SPECIFICATION

— FOR —

Heating, Ventilating,

STEAM APPARATUS AND MOTIVE POWER,

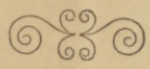
— BY —

ROBERT BRIGGS, C.E.

Cor. Mem. Am. Inst. Archts., Consulting Engineer.

FOR GIRARD COLLEGE BUILDINGS.

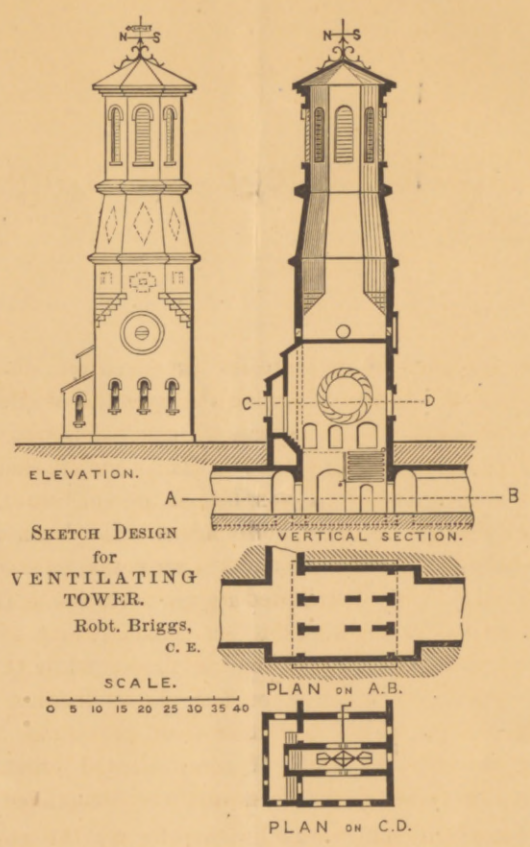
J. H. WINDRIM, Architect.



PHILADELPHIA :

KILDARE'S PRINTING HOUSE, 734 AND 736 SANSOM STREET.

1877.



SKETCH DESIGN
for
VENTILATING
TOWER.

Robt. Briggs,
C. E.

HEATING AND VENTILATING APPARATUS

—FOR—

Girard College Buildings.

§ It is intended to provide for the eventual heating and ventilation of all the buildings on the grounds at Girard College (now existing and in process of construction); by steam heat, derived from boilers placed in the proposed boiler house, and by a system of forced ventilation, proceeding from fans located adjoining the same boiler house; the fresh air being impelled through subterranean ducts or air passages to the several buildings, and being distributed by air passages in the cellars or basements to chambers at the foot of flues, which will convey it to the rooms of all stories in the buildings; while the vitiated air is removed by other flues and ducts leading to local aspirating shafts, which will have had provisions to insure ascending currents, by coils of steam-heated pipes, Bunsen burners or otherwise, if circumstances have demanded.

The rooms will be warmed generally by the currents of heated air for ventilation, when the heating coils or surfaces will be placed in the chambers at the foot of the fresh air flues; but some of the rooms and passages will be heated directly by radiators of some kind placed in them, some of which radiators

may be exposed to direct currents of air either from the ventilating ducts or by openings from the external atmosphere.

The air is to be introduced, generally, at the foot of the side walls of the rooms, and is to be directed so as to flow upon the floor, but in some instances it may be introduced at or near windows, and the way of introduction will then be arranged to establish an ascending current against them. The vitiated air is to be discharged at outlets provided (in general) both at the top and at the foot of the side walls; with lock registers upon the upper outlets, so that they can be closed beyond the control of the occupants of the rooms in winter (or when heated air is needed), to accompany ventilation. Wherever it is practicable, these discharge outlets will be placed on opposite sides of the rooms from the inlets for supply of fresh air.

