The Design

on

Steam Heating and Air Conditioning

of

NATIONAL HOSPITAL OF ALEPPO

by

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CONTENT

Intorduction:

It is well in beginning the thesis to write something about the history of the system of heating I am going to design.

Heating and Air Conditioning has grown to be one of the important industries. We may properly term it domestic engineering, as on the work of the heating and ventilating engineer depends largely the health and consequently the happiness of the great body of civilized people of the world.

Now referring to the design, I have to say something about the development of the steam heating system. Steam was probably first used for heating purposes in the early part of the ninteenth century, when efforts were made to heat a factory by steam at a high pressure. The development of steam heating from that date to the present time has been both rapid and constant, although the last decade has seen this industry advanced to a state of perfection never dreamed of by the early heating engineers. From a loose and haphazard method of figuring and installing work of this character, it has reached a scientific stage and as such is more or less understood by a large majority of those engaged in the business.

The early method of heating by steam was with the two pipe system, small sizes of pipe being used and a high pressure of steam maintained;as our knowledge of steam heating increased larger piping and a lower pressure were made use of.

At the present time there are many buildings such as factories and offices, or commercial buildings, where a medium or comparatively high pressure is used, the steam being generated at high pressure by the boiler and reduced for use in heating system. Usually the water of condensation is returned to the boiler by retrun steam traps or by pump.

The advantage of steam heating over other systems are: (1) there is less liability of damage by frost; (2) smaller radiators and piping are used, hence more economical regarding first cost; (3) rooms are more quickly warmed and cooled and (4) where a system of ventilation is used, the air is more quickly purified.

Also by the use of automatic dampor regulators safety valves etc. the danger of explosion has been practically eliminated, so that now steam may be used with as great a degree of safety as any other system.

While designing the steam system one should take in mind the following consideration. In the first place, the heating engineer must entertain no idea that the piping of steam works has any relationship to that of a hot water apparatus. Both may consist of lines of pipes and in most cases there has to be a kind of circulation established; but beyond this, to associate hot water practices with those of steam work must only end in confusion and failure. This is mentioned as the idea that the two bear a resemblance to each other is not a rare one.

With many there prevails an impression that steam heating is very simple, owing to the fact that steam can be made to readily pass through pipes, and in this respect the impression may be a correct one. With any method of heating by steam there are two difficulties to be overcome, and it might almost be said that the skill required by the engineer lies in dealing with these, One, the chief one, lies in disposing of the condensed water; the other in defeating the ill effect that air in the apparatus can produce. In affording heat by steam the chief result, other than obtaining heat is the condensation of the steam into water; for only by this means can the heat distributing surfaces - pipe or radiators- in any modern form of apparatus be kept supplied with new steam. A radiator, for instance, when doing its work is perpetually losing heat, with a consequent return to water of some of the steam with in it. This causes a state of vacuum to occur, which is as quickly filled by new steam flowing in it is a comparatively easy matter to get this action of steam supply to occur, but before it will happen all air must be driven out of the apparatus and the resulting condensed water must not only be disposed of, but it must be prevented from interferring with the steam supply.

Another natural phenomenon that the steam-heating engineer relies on is the fact that water has its volume increased 1640 times (varying somewhat according to pressure) when converted into steam. This enables him to fill an extensive system of pipes etc. with steam without causing a serious drop of the water line in his boiler.

Still another natural and highly important phenomenon is the latent heat of steam. The term "latent" meaning hidden, is a correct one, for although a pound of water at 212°F will still register a temperature of 212° when converted to steam, it will have taken up no less than 966 units of heat in the change. It only takes 212 units to heat a pound from 0° to 212° theoretically, so that when this weight of water is converted to steam it has absorbed sufficient heat to raise about five times its weight from say, freezing to boiling. In other words a pound of steam, at 212° carries 966 units plus 212 which it has received as water to reach boiling point, making together a total of 1178 units. Of these, as will be understood, it has 966 to give out from the heat-distributing radiators, or pipes, before it assume the form of water again.

As already stated, condensed water can give considerable trouble if it is not properly disposed of either by retarding the flow of steam, blocking the steam from its work, or coming in conflict with it. On this account the covering of steam mains to prevent loss of heat- chiefly to prevent the occurence of water in them- is very important, and it is desirable also from the fact that cooled steam means steam and heat completely lost. With hot water mains a little loss of heat, wasteful as it may be may scarcely show at the radiators, buth with steam it means the disappearance of a certain proportion of the heating power.

A remaining detail that may be mentioned here relates to the practical use of steam in the apparatus. When a radiator, or coil of pipes, is connected on the one pipe system, the branch, as will be learned directly is a single pipe, and this has the customary stop valve where it joins the radiator. With the two pipe system each radiator has as pair of branch pipes and each pipe has a stop valve, so that every radiator with this system has a valve at each end. The reason for thus putting two valves and the same reason applies with the single valve in the one pipe branch- is that when it si required to shut of steam from a radiator it must be completely

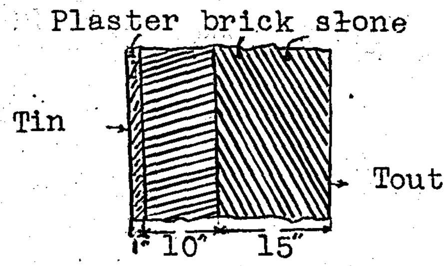
Through this one pipe and valve steam has to pass the radiator in one direction and condensing water has to come back through the other way. These two contrary movements will readily come into conflict, with bad results, if they are allowed to , and it is only prevented by having the pipe and valve of a recognized sufficient size. Thus if a 1 1/4 inch pipe is considered correct then the valve must be 1 1/4 inch also, and it must clear open way through it of this size. If the valve is partially closed with the idea of regulating the steam supply and the heat of the radiator, all the condition of using too small a valve are immediately obtained. On this account the valve must always be wide open or tightly closed.

Similarly with a radiator connected on two pipe system, it will be found, however, that on partially closing the steam supply valve the balance of pressure between the two branches will be disturbed, and the result will be a rise of water up the return pipe.

2,

the conductivity of the material

wall construction



K for brick = 5.0

" plaster = 3.3

" stone = 12.5

fi = 1.9

fi is a constant which represents the surface conductance. The over all transmission coefficient for the wall then would be:

$$u = \frac{1}{\frac{2}{fi} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3}}$$

where x is the thickness of the wall.

$$u = \frac{1}{\frac{2}{1.9} + \frac{10}{5} + \frac{15}{12.5} + \frac{1}{3.3}} = 0.218 \text{ BTU/hr/}^{\circ}\text{F/ft}^2$$

u for glass = 1.13

u for the floor (concrete floor against earth)

= 1.07 (heating and Air conditioning by Allen and Walker table 10)

u for the roof (Allen and Walker) = 0.35

u for the doors (hard wood) = 0.5

Outline and Data assumed:

Infiltration:

Allen and Walker Book P. 33 gives a table of air changes for different kinds of room.

The following values have been obtained from that table:

Kind of Room	The changes per hour
Rooms wind or 1 or 2 sides	1 1/2
Entrance Halls	3
small stores	3
waiting rooms	2

The coldest outside temperature is assumed to be 32°F. The inside temperature for different rooms as given by Allen and Walker P. 37

70°F for living rooms and 65°F for stores

At the same time G.A.T. Middleton P. 103 gives a table of required temperature:

55°F for bedroom and places of employment.

