if the machinery requires maintenance, this will result in quicker fixes of machinery and less down time, each section of the building will be able to monitor their energy usage throughout the week and have a data analysis provided. All these benefits will help reduce energy usage and CO2 emissions within the building. (Rosone, 2016) (Thorlux Lighting, 2021) (MS Electronics Ltd, 2021) (Chappell-Smith, 2021)

4.5 Internet of Things – The IOT can be crucial for the multi-use building. Connectivity will be a massive element especially for the users, businesses need connectivity to run as well as the people using the apartments would require connectivity and internet. If the connectivity is not right, it can be hard to rent out the spaces to shops and businesses as well as many complaints from tenants in the apartments. Controlling data, undertaking analytics and diagnostics as well as managing each separate use of the building are things that will not be able to run efficiently if the connectivity is not right. Knowing this a professional company has been appointed to run all data points and systems through the building to ensure connectivity is at its highest and most efficient throughout each floor. The IOT will also allow the building to become smarter and let each individual control their working environment, this will include lighting, heating, ventilation and air-conditioning controls. Utilising the IOT in the correct way will reduce energy consumption and CO2 emissions, improve building efficiency, predict maintenance or issues within mechanical systems, increase productivity and reduce down time as well as provide data to show usage of resources so better distribution can be adopted. (InfraRed Intergrated Systems Ltd, 2019) (Desinging Buildings Ltd, 2020) (Springwise Intelligence Ltd, 2018) (GSM Association, 2014) (Royal academy of engineering and PETRAS, n.d.)

4.6 Thermal mass – The thermal characteristics of the building should be designed to moderate the external environment and maintain the internal environment without using much energy and expensive materials. Thermal mass is achieved by implementing thermal insulation and passive building services systems. Materials and systems should store high thermal loads by absorbing heat which has been introduced from outside of the building, these types of external heat come from solar radiation as well as internal appliances, lights and monitors etc, these should also be able to store and release heat. Examples of thermal mass are concrete floor slabs which can absorb heat gains during the day and then ventilate outside during the night which then allows for more heat to be absorbed then next day. (Ministry of Business, Innovation and Employment, n.d.) (Designing Buildings Ltd, 2020)

4.7 Air curtains – These will be implemented at the main entrance of the building as well as most of the retail shops. This will keep a comfortable climate at the entrance for customers as the natural convections will be disrupted, on hot and cold days the air curtains can keep the indoor climate near the entrance comfortable and

consistent. The air curtains will reduce energy costs by preventing the inflow of external air and preventing the internal air from escaping, this will reduce the need for additional heating if the building gets too cold from the external climate getting in. Any insects, pollen, dust and fumes from traffic can be restricted and won't get into the building through the installation of air curtains. These curtains will allow the entrance doors to stay open constantly in business hours making it an approachable building as well as reducing the amount of opening and closing doors. (Schwank, 2021) (Airtechnics, 2021) (Condair Group, 2020)

4.8 Solar Panels – These panels can be fixed and fitted to the roof of the building and pitched to face where the most sunlight will come from. Solar panels will provide a renewable energy source as we can never run out of solar energy. Electricity bills can be reduced dependent on how much solar energy the panels have absorbed, as well as this if the solar panels have surpassed the electricity bill the surplus energy can be sold on through the smart export guarantee. The energy generated can be used for photovoltaics/electricity or heat/solar thermal. Solar panels don't tend to need much maintenance they just need to be kept clean to optimize solar gains, many companies offer yearly cleaning of solar panels for around 30 pounds. The downsides of solar panels will include initial cost, the panels do cost a fair amount to install and due to the size of the building covering the roof would cost a lot, they are also weather dependent, this means in the winter months when there is not so much sun the benefits of the solar panels can seem very small. Overall solar panels are a good investment and provide sustainability as well as cost savings over time. Some will argue solar panels can create pollution due to transportation of the product and installation, this has been dealt with as a local company will be employed to fit and install the solar panels, keeping transportation to a minimum. (Vourvoulias, 2021) (Energy Saving Trust, 2021) (Solar Shop, 2020)