The fans for supplying the air for ventilation will be erected in ventilating towers, and receive their air from above. The air will then be delivered downwards into a chamber beneath each fan, in which is placed an auxiliary heating coil. This coil (in three divisions) occupies one-half the chamber on the plan, and is provided with sliding or regulating doors, which, in one position, cover the top of the coil, and prevent the entrance of cold air upon it, and in the other position, close up that part of the chamber not occupied by the coil, and preclude the passage of air downwards except through the coil. By the adjustment of position of these regulating doors, the temperature of the air in the lower part of the chamber can be controlled without necessary regulation of the steam supply to the coil or its divisions. It is presumed that the air, reaching the lower part of the chamber below the coil where the underground ducts connect or diverge, will be tempered or warmed to about the natural heat of the ground at all seasons, or a little less, say about 50° in the coldest weather.

The same principle will be applied in tempering the air for admission to the several rooms to be heated and ventilated, so that the regulation of steam supply to heating surfaces or coils

in the chambers at the flues, to meet the changes of external temperature, may be almost entirely avoided. The fresh air flues are to be carried down below the heating surfaces, and are to open into the air supply beneath such surface, as well as into the heated air space above it. These two openings are to be regulated so that when one opens the other becomes closed, thus controlling the temperature, but precluding any change in the volume of supply of air to the room. In this arrangement some provision for admixture of currents of hot and cold air may be found requisite for inlets to rooms close to the heating chambers.

The flues supplying the air to school and class rooms, and to the dormitories above them, will be common to both stories, and have but the one heating chamber, or division of a heating chamber; and beside the temperature regulator, which must be made convenient to manipulate on either story, there must be provided, also, to operate in either story, a damper arrangement for diverting the air supply, so that five-sixths of it can pass into the rooms of one story, and one-sixth into those of the other, or the opposite. The full supply of air for ventilation being furnished to either room which may be occupied, and the limited volume, for preservation of freshness from emanations from the walls or furniture, being given to the unoccupied room.

§ There will be required at the present time, as follows:

Eight Steam Boilers, for the generation of steam for present and proposed use in heating, motive power and other requirements about the College.

These will be underfired horizontal tubular boilers, of the form known as "the plain tubular cylinder boilers, with dome." Each boiler will be 14 ft. long by 5 ft. in diameter; the steam dome will be 2½ ft. high by 2½ ft. diameter. Each boiler will have forty-three 4″ wrought iron tubes. The tubes will be

placed in vertical rows, and not staggered; the space between the upper and the second horizontal rows of tubes will come on the centre line of the boiler. There will be space *below* the tubes for a man-hole of usual size, to be made in the front end of the boiler, and there will be a similar man-hole to the steam space above the tubes, made in the back end of the boiler. The man-hole rings to be of wrought iron $2\frac{3}{4}'' \times \frac{3}{4}''$. A circular hole, 12 inches in diameter, will be cut in the dome sheet in the central line of the dome, and a row of holes 1″ in diameter, 3″ *c.* to *c.*, will be punched in the dome plate on the line of the inside of the dome sides. A stay sheet, 20 inches wide by 3 ft. long, will cross the dome opening as a chord, and be double riveted to the dome sheet on both sides. This stay sheet is to be abundantly perforated by 1″ holes. The heads of the boiler are to be securely stayed above and below the tubes. The sheets must be bevel sheared, not chipped after riveting. The horizontal seams of the shell are to be double riveted in staggered rows, the remaining joints to be single riveted—preference will be given to machine riveting over hand riveting. The iron of the shells will be C. No. 1, no blister; of the heads, C. flange, of the following thicknesses: shell of boiler, 0·4″; heads, 0·6″; shell of dome, 0·25″; head of dome, 0·31″. Throughout, these boilers are to be of the best material and workmanship, and, when completed, they are to pass the City inspection, to work at 80 lbs. steam pressure per square inch.

Four substantial cast iron lugs will be riveted to the shell, which will rest on plates of cast iron, $9'' \times 18'' \times 1''$, placed on the side walls. Under the front lugs $1\frac{1}{4}''$ round iron rollers will be placed, so that the boiler can expand without cracking the brickwork. These boilers will be set in brickwork "settings" of two groups of four boilers in one "setting."

The construction of the settings will provide for fire place with ash pit under front end. The gases of combustion to pass from the fire place over a bridge wall along the under side of the boiler to the back end, thence returning through the tubes to

the front and back again over the top of the boiler to a downtake flue in the side wall between two boilers (or at the end of a setting to an outside wall), to the horizontal underground flue leading to the chimney. The fire place, and parts adjacent to it exposed to the extreme heat of the fire, will be in fire-brick masonry, other portions of the settings in hard salmon brick, laid in lime mortar.