70°F for bath-rooms

60°F for living rooms and offices.

As a result I chose temperature in between. So throughout the design 65° was considered a comfortable temperature for living rooms and waiting rooms, 60°F for bed rooms, and 70° for bath-rooms.

The hospital I am designing is assumed to be at Aleppo, Syria, where the temperature during winter time is almost about 32°F.

Also throughout the design I had to do assumption due to lacking of data concerning the material of the building. In the case of exposure I assumed 5 - 10 % on the amount of heat loss according to the situation of the room and its size.

Sample of calculation:

Heat loss:

The drawing scale is 2.7' = 1 cm

The hight of the building is :

Basement	= 9 1/2 ft.
Ground floor	= 11.6'
First floor	= 13.6'
Second floor	= 13.0'
Third floor	= 12.0'

Servant Hall (Basement)

Wall area :	16.2 x 9 1/2	= 154
	21.6 x 9 1/2	= 205
(Gross wall area)		359 sq.ft.
2 windows at 6 3/4 x 3 1/2		= 47.4 sq.ft.
net wall area		311.6 sq.ft.

Floor area = 16.2 x 21.6 = 350 sq.ft.

Volume = 350 x 9.5 = 3320 cu.ft.

Loss through wall:

$H = A \times u \times (t_{in} - t_{out})$

$= 311.6 \times .218 \times (65 - 32)$

$= 2240$ B.T.U /hr.

Loss through window:

$H = A\,U\,(t_{in} - t_{out})$

$= 47.40 \times 1.13 \times (65 - 32)$

$= 1690$ B.T.U./hr.

Loss through floor:

$H = A\,U\,(t_{in} - t_{out})$

$= 350 \times 1.07 \times 20$

$= 7500$ B.T.U./hr.

Infiltration loss:

$H = \dfrac{v \times N \times \Delta t}{55.2}$

v = volume cu.ft?

N = Number of air changes/hr.

$\Delta t = (t_{in} - t_{out})$

$= \dfrac{3320 \times 3 \times 33}{55.2}$

$= 5950$ B.T.U./hr.

Total loss -

$= 2240 + 7500 + 1690 + 5950$

$= 17,380$ B.T.U/hr.

Assume 5 % loss due to exposure, then

Total loss = 17380 x 1.05 = 18200 BTU/hr.

Infirmary: (thrid floor)

Exposed wall : 17.5 x 12 = 210 ft^2 (Gross)

2 windows at 3 1/2 x 5 = 35 ft^2

net wall area 175 ft^2

Ceiling area = 17.5 x 10.7 = 187 ft^2

Volume = 187 x 12 = 2240 cu.ft.

Loss through wall = 175 x .218 x 33

= 1250 B.T.U./hr.

" through windows = 35 x 1.13 x 33

= 1300 B.T.U/hr

" " ceiling = 187 x .32 x (70-32)

= 2280 B.T.U./hr.

Infiltration: $= \frac{2240 \times 2 \times 33}{55.2} =$

= 2680 B.T.U./hr.

Total Loss plus 10% exp.:

= 7510 x 1.10 =

8250 B.T.U./hr.

I especially took the sample of calculation from the Basement in order to include the gound and the ceiling, for in the rest the ~~gound~~ floor and ceiling should not be considered.

<u>Area of the Basement:</u>

Room	Gross Wall area ft^2	Number and area of windows ft^2	Net wall area ft^2	floor area ft^2	Volume ft^3	Door area ft^2
Post.	444	3 = 71	373	190	1810	32
Wash House	282	2 = 47.4	234.6	253	2400	--
Store No.1	76	--	76	86.5	820	--
Store No.2	257	--	257	153	1450	--
Bath	101.5	--	101.5	87.6	822	--
Kitchen	359	2 = 47.4	311.6	350	3320	--
Large Hall and corridors	--	--	--	957	9100	--
Scullers	128	2 = 47.4	45	189	1800	36
Servant Hall	359	2 = 47.4	311.6	350	3320	--
Bed room	256	1 = 24	232	182	1725	--
Ladder Space	128	--	128	73	694	--
Dormitory	524	4 = 95	429	358	3400	--
Linen	205	5 = 71	134	262	2490	

Heat Loss:

Room	Walls Loss	Windows and Door Loss	Floor Loss	Infiltration	Total Loss	Total and 5-10% exp.
Post.	2685	2640 791	4060	3250	13426	14800
Wash House	1690	1740	5400	2890	11700	12900
Store No.1	546	--	1850	1465	3861	3861
Store No.2	1850	--	3280	2600	7730	7730
Bath	845	--	2340	565	3750	3750
Kitchen	2240	1690	7500	5950	17380	19100
Large Hall and corridors	--	--	20500	16300	36800	36800
Scullers	325	1690 594	4050	2150	8810	9250
Servant Hall	2240	1690	7500	5950	17380	18200
Bedroom	1565	716	3890	885	7056	7056
Ladder Space	920	845	157	1240	3162	3162
Dormitory	3200	3000	7660	2600	16460	18100
Linen	965	2640	5620	2980	12205	13400

Area of the ground floor:

Room	Gross Wall area ft^2	Number and area of windos ft^2	Net wall area ft^2	Door area ~~32~~	Volume ft^3
Vestibule	343	2 = 59.5	283.5	51	405
Entrence Hall	--	--	--	--	1525
Surgeons sitting room	124	1 = 30	94	--	2020
Surgeons bed room	299	2 = 59.5	239.5	--	2095
Board room	448	3 = 82	366	--	4160
Secretary room	310	2 = 42.1	267.3	--	2100
Hall	124	2 = 59.5	69.5	--	4600
Porters bedroom	115	1 = 30	85	--	1240
Porter	115	1 = 3	85	--	735
Corridor	--	--	--	--	4320
Operatin Room	--	2 = 59.5	--	--	2660
Accident and sur-geon	445	4 = 119	324	--	4300
Registrar	78	1 = 30	48	--	900
Surgeon	165	59.5	105.5	--	1985

Dressing room	62	30	32	--	745
Waiting room	258	3 = 89	179	54	5630
N.Part	263	--	263	21.2	1840
Physician	331	2 = 89	242	--	2240
Dispensary	150	--	150	--	1200

Heat Loss of the gound floor:

Room	Loss through wall B.T.U.	through window B.T.U.	Door loss B.T.U.	Infiltration B.T.U.	Total Loss B.T.U.	Total 5% to 10 % B.T.U.
Vestibule	2400	2170	940	845	6355	7000
Entrance Hall	--	--	--	2800	2800	2800
Surgeon sitting room	675	1120	--	1820	3615	4000
Surgeon bed room	1460	1885	--	1600	4945	5400
Board Room	3200	3250	--	3730	10180	11020
Secretary room	1930	1590	--	1880	5400	6000
Hall	463	2220	--	8240	10923	10923
Porters bed room	610	1120	--	1110	2840	3160
Porter	610	1120	--	1320	3050	3200
Corridor	--	--	--	7800	7800	7800
Operating room	--	2220	--	3180	5420	5420
Accident and surgeon	2330	4450	--	3850	10630	11700