5.0 Appendix

Figure 2.1

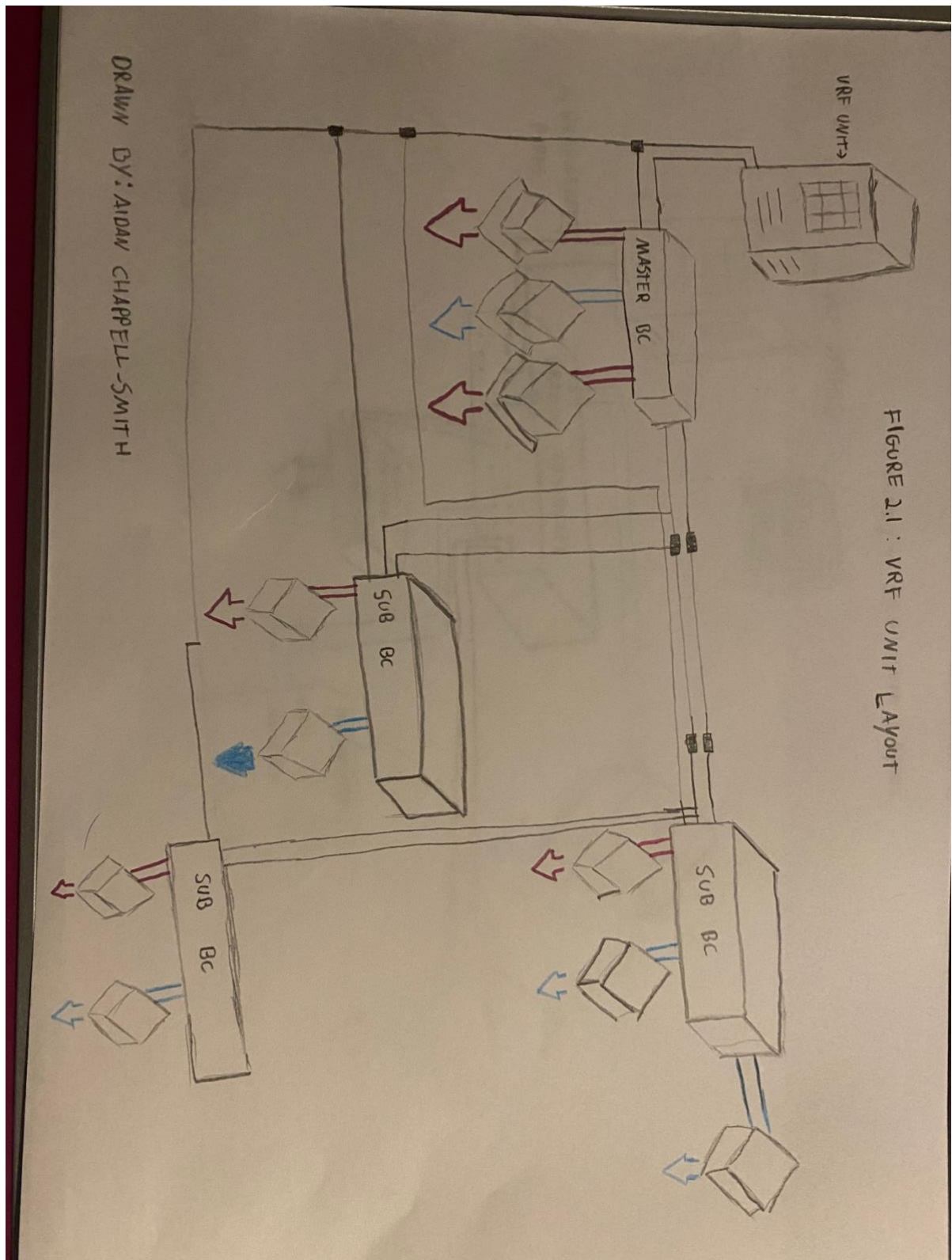