The brickwork of the setting will be supplied by the College through other contractors than those who furnish the iron-work, but the iron-work is to be set in position ready for the brick masons to build to, by the contractor for heating, ventilating, etc., apparatus.

The boiler settings will have cast iron fronts, of neat architectural design, ash pit and fire doors to swing from the centre both ways and to give an opening of 4 feet clear width. The fire doors to be shielded. A circular wrought iron sweeping door, in front of the boiler, 4 ft. 8 in. clear opening (0·2 thick), and wrought or cast iron man-plate doors to the flues over the boiler in the spandrils over the circular opening. These doors to the flues and tubes are to clamp air-tight to the front. The casting of the front must be stayed or reinforced by substantial wrought iron bars (angle or flat), above and below the ash pit and fire doors. At the fire doors these bars must be shielded by the dead plate. Over the fire doors must be placed a "Morse" (not patented) arch bar. At the back end of the boiler there will be a wrought iron half circular sweeping door with frame of L iron of same shape, and cast iron cover plate for the uptake, also an ash or dust door, 18″ × 18″ (with frame) to clear out chamber back of fire bridge. These doors must clamp air-tight. Buckstaves and binder bolts of sufficient strength will be required to secure the brickwork of the settings. Care must be taken to release the binder bolts when the boilers are first put at work, to avoid breakage by expansion. The downtake flue from each boiler must be provided with a throttle

damper which will be actuated by a LeVan (not patented) damper-regulator, or one similar thereto.

Each boiler will have 5 ft. × 5 ft. of grate surface, which will rate them as 40 horse power each (the h. p. being accepted as equal to the evaporation of one cubic foot of water (60 lbs.) from and at 212° per hour). The grate will be a plain single bar grate—bars, ¾ wide, ⅝ space—which will be preferred to any patent grate.

Each boiler will have a brass 3 inch angle feed valve, and be connected by 3 inch wrought iron pipe to a 4 inch wrought iron feed main, common of one setting of four boilers, (there will be no check valve between feed main and boiler)—a 2½ inch brass blow-off cock connected to a 6 inch cast iron blow-off main (flanged pipe common to both settings of boilers), to sewer, or to 5 feet outside of wall of boiler room—two 2½″ safety valves —one 5″ angle valve with 5 inch wrought iron pipe connection to 10 inch wrought iron main (common to each setting of four boilers);—three gauge cocks—one glass gauge—one steam gauge—one damper regulator (before named), and such other connections and adjuncts as will be needful to place each boiler or the settings of four boilers in approved working condition.

The feed main for each set of boilers shall connect by a 3 inch pipe to a 12 inch cast iron stand pipe or column, into which the feed (or return) water will enter before coming to the feed main. The stand column will have its base about one foot above level of boiler room floor (standing on a neat pedestal), and will reach to the level of the top of the steam domes. Two 3 inch brass check valves (one on each side, so that the feed water can neither return from the boilers to the stand column, nor flow out of the stand column towards the feed pumps), shall be attached to the column. A 3 inch steam connection, with brass valve, is to be made between the top of the stand column and the steam main. A glass gauge on the column will show the water level. The purpose of this column is to avoid the feeding of cold water

into the boiler at any time. In its construction the inlet feed pipe shall be carried down and terminate pointing downwards 1 foot from bottom of column, while the outlet feed pipe must lead off 6 inches below the low water line in the boilers. A $\frac{3}{4}''$ brass air cock is to be attached 1 foot above high water line of boilers, and a $1''$ brass drain cock (bib) is to be placed to empty the column when desired. At the foot of the column is to be provided a $6'' \times 4''$ hand-hole, with plate and clip.

The safety valves will be connected by $2\frac{1}{2}''$ pipe branches to a $5''$ main for each set of boilers. The two $5''$ escape steam mains shall be brought, by an elastic U or S connection into a common $8''$ cast iron main, led into the chimney, and turning up 5 feet in the flue. The $5''$ escape steam mains are to have $1\frac{1}{2}''$ drip pipes led to the sewer, or 5 feet beyond wall of boiler room.