Room	Loss through wall BTU	through window BTU	Door loss BTU	Infiltration BTU	Total Loss	Total 5% to 10%
Registrar	346	1120	--	805	2271	2500
Surgeon room	760	2220	--	1780	4760	5250
Dressing room	23	1110	--	665	1798	2002
Waiting room	1290	3320	890	10100	15600	17100
N.Part	1890	--	350	3300	5540	6000
Physician	1745	3320	--	2000	7065	7800
Dispensary	1080	--	--	1075	2155	2370

Area of the First floor:

Room	Gross wall area ft^2	Number and area of window ft^2	Net wall area ft^2	Door area ft^2	Volume ft^3
Men's ward No.1	2250	12 = 356	1894	--	20800
Bath room No.1	708	5 = 81	627	--	2410
Corridors	872	7 = 157	715	--	6720
Duty room	516	2 = 59	457	--	2410
Single wards	145	1.5 = 45	100	--	1880
Men's ward No.2	845	6 = 178	667	--	6550
Bath room No.2	645	4 = 68	566	--	1950

Heat Loss of the 1st floor:

Room	Walls Loss BTU	Window Loss BTU	Floor Loss BTU	Infiltration BTU	Total Loss BTU	Total 5%-10% exp.
Men's ward No.1	13600	13600	--	20485	47685	52500
Bath room No.1	5200	3480	--	3320	13200	13200
Corridors	5140	5850	--	12000	22990	25300
Duty Room	3290	2200	--	1970	7460	8200
Single wards	720	680	--	1680	3080	3390
Men's ward No.2	4800	6650	--	7850	19300	21200
Bath room No.2.	4860	3920	--	1480	8260	9100

Area of the 2nd Floor:

Room	Gross wall area ft^2	Number and area of windows ft^2	Net wall area ft^2	Ceiling area ft^2	Volume ft^3
Women's ward	832	7 = 208	624	--	13000
Double ward	415	3 = 89	326	--	3250
Single ward	315	3 = 89	224	--	1900
Bath room No.1	708	5 = 81	627	--	2410
Duty room	516	2 = 59	457	--	2410
Corridor No. 1	570	9 = 122.6	447	--	6350
Corridor No.2	--	--	--	292	3800
Bath room No.2	708	5 = 81	627	144	2410
Special wards No. 1 and 2	(145)2	3 = (90)1	100	276	1880
Isolation ward	541	4 = 119	422	355	4600

Heat Loss of the 2nd Floor:

Room	Walls Loss BTU	Window Loss BTU	Ceiling Loss BTU	Infiltration Loss BTU	Total Loss BTU	Total 5-10% exp. BTU
Women's ward	6000	7750	--	15500	29250	32125
Double ward	2950	3310	--	3000	9260	10200
Single ward	1610	3310	--	1700	6620	7300
Bath Room No.1	5200	3480	--	3320	13200	13200
Duty room	3290	2200	--	1970	7460	8200
Corridor No.1	3210	4560	--	11400	19170	21000
Corridor No.2	--	--	6000	6800	12800	12800
Bath room No.2	4860	3920	3470	1480	12570	12570
Special ward No. 1 and 2	1440	1360	5660	3360	12440	12440
Isolation ward	3040	4450	7300	4120	18910	20800

Area of the 3rd Floor:

Room	Gross wall area ft^2	~~Number and~~ area of window ft^2	Net wall area ft^2	Ceiling area ft^2	Volume ft^3
Sisters room	554	89	465	508	6100
Bathroom	317	46	271	168	2000
Infirmary	210	35	175	187	2240
Sitting room	338	555	282.5	187	2240
Dining room	negligible	35	--	187	2240
Sewing room	"	35	--	187	2240
Corridors	--	--	--	192	2310
Library ~~Chapel~~	980	87.5	892.5	607	7300

Heat Loss of the 3rd Floor:

Room	Wall Loss BTU	Window Loss BTU	Ceiling Loss BTU	Infiltration Loss BTU	Total Loss BTU	Total 5-10% exp. BTU
Sisters Room	2840	2820	5360	4150	15170	16650
Bathroom	2240	1980	2310	2750	9280	10200
Infirmary	1250	1300	2280	2680	7510	8250
Sitting room	2040	1950	2280	2000	8270	9100
Dining room	negligible	1300	2280	2000	5580	5580
Sewing room	2040	1950	2280	2000	8270	9100
Corridors	--	--	2320	4260	6580	6580
Library ~~Chapel~~	6420	3260	7820	10900	28400	31250

Total heat loss = ?

= 679 789 Btu/hr

≈ 700 000

Choosing the radiators:

Having found the H.S. required (by dividing the heat loss by 240). The windows are 3' above the floor, therefore if the radiators are to be located bellow the window - the best suitable place- then a height of 32" for the radiator would be convenient.

Page 73, table 15 of Allen and Walker Heating and Air conditioning gives the square feet of heating surface for different kinds of radiatiors. According to that table the radiator sizes have been computed. The length of each section is given to be 2 1/2" and the tapping 1 1/2" top and bottom.

The number of radiators and their number are shown in the drawing.

The total heating surface required for the whole building is:

Basement	= 700 sq.ft.
Ground Floor	= 506 sq.ft.
Ist Floor	= 596 " "
2nd "	= 680 " "
3rd "	= 403 " "
Total	2885 Sq.ft.

Table showing Sizes of Radiators:

(Refer to final Drawing)

Basement

Rad.No. (ref. to drawing)	H.S.	Height	Tube No.	Sec.	Length	Tapping Supply	Tapping Return
1	60	32"	6	12	30	1	3/4"
2	55	32	6	11	27$\frac{1}{2}$	1	
3	17 1/2	32	4	5	12 1/2	1	
4	39	32	5	9	22 1/2	1	
5	14	16	4	8	20	1	
6	39	32	5	9	22 1/2	1	
7	39	"	5	9	22 1/2	1	
8	39	"	5	9	22 1/2	1	
9	39	"	5	9	22 1/2	1	
10	39	"	5	9	22 1/2	1	
11	39	"	5	9	22 1/2	1	
12	17 1/2	"	4	5	12 1/2	1	
13	17 1/2	"	4	5	12 1/2		
14	39	"	5	9	22 1/2		
15	39	"	5	9	22 1/2		
16	55	"	6	11	27 1/2		
17	39	"	5	9	27 1/2		
Gr. Floor							
18	28	"	4	8	20		
19	14	16	4	8	20		
20	45	32	6	9	22 1/2		
21	24.6	"	4	7	17 1/2		
22	24.6	"	4	7	17 1/2		

23	24.6	"	4	7	17 1/2	1"	3/4"
24	31 1/2	"	4	9	22 1/2		
25	10.5	16	4	6	15		
26	21.6	32	5	5	12 1/2		
27	10.5	16	4	6	15		
28	10.5	16	4	6	15		
29	24.6	32	4	7	17 1/2		
30	30.5	"	4	9	22 1/2		
31	30.5	"	4	9	22 1/2		
32	14	16	4	8	20		
33	31 1/2	32	4	9	22 1/2		
34	24.6	"	4	7	17 1/2		
35	14	16	4	8	20		
36	45	32	6	9	22 1/2	1"	3/4"
37	17 1/2	32	4	5	17 1/2		
38	21.6	32	5	5	17 1/2		
1st Floor							
39	31 1/2	32	4	9	29 1/2		
40	31 1/2	32	4	9	22 1/2		
41	55	32	6	11	27 1/2		
42	38	32	4	11	27 1/2		
43	45	32	6	9	22 1/2		
44	45	32	6	9	22 1/2		
45	34 1/2	32	5	8	20		
46	55	32	6	11	27 1/2		