Figure 2.2

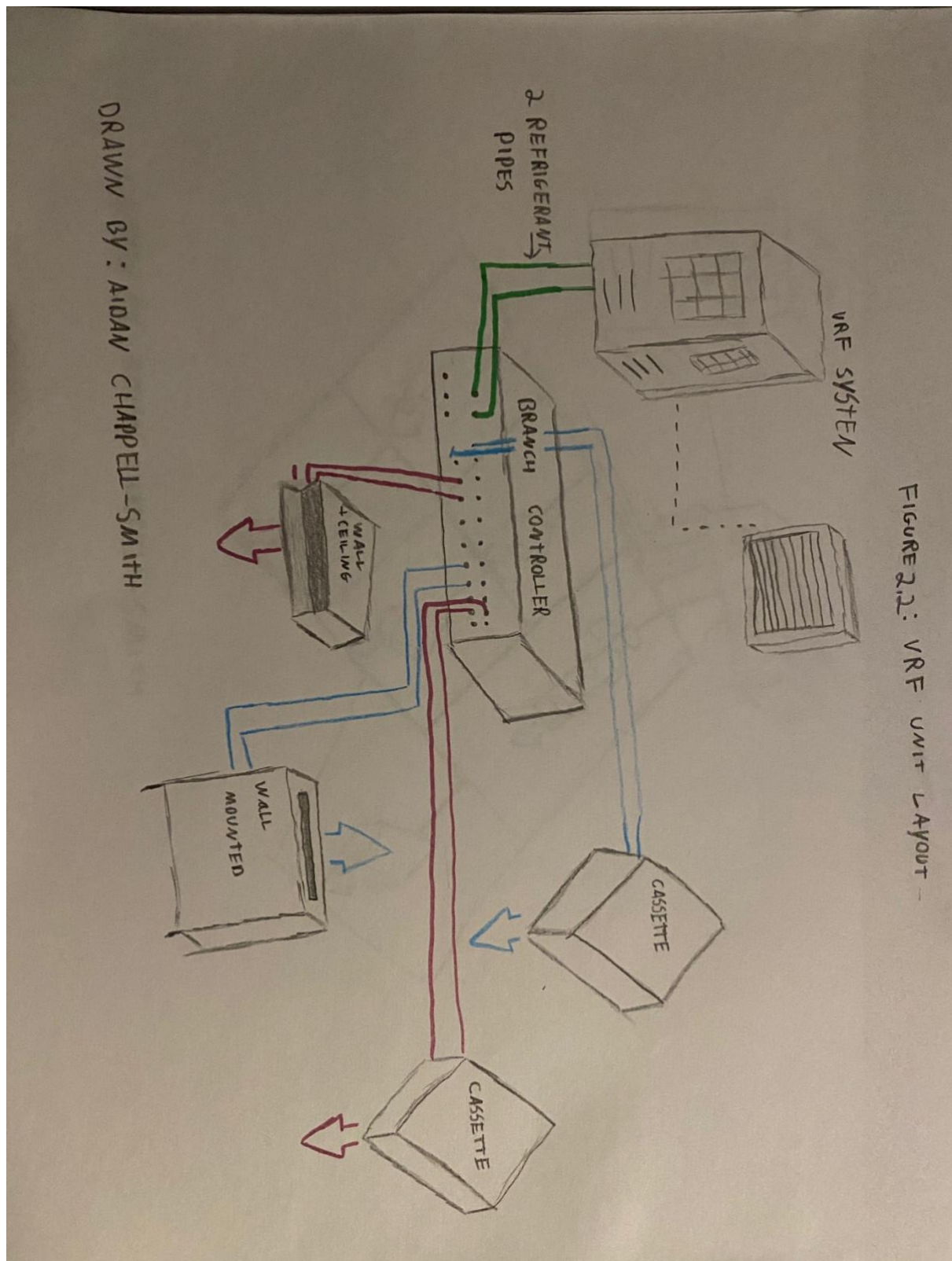


Figure 2.3