All valves in the boiler or engine rooms must have finished centre pieces and yokes, and finished wheels with non-conducting rims; all cocks must be finished all over, and pipes below $2\frac{1}{2}''$ diameter, exposed to view, must be seamless brass or brass cased, wherever such finish is usual for the best workmanship. Ample provision for expansion and contraction of steam, feed, escape and exhaust pipe is to be made in elbows or bends in the most approved way.

§ Pumps for Feeding the Boilers.—Two Knowles & Sibley —Blake—or Worthington-duplex pumps are to be furnished— of suitable size to supply at moderate rates of speed the feed for a set of four boilers, supposing them to be fed exclusively by these pumps, and also of such size that each alone will be ample in emergency to feed the two sets of four boilers when actively fired. All pipes, valves (brass), cocks (brass), for steam, exhaust, water and drain connections are to be supplied. The steam connections to be made directly, and by cross connection, to the sets of boilers. The exhaust connections are to be

carried to the chimney. The water connections to be made from the pumps to the feed columns, with cross connections; and from the pump to the water supply, within the boiler room. The drip or drain connections to the sewer, or 5 feet beyond wall of boiler room. The pumps must be extra finish, such as are usual in the best appointed boiler rooms.

The location of the pumps *within* the boiler room will be hereafter determined; they will be set upon single block granite foundations, which will be placed in position by other contractors, but the anchor bolts will be supplied and set, by the contractor for heating and ventilating apparatus.

§ Tools for the Boiler Room.—Two sets of stoking tools, of all kinds needed about the boilers, 8 steel coal and ordinary shovels, 4 iron coal and ash barrows, 2 sledges, 4 hand hammers, 4 monkey-wrenches, 4 spanner-wrenches, 2 dozen chisels, one axe, a set of oilers, and whatever other tools may be required for use, either constantly or occasionally, by the firemen or engineers in the boiler room, will be furnished.

§ Elevator from Boiler Room.—A power elevator, with platform 6′ by 6′, of some approved make, to be accepted by the architect, will be supplied and erected where shown on the plans of the boiler room. As the platform will not be enclosed, the upper hatchway will be made 9″ all round larger than the platform and the opening closed over by hinged flaps, to raise if any person or thing projects beyond the edge of the platform when it is lifting; the iron and wood work for this arrangement will be deemed part of the elevator, as will be all iron or wood work necessary to attach this elevator, its machinery or shafting to the ordinary brick or stone work or carpentry of the building. This elevator will derive its power from the laundry engine, and the shafting and belting necessary for the transmission of power must be furnished.

§ FANS.—Two ventilating fans are to be erected in the fan rooms, or shafts. These will be rotary fans, 12 feet in diameter, entirely of iron, with iron entrance rings (mouths) and sides; which rings are built into the walls that form the sides of "case" or chamber. (They will be of the same dimensions and shape as those at the State Hospitals for the Insane, at Danville, and Harrisburg, Pa.)

These fans can be described by stating the general dimensions: Diameter of fan, 12 feet; width between brick walls which enclose it, 5 feet; diameter of smallest opening of mouth, 8·9 feet; width of fan blades at this place, 4·2 feet; width of fan blades at outside of fan, 2·4 feet; number of blades, 16. The shafts are of wrought iron, 6 inches in diameter between the (mouth) bearings, and $5\frac{1}{2}$ inches in diameter in and beyond these bearings. The shafts will be 14 or 15 feet in length, so as to project across the cold air passage, and through the wall into the engine room, with length enough for a pulley (to drive shafting for rotary pump, as hereinafter designated), the main bearing of engine, and for the crank. Upon the shaft, in the centre between sides of the fan, is keyed a cast iron hub with flange faced up true, to which hub, by numerous turned and fitted pins or bolts, is bolted the "disc," which is a plate 12 ft. in diameter, by 0·42 thick, made of two sheets very carefully straightened, with edges planed to butt solid, and joined by double (cold) riveted plates $8'' \times \frac{1}{4}''$ on both sides; the rivets may be $\frac{1}{2}'' \times 4''$ *c.* to *c.* The disc must be carefully straightened, trimmed to a perfect circle, and when bolted solid to the hub in the centre, must run true. The blades will be No. 9 (Birmingham gauge) sheet iron, bent on a block to the form of a logarithmic spiral of 45°, with a flange $1\frac{1}{2}''$ wide, thrown down on the "disc" edge, to fasten to the disc by rivets, $3\frac{1}{2}''$ *c.* to *c.*, confining the blades on both sides of the disc. Each blade will have two diagonal braces, of half round iron $1\frac{1}{4}'' \times \frac{1}{2}''$, placed on the inside of the curvature to stiffen the outer projecting edge against any tremulous vibration, and to help to resist the