47	55	32	6	11	27 1/2	1"	3/4"
48	31 1/2	32	4	9	22 1/2		
49	34 1/2	32	5	8	20		
50	31 1/2	32	4	9	22 1/2		
51	14	32	4	4	10		
52	14	32	4	4	10		
53	14	32	4	4	10		
2nd Floor 54	49	32	4	12	30		
55	34 1/2	32	5	8	20		
56	34 1/2	32	5	8	20		
57	55	32	6	11	27 1/2		
58	52	32	5	12	30		
59	49	32	4	12	30		
60	52	32	5	12	30		
61	43 1/2	32	5	10	25		
62	30	32	6	6	15		
63	43 1/2	32	5	10	25		
64	34 1/2	32	5	8	20		
65	34 1/2	32	5	8	20		
66	34 1/2	32	5	8	20		
67	52	32	5	12	30		
68	52	32	5	12	30		
69	43 1/2	32	5	10	25		
3rd Floor 70	34 1/2	32	5	8	20		

71	43 1/2	32	5	10	25	1"	3/4"
72	43 1/2	32	6	10	25		
73	38 1/2	32	4	11	27 1/2		
74	43 1/2	32	5	10	25		
75	28	32	4	8	20		
76	43 1/2	32	5	10	25		
77	38 1/2	32	4	11	27 1/2		
78	24 1/2	32	4	7	17 1/2		
79	34 1/2	32	5	8	20		
80	34 1/2	32	5	8	20		

Calculation of Mains:

There are two main pipe leaving the boiler. They have length of 38 ft. and 220 ft. respectively. The short one has only 3 risers and supply steam for a total heating surface of 630 ft^2. The long one supplies heat for 13 risers of total heating surface of 2020 sq.ft?

Total heating surface connected to each riser:

Riser No.	Heating Surface	Riser No	Heating Surface
1	219	9	93
2	229	10	28
3	182	11	175
4	239	12	143
5	137	13	196
6	160	14	42
7	181	15	224
8	272	16	129

Here if the two mains were supplying steam for the same amount of heating surface, then the boiler would be load center and the pressure drop consequently would be equal for the two main. Unfortunately in this design the boiler room is located at one corner of the building, because the architect had to construct the hospital on a restrict land on which he could not give another shape, and as a result he did not take into consideration the heating problem at all.

However, one possibility of balancing the load was by making tunnels and thus passing the pipes from there, but this method would be too expensive, and as a result the conditions were taken as stated in the beginning.

By reference to formula 7 page 189 of heating and air conditioning by Allen and Walker a pressure drop of 1/4 lb. has been approximated for the short main and 3/4 lb. for the long main. The pressure drop of the short pipe per 10 ft. will be:

$$\frac{0.25 \times 10}{30} = .04$$

Referring then to the chart Fig. 117 Page 190 of the same book, we see that for a pressure drop of .04 lb/in^2 per 10 ft. of pipe and for a heating surface of 630 sq.ft. a pipe of 1 3/4 "say 2" is required, but this size is based on a pressure at the boiler of 2# gage. In this design less gage pressure is to be use (one lb), therefore a larger size would be safer say 2 1/2".

Similarly for the larger main the pipe size is found to be

$$\frac{0.75 \times 10}{220} = .034$$

H.S. = 2020 sq.ft. a pipe size of 2.8" is found from the figure say 3", but this size will not be the same through out, because the heating surface for which steam has to be applied by the main reduces as branches (r~~i~~vers) decreases in number.

Thus for main one after the branches one and two the heating surface to 182 sq.ft., and as a result the size of the main for the remaining section will be 1 1/4".

Also for main two after the T between section 7 and 8 the heating surface to be supplied reduces 1203 and the pipe size reduces to 2 1/2. In this way the rest of the pipe size is found out and tabulated in the following table. (The pipe size was always chosen to be the nearest larger size bacause the pressure of the boiler is lower than ~~No~~. 2# gage:

Main I

Section	H.S. supplied	Size of supply pipe inch	Size of return pipe inch
Boiler -riser 1 and 2	6 30	2 1/2	1 1/2
Riser 1 and 2-3	182	1 1/4	1

Main II

Section	HS supplied	Size of supply pipe	Size of return pipe
Boiler to T between 7 and 8	2020	3"	2"
Between 7 and 8 to risers	376	1 1/2"	1"
Between 7 and 8 to riser 8	1203	2 1/2"	1 1/2"
Section sup. Riser 10 and 11	203	1 1/2"	1"
Riser 8 to riser 13	734	2"	1 1/4"
Riser 13-15	395	1 1/2"	1"
Riser 15-16	129	1 1/4"	1"

The size of the return pipe is based on practical values obtained from designes of similar installation and from the table given on page 24 of Heating and air conditioning.

Calculation of the risers:

Assume a pressure drop of a 1 for the risers.

Riser No.	Heating Surface	Riser size inch	Retuer size inch
1	219	1 1/4"	3/4"
2	229	1 1/4"	3/4"
3	182	1"	3/4"
4	239	1 1/4"	3/4"
5	137	1 "	3/4"
6	160	1 "	3/4
7	180	1 "	3/4
8	272	1 1/4"	3/4
9	93	1 "	3/4
10	28	1 "	3/4
11	175	1 "	3/4
12	143	1 "	3/4
13	196	1 "	3/4
14	42	1 "	3/4
15	224	1 1/4"	3/4
16	129	1 "	3/4

Although the values of the risers diameter are obtained from the chart and are theoretically correct, it is always advisable to install some what larger sizes in practice than the values included, because there is a danger of the pipe being filled with sleet and dirt and thus decreases the inside diameter. Therefore the actual values given on the drawing are very slightly changed to suit the conditions in practice. These changes have been done according to table 16 on page 24 of Allen and Walker "Heating and air conditionning."

It should be noted that although the mains are covered with insulated material such as corrugated asbestos, magnesia, or rock wool, we still have values of heat transfer and figure 92 page 169 of the above mentioned book gives values for the coefficient for insulated pipe.

If an average value of 0.5 B.T.U/hr. per sq.ft.of pipe surface per ^{o}F difference between outside and inside temperature of pipe and air is assumed then we would have about 60 B.T.U per hr. per sq.ft. of pipe. This is not much but it will have an effect in the basement, in some rooms where long pipes pass through it, especially the corridor, the effect is quite appreciable.

Taking this into account for some of the rooms the heating surface the D.S. has been recalculated and a few section taken out from the radiators previously installed.

Selection of the Boilers:

Total heating surface = 2650 sq.ft. an allowance of 15% to 25% should be made to include the heating surface of the mains and risers.

The direct heating surface would be:

1.2 x 2650 = 3180 sq.ft.