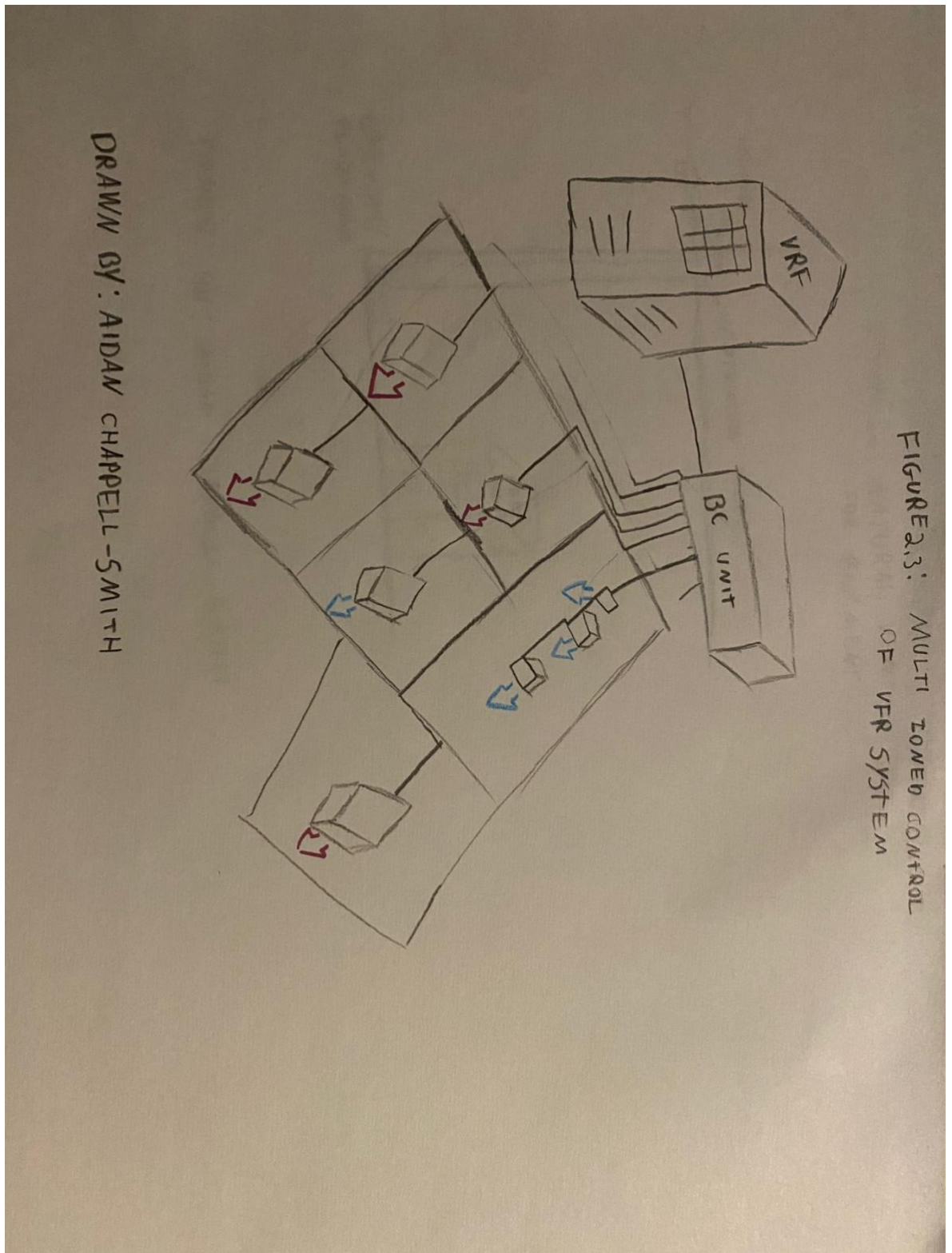


Figure 2.4