centrifugal force upon the blades themselves. The cones may be *umbrellas* of wrought iron, with T ribs $2'' \times 2''$, and No. 18 iron covering, but will be preferred of cast iron, swept to shape *not over* $\frac{1}{2}''$ *thick* and preferably lighter. Such cones must be faced where they join the disc, and bored out true by the facing. The bolts to the disc must be rough body-bound bolts.

The mouth pieces to the fan consist, first, of two castings (to each fan, one on either side) which resemble cast iron pulleys, about 9·4 ft. outside diameter, and $9\frac{1}{2}''$ broad on the flat of the rim, and about 6″ more of a U shaped flange on one edge of the rim. These pulleys will have six flat arms (9″ wide) joined to a ⊓ shaped central opening of the same width of iron-work about the opening. The general thickness of iron in these mouth-piece castings will be $1\frac{1}{8}''$ to $1\frac{1}{4}''$. The bearings will be $5\frac{1}{2}''$ diameter by 15″ long, with cast iron boxes, with balls to rest in the corresponding sockets in the pedestals, which are placed and carried in the ⊓ shaped centre openings. To the U formed flange on the inside of the rim of the mouth-pieces, are attached the sides of the fan, consisting of two conical frustra of No. 12 Birmingham gauge sheet iron, made to conform to the angle of the edges of the blades, and to come about one inch away from them. The outer edges of these frustra will have a bar of $1\frac{1}{4}'' \times \frac{1}{2}''$ half round iron to stiffen them, and at six points, knee-pieces $2'' \times \frac{1}{2}''$ flat iron will be attached to project 6″ beyond the edge, with distance braces of $\frac{3}{4}''$ pipe enclosing a $\frac{5}{8}''$ bolt crossing the fan space (this provision will be found necessary for convenience of erection).

Oilers and oil tubes for the fan bearings, and drip-pans for catching oil from the same, must be provided.

When completed the fans must run within a half inch of truth when running at full or any speed, both edgewise and sidewise. They must be balanced on their own shafts on parallel edges to perfect equilibrium, before attachment of engine crank. The engine crank must be a plate crank, in balance for the crank and moving parts of the engine.

The brickwork of the fan, its chamber or enclosure will be supplied and erected by the College through other contractors than those who furnish the iron-work, but the iron-work is to be set in position ready for the brick masons to build to, by the contractor for heating, ventilating, etc., apparatus.

Complete drawings of the fan will be supplied to accompany this specification.

These fans will, either of them—with adequate air ducts, that is to say 128 square feet of unobstructed entrance to mouths, and 90·5 square feet of unobstructed discharge area of duct at the fan, enlarging to double area at four hundred feet distance; and with resistance from flues, rooms or other ducts or chambers, of from 0·31 to 1·23 inches of water column pressure; when the speed of the fans is made from 83 to 167 revolutions per minute—deliver in each minute 57,500 to 115,000 cubic feet of air. The contractor has no responsibility as to result, in regard to quantity of air or pressure, but is solely responsible for workmanship and mechanical performances.

§ Engines for the Fans.—Each fan will have set up and connected in the engine room, adjoining the fan room or shaft, a vertical steam engine of 37 (nominal) horse-power.