From catalog. Boilers and radiators Na 1362

H.B Smith and Co.

Page 7. The Boiler

Number of section: 9

Nominal size : 34" x 48"

Fire heating surface: 247.5 sq.ft.

Steam rating : 3200

Nominal size of Fire pot: 34" x 48"

Total Length Boiler: 78"

Length of Fire Pot : 48"

Length of Foundation: 55"

Size of smoke Pipe opening: 12 1/8"x15 3/8 =

= 14 round.

Width at foundation: 36"

Width of boiler : 51"

Height of Boiler : 78"

Air Conditioning

The Split System - heating by radiator and fans used for ventilation only.

In quite a big number of mechanical systems,perhaps the majority, the heating of the building is done by radiator, and the fan system supplies air at room temperature. In such arrangement the fan system can be made use of to any degree described. In this design; the building is brought up to the temperature required by the radiator and the fans started then to heat the air and the rooms.

It was observed that the line of effective temperature at which the maximum number of people were most comfortable is 66°F for the winter comfort zone, and 71°F for the summer comfort zone, the air movement being 15-25 ft/minute.

The first step in the design of a fan-system is the calculation of the quantity of air to be handled and the amount of heat which must be imparted to it.

In the case of a fan system supplying air for ventilation only as in the "Split system" the heat which must be added to the air is that which is required to raise the temperature from the outside temperature(the minimum is considered) to the temperature of delivery to the rooms.

If Q is considered the total amount of out door air to be needed per hour, and H the amount of B.T.U.'s of heat which must be added to the air per hour then:

$$H = Q \quad D_2 \quad C_p \quad (t_2 - t_1)$$

D_2 = density of air at 68° in pounds

= 0.075 /Cu.ft.

cp = Specific heat of air at constant pressure = 0.2415

t_1 = temperature of outside air

t_2 = temperature of heated air to room temperature.

In this expression the heat absorbed by the water vapor is neglected but the formula is sufficiently accurate for ordinary purposes.

Quantities of Air Desirable for Ventilation:

Ward:	10-15	changes/hr.
Dining room :	12-20	changes /hr.
Ward robes-lockers:	5-10	" "
Bath room :	10-15	" "
Toilets :	10-15	" "

authority ?

Tal

Computation for the required air

Sample of calculation

Post room (Basement)

Volume $= 1810$ cu.ft.

$= 1810 \times 5 = 9100$ cu.ft.

Toilet and Bath $= 12 \times 822 = \underline{9900}$

Total 19000 cu.ft.

In this manner all the rooms were calculated, note that some of the rooms I did not consider for they do not need special ventilation, also I have to mention that half the air coming from the room is recirculated and that toilets and stores air was not used in the recirculation process.

The total amount of air required was found to be 926,500, and since we need to circulate only half of it say 500,00 cu.ft. of air then the amount of heat required is $H = Q\ D\ cp.\ (t_2 - t_1)$

$= 500{,}000 \times .075\ (68-32) = 1{,}380{,}000$ BTU/hr.

The size of air ducts were calculated by the help of the formula $Q = C\ A\ V$ assuming $v = 1100'/\text{min.}$

$C = 0.91$

Ground floor

surgeon room: $A = \frac{Q}{cv} = \frac{d^2}{4}$

$d = .01265\ Q$

$= .01265 \times 51{,}500$

$= 11''$

The volume of air and size of ducts and return were calculated and tabled together in the coming table:

Basement Floor

Room	Change/hr	Volume	cu.ft./hr	Duct riser in"	Size retun in"	Register
Post	5	1810	9100	5	5	7 1/2
Toilet and Bath	12	822	9900	5	5	7 1/2

Ground floor

Room	Change/hr	Volume	cu.ft./hr	Duct riser in"	Size retun in"	Register
Surgeons sitting Room.	5	2,020	10,100	5	5	7 1/2
Secretary R	8	2,010	16,080	6	6	9
Porters R.	5	1,240	6,200	4	4	6
Operating R.	12	2,660	32,000	8 1/2	8 1/2	13
Auc.and Surgeon R.	12	4,300	51,600	11	11	16 1/2
Registrar R.	8	900	7,200	4	4	6
Surgeon R.	8	1,985	15,750	6	6	9
Dressing R.	5	745	3,720	4	4	6
Waiting R.	10	5,630	56,300	11	11	16 1/2
Physician R.	10	2,240	22,400	7	7	10 1/2
Dispensary	10	1,200	12,000	6	6	9

First Floor

Room	Changes/hr.	Volume	cu.ft./hr.	Duct riser	Size return	Register
Men's Ward No. 1	10	20,800	208,000	21	21	32
Bath room No. 1	12	2,410	29,000	8	8	12
Duty Room	5	2,410	12,000	6	6	9
Single Ward 4 at	10	1,880	18,800	6 1/2	6 1/2	10
Men's Ward No.2	12	6,550	65,500	13	13	14 1/2
		1,950	23,400	7 1/2	7 1/2	11
Second Floor						
Women's Ward No.1	10	13,000	130,000	17	17	25 1/2
Double Ward	10	3,250	32,500	8 1/2	8 1/2	13 1/2
Single Ward	10	1,900	19,00	7	7	10 1/2
Bath room No. 1	12	2,410	29,000	8	8	12
Bath room No. 2	12	1,950	23,400	7 1/2	7 1/2	11
Special Ward No. 1 and 2	10	3,760	37,600	9	9	13 1/2
Isolation Ward	10	4,600	66,000	10 1/2	10 1/2	16

Third Floor

Room	Change/hr.	Volume	cu.ft./hr.	Duct rizer	Size return	Register
Sister's Room	5	6,100	30,500	8	8	12
Bath room	12	2,000	24,000	7 1/2	7 1/2	10 $\frac{1}{2}$
Infirmary	6	2,240	13,440	6	6	9
Sitting Room	5	2,240	11,200	6	6	9
Dining Room	15	2,240	33,600	9	9	13 $\frac{1}{2}$
Sewing room	5	2,240	11,200	6	6	9
~~Chapel~~	30 person	1,200/hr	36,000	9	9	13 $\frac{1}{2}$

Power required for moving air:

The power required for moving air through a system of duct may be calculated by the formula:

$$AHP = \frac{av \times 144}{12 \times 2.31 \times 33000}$$

Page 347 of Heating and air conditioning by Allen and Walker.

Also knowing the volume to be handled per minute from table 63 page 352 we can chose the pres.

926 500 ÷ 60 = 15,500 cu.ft./min

for a velume of 16170 cu.ft./min.

outlet velocity 1300 ft./min.

1 1/4" static pressure.

R.P.M $=$ 564

b.HP of the fan $=$ 4.35

Type of the fan $=$ American H.S.Fan.

Heater

$$Q = AV$$

$$A = \frac{Q}{V} = \frac{500000}{1000 \times 60}$$

$$= 8.35 \text{ sq.ft.}$$

Referring to table 66 on Page 374 "Free Area of vento section" of Heating and Air Conditioning, we see by using 14 of the 40' section 5" centers the free area will be

$$14 \times 0.620 = 8.66 \text{ sq.ft.}$$

Then from table 67 on Page 375 of the same book is that a heater with two stalks deep would raise the air from a temperature 30°F to 83°F or from 20 to 76 at a velocity of 1000 ft/minute.