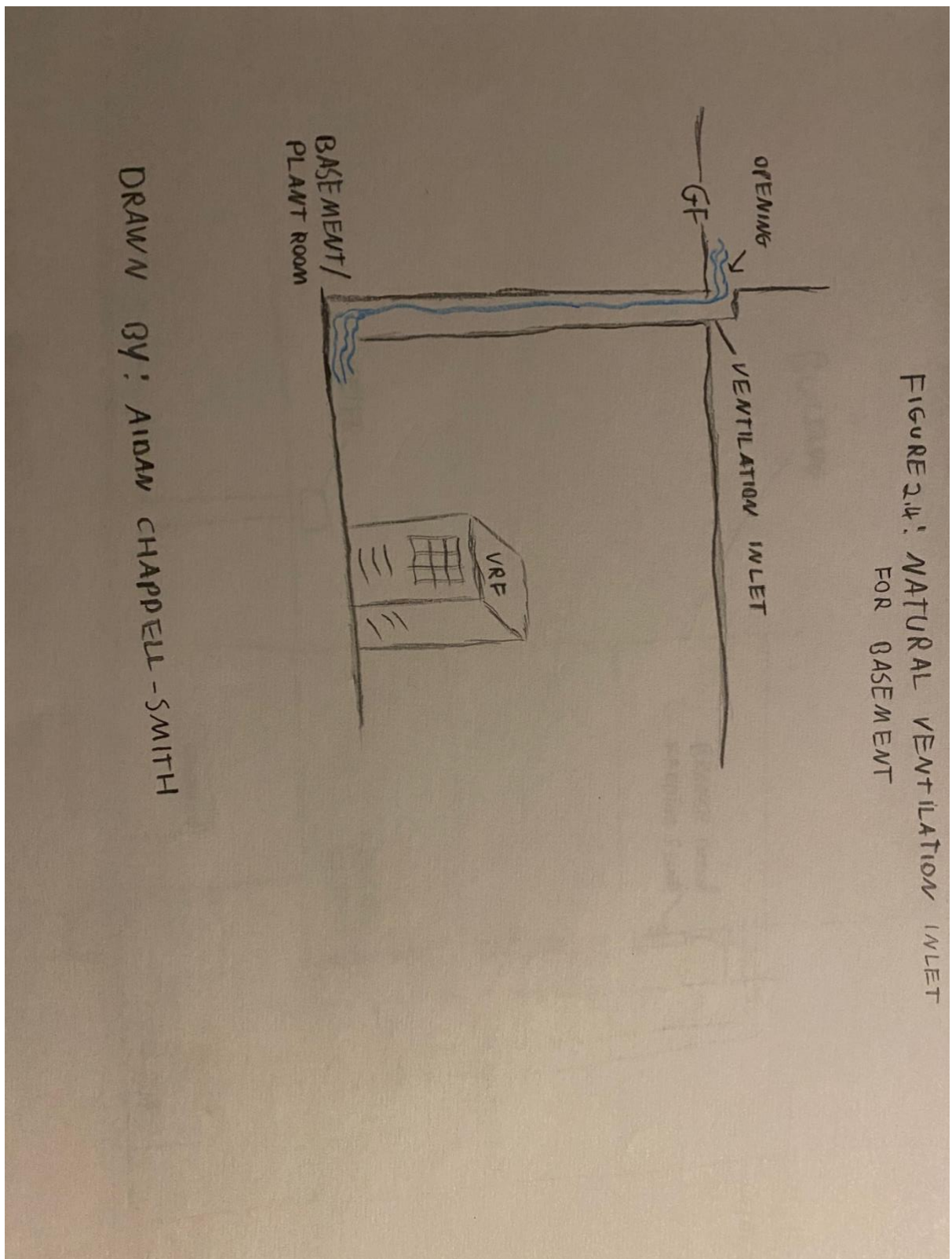
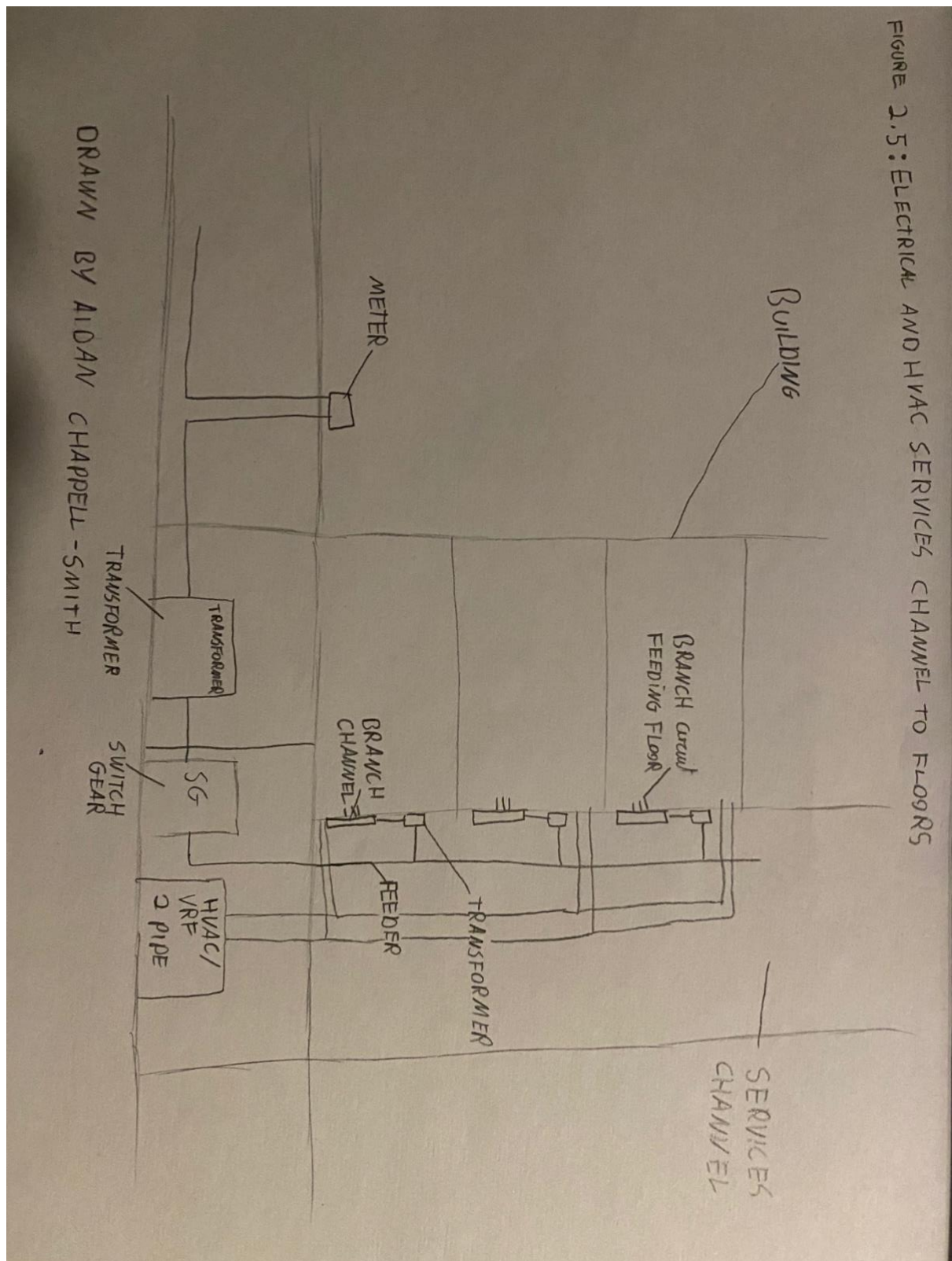


Figure 2.5



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