This engine will be a high pressure one, with lap slide valve to cut off at five-eighths the stroke, substantial in all its parts, suited for continuous day and night running. It will have a cylinder 12″ in diameter by 18″ stroke, and will be run under control of a governor at three speeds of 60–90–120 revolutions per minute. [The large size of these engines is assumed to permit the boilers to be run on very low steam, say 30 pounds, if desired.] The governors used may be Watson, Pickering, or Porter governors, the changes of speed to be made by a cone of pulleys, or by a variable adjustment of load on balls. The engine frame must be of neat design, and the finish must be such as is usual for engines in conspicuous places for exhibition

to visitors. Oil cups, drip catches, drip pipes, etc., and every accessory for the cleanliness of the engine, must be supplied.

Tools for the Engine Rooms.—Oilers,—oil cans, for hand use,—stand for these, all nickel-plated,—monkey-wrenches, two sizes,—finished spanner wrenches to fit every nut on the engine,—2 hand hammers,—1 soft brass maul of three pounds weight, with such other tools as the engineer may require—all neatly exposed in a black walnut, oil-finished, open case, will be supplied for *each* engine room.

Pipe Connections to Engines.—Each engine will have an independent 2″ wrought iron steam-pipe connection from the 10″ mains of the boilers (with valves in boiler .room near the mains as well as at the engine) to the engine, with a cross connection and valve in the boiler room, so that either or both engines can be driven from either set of boilers. Whence the branch from either boiler main, with its valve, must be 3″, which is double capacity of requirement for one engine. The exhaust steam will pass from each engine into an exhaust steam recipient, and thence to the heaters for hot water for the laundry and other purposes, which heaters will be located in, or within 40 feet distance from, the boiler room.

The exhaust steam recipient will be 16″ diameter × 4′ 0″ long (or properly high). It will be placed on an iron stand, to elevate it the proper height from the floor of the engine room (or some room adjoining). The 2½″ exhaust steam pipe will enter it about 18″ from the top, and there will be a back-pressure valve at the top (to work from 1 to 5 lbs. back pressure), from which a 2½″ exhaust steam pipe shall be taken to the chimney. Within the chimney shall be placed a length of 6″ cast iron pipe 6 ft. long, to give the exhaust steam a vertical direction. This exhaust pipe will rest on a T piece, the head of the ⊣ forming a well on the under side and joining the pipe on the upper; the well to be closed by a flange with a 1½″ hole

for escape of drip. All the exhaust steam pipes leading to the chimney will drain towards it, at least $\frac{1}{2}''$ in each 10 ft. of horizontal length. Exhaust steam pipes must be directed into the T. The heater pipe, 3″ diameter, will take out of the recipient, by a brass valve either one foot above or one foot below the exhaust inlet, and this pipe will be carried over to the heater as hereinafter described.

These recipients will be trapped to remove condense water by means of a No. 3 Nason steam trap, which trap is to be connected to the sewer, or the pipe from it is to be carried 5 feet outside of building (galvanized iron pipe to be used underground in all cases). They will have a $\frac{1}{2}''$ air cock, 1 foot from bottom, a $\frac{1}{2}''$ draw cock in bottom, and a $6'' \times 4''$ hand-hole and clip near the lower end.

§ Auxiliary Heating Coils and Appurtenances.—In the chambers below each of the fans (which is a room in three divisions, separated by the piers supporting the side walls of the fan case above) will be placed three return bend coils of $1\frac{1}{4}''$ wrought iron pipe, each coil 20 pipes wide by 21 pipes high, with 8′ 6″ long (end to end of screw).

The drawings accompanying this specification show these coils and their details. They will have wrought iron coil stands, and each section will be suspended to girders built into the walls. Provision is to be made to lift, unhook and drop down each section separately, for repair at any time, by means of a movable clip on another girder, 6 ft. or so above the coil, and a half ton Weston differential block. These auxiliary coils occupy on the plan one-half of their chambers, and a vertical corrugated galvanized iron, No. 18 W. G., partition, with angle bars top and bottom, will close in the end of the coils and partition off the other half.