As a result we see that the heater should be of two stalks deep.

Washer

For the hospital that is being designed it is necessary to use separately any filter. The air Washer is f fairly effective in cleaning the air of dust and also act as a humidifier or dehumidifier as the conditions may be. In order to be able to humidify sufficiently and with proper control in winter it is necessary to warm the spray water to a temperature depending upon the amount of humidity wanted.

The washer in any case going to handle 500,000 cu.ft. of air /hr. The final temperature of air going to be about 68-70 while the relative humidity is between 55-60%. These last values are taken from the psychrometric charts.

-o-o-o-o-o-o-

Reference Books:

1. Modern Buildings:

Their Planning, Construction, and Equipment

Editted by G.A.T. Middleton A.R.I.B.A.

Vol.3.

2. Practical Steam and Hot Water Heating

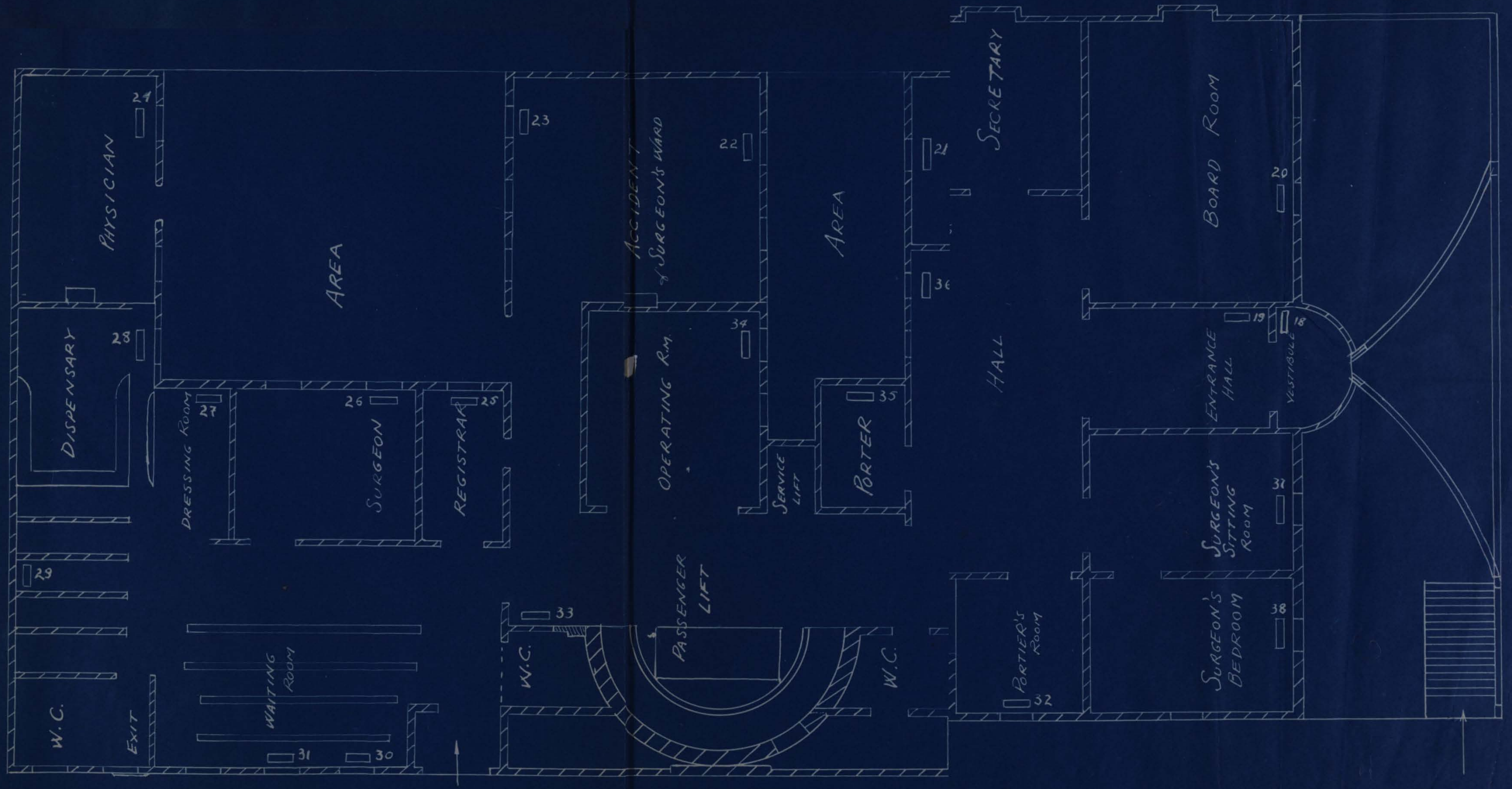
by

Alfred G. King

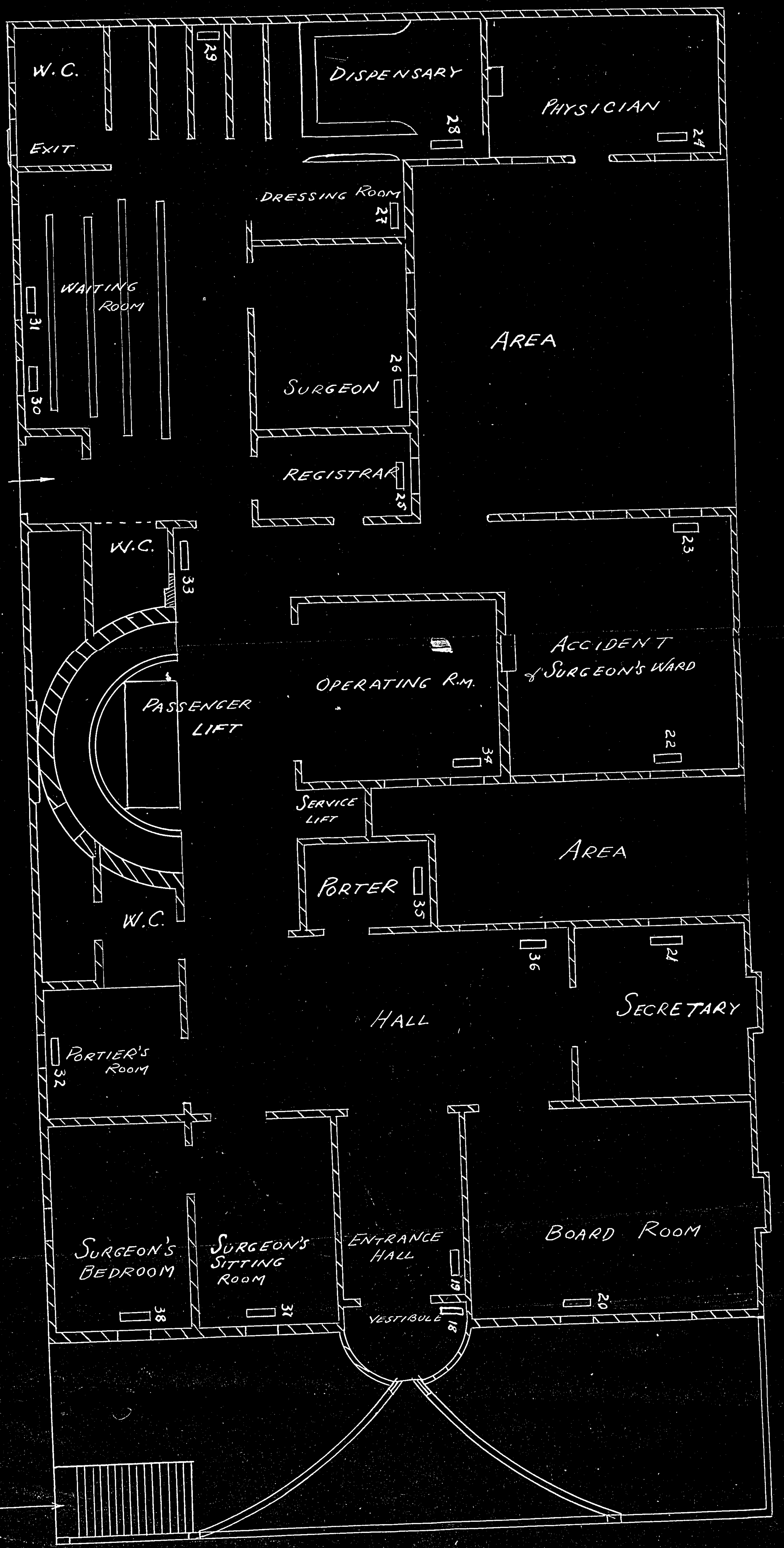
3. Heating and Air Conditioning

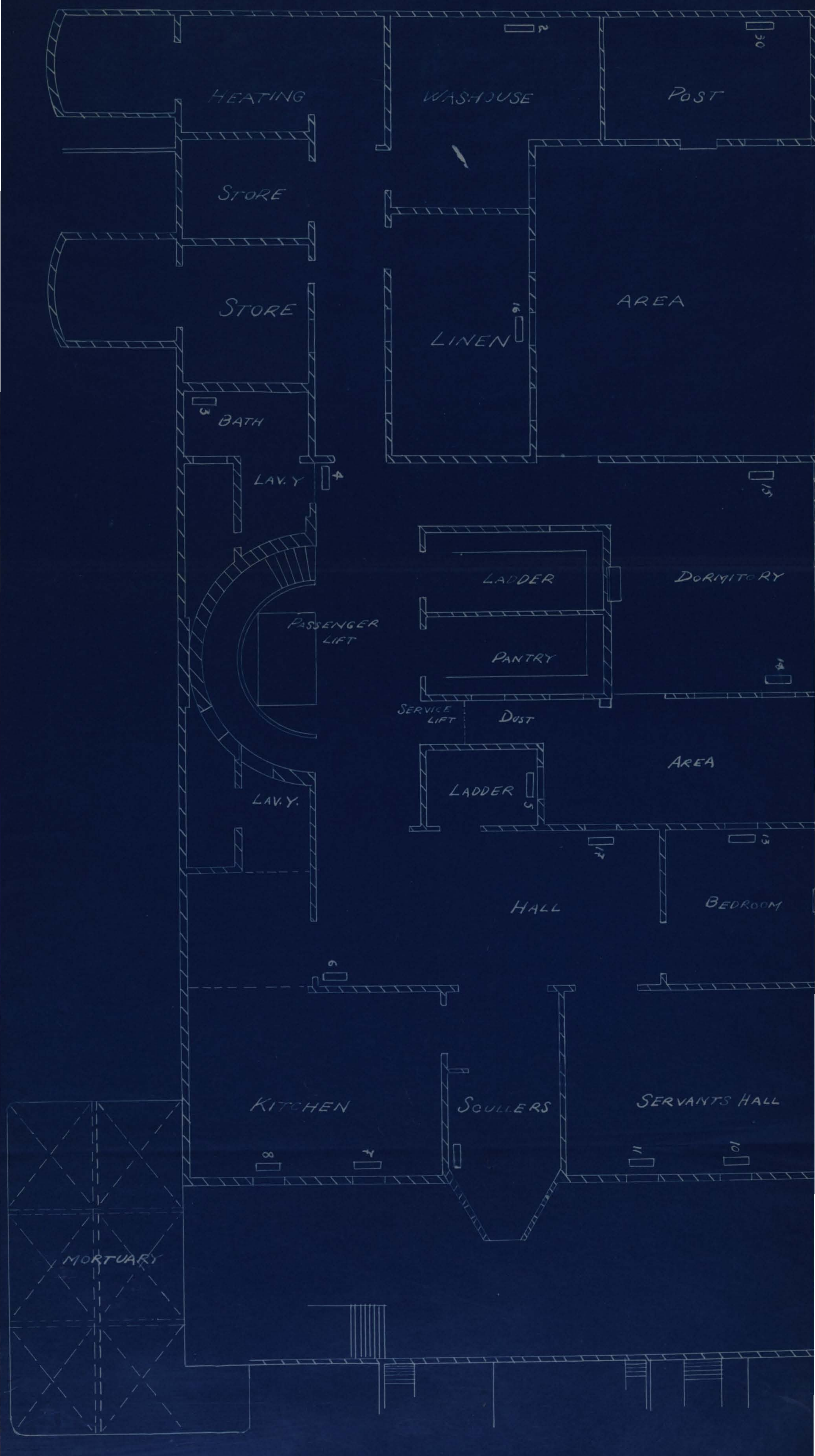
by

Allen and Walker.

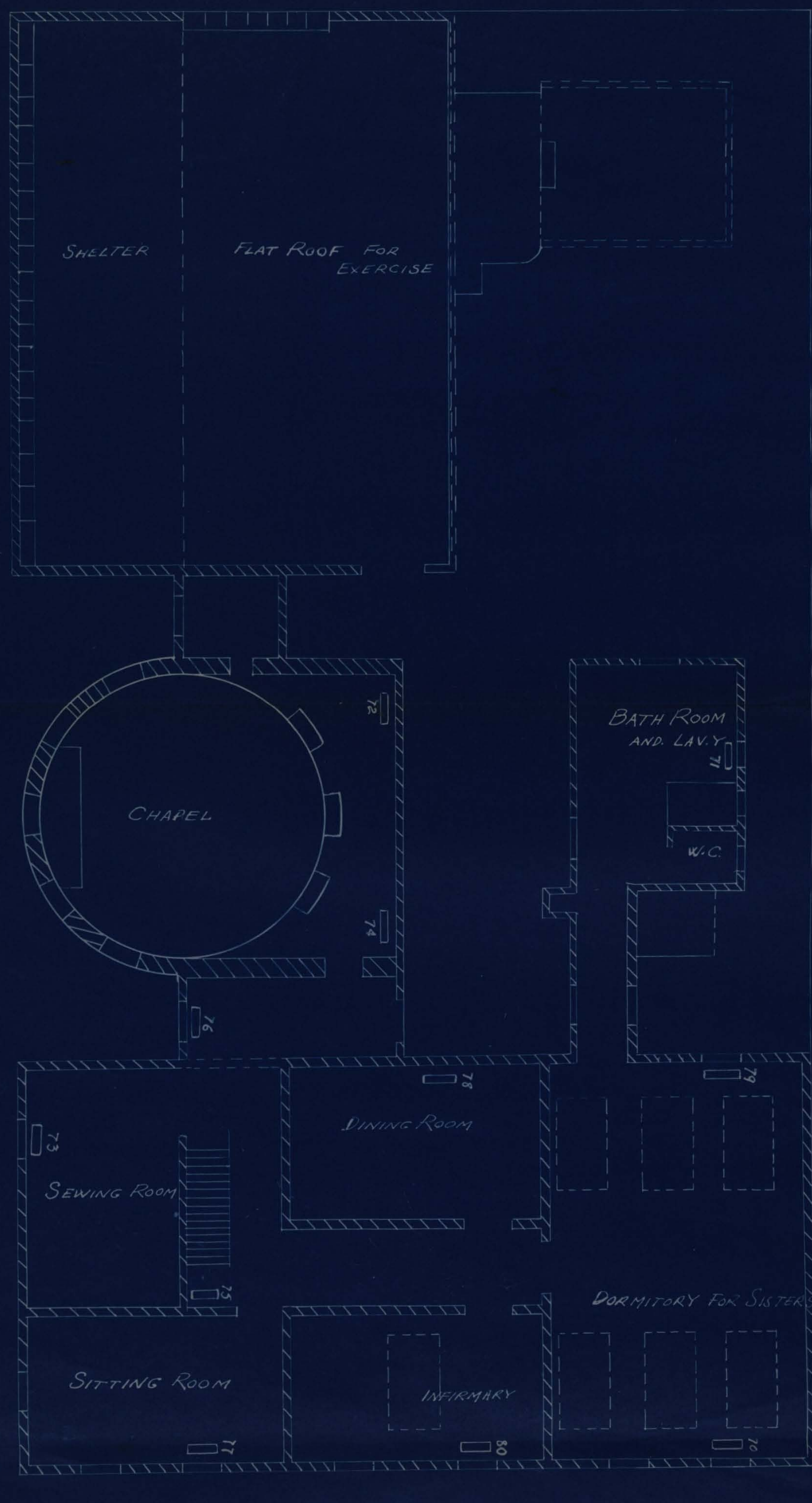


PHYSICIAN
24
AREA
23
ACCIDENT & SURGEON'S WARD
22
AREA
21
36
SECRETARY
BOARD ROOM
20
DISPENSARY
28
DRESSING ROOM
27
SURGEON
26
REGISTRAR
25
OPERATING RM.
34
SERVICE LIFT
PORTER
35
HALL
ENTRANCE HALL
19
VESTIBULE
18
SURGEON'S SITTING ROOM
37
29
PASSENGER LIFT
33
W.C.
WAITING ROOM
31
30
EXIT
W.C.
W.C.
PORTIER'S ROOM
32
SURGEON'S BEDROOM
38

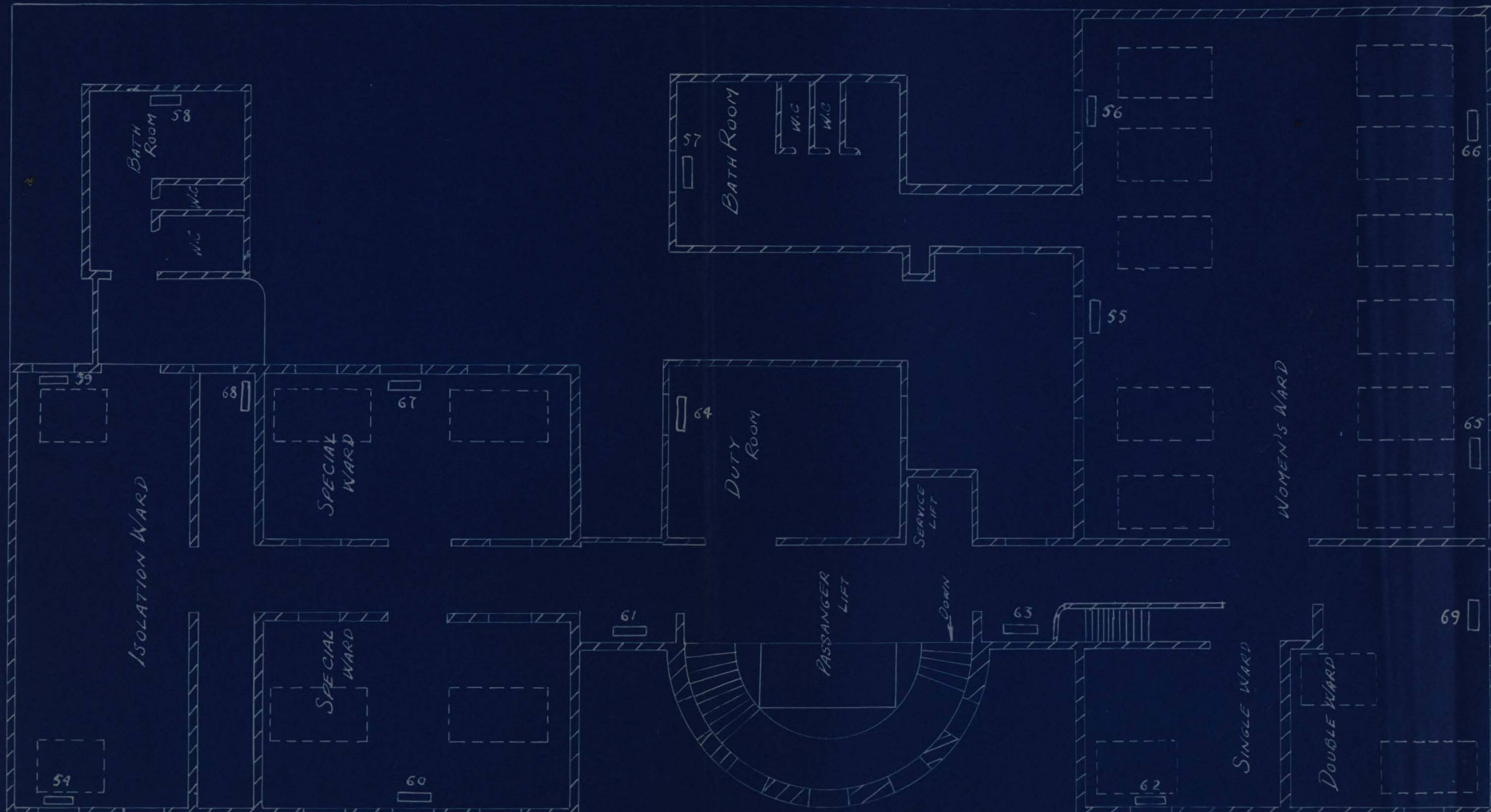

Physician
24
Area
23
Accident & Surgeon's Ward
22
Area
21
Secretary
Board Room
20
36
Dispensary
28
Dressing Room
27
Surgeon
26
Registrar
25
Operating Rm.
34
Service Lift
Porter
35
Hall
Entrance Hall
19
18
Vestibule
29
Passenger Lift
W.C.
33
W.C.
Portier's Room
32
Surgeon's Sitting Room
37
Surgeon's Bedroom
38
Waiting Room
31
30
W.C.
Exit



BASEMENT PLAN



THIRD FLOOR PLAN



Second Floor Plan