In the three divisions of each chamber, are to be laid in the side-walls, track, sliding or traverse bars on which these horizontal doors will move on wheels. Each of the doors, in

one position will cover the coil entirely, in the other position, when removed from the top of the coil, will cover the open air space or passage. Their regulation of position will therefore control the proportion of heat imparted to the air entering the ducts, which go out of the chamber at a lower level than the under side of the coil. That is, a volume of heated air is supplied and mixed with some other volume of cooler air, and thus produces the desired temperature, at the command of those who operate these doors. It is provided that when the coils are entirely uncovered, and the largest amount of heat is imparted to the current of entering air, the unobstructed area will be only 60 square ft., it being assumed then (in the coldest weather), only two-thirds of the quantity of air demanded at other times will be needed for the comfort and health of the occupants of the College. Means for operating the doors in the engine room with an indicator showing their position at any time, must be provided.

Each of the coils must be connected separately with 2″ steam pipes, with valve in the engine room, and thence by a 3½″ main branch to the general flow main, or to the 10″ main on the boilers. The returns will have 1½ separate connection with stop valve in the engine room joining into a general 2½ return main. If there be sufficient elevation for the return, the water can be taken at once through a check valve to the stand column, if otherwise the return is to be made to a small stand column (cast iron pipe 6 or 8 in. drain by 3 ft. long, with air cocks and drain cock), beyond which will be placed a 3″ rotary pump (centrifugal or otherwise, only to be a durable piece of apparatus), which will remove the water from the coils, and supply the column of pressure needed to induce the circulation. This pump will be driven by belts and shafting, deriving its motion from the fan engine.

All the iron-work or machinery of the fans, engines and appliances, its fitting and erection and the care and responsibility for placing correctly, whatever is to be built into the

walls, will be a part of the undertaking of the contractor for this portion of the heating and ventilating apparatus.

§ Means for supplying Moisture to the Air.—For the purpose of supplying at times when desired, a small amount of moisture to the air, there will be furnished in each main air duct near the auxiliary coil—A 1″ pipe will be taken from the auxiliary coil main (with valve in the engine room), which shall pass down to the duct, and shall have four diffusing nozzles connected to a T head, which is to be placed across the top of the duct. These diffusing nozzles will be of brass, with $\frac{1}{2}$″ inlet and 4″ outlet, with such baffling plates as will cause the effiux of steam to take place silently.

There is also to be supplied for each main duct near the auxiliary coil, an arrangement for producing a spray of water for imparting moisture to the air in hot, dry weather, or when desired. Such arrangement may consist of a line of 1″ brass tube, placed across the upper part of the duct, with twenty-four $\frac{1}{8}$″ brass nibs or jets, discharging against a continuous brass spray plate, each jet being controlled separately by a $\frac{3}{8}$″ cock, the whole connected to the water supply piping in the boiler room, not over 50 ft. distant, by $1\frac{1}{4}$″ galvanized iron pipe, with a brass cock at the spray pipe and another—stop and waste—at or near the junction to water supply in boiler room. This arrangement must be constructed so as to give a diffused sheet of spray across the section of the duct, and be permanent and serviceable.

§ Thermometers.—There will be placed in each duct about fifty feet from the fan, a metallic thermometer which shall be connected by a wire connection to a dial in the engine room, and indicate the temperature in the duct at any time. These thermometers and fixtures may be estimated to cost $80.00 each.

§ Heating Surface and Arrangement.—The heating surface employed, may be cast iron (so-called) radiators or wrought iron tubes. It is estimated that all the needed heat can be furnished, if there is provided with judicious arrangement of surface for the several local requirements for heat and for air supply, one square foot of steam heated surface to each eighty cubic feet of contents of buildings, measuring them from out to out. Projections or extensions of surface of "radiators" could be taken as possessing half the efficiency of proper steam heated surface.

In the arrangement of the heating surface in chambers at the feet of the flues, each cluster or coil must have a brass stop valve on both flow and return main, and a brass air or test cock.

The clusters or coils must be enclosed in chambers, constructed of 1″ boards, not over 4″ wide, perfectly seasoned, well planed on both sides, and tongued and grooved, stripped and battened in workmanlike method, lined throughout with bright tin; or the chambers may be constructed, *preferably*, of No. 20 or 22 W. G. galvanized iron, with angle iron corners, close riveted or screwed at all joints. These chambers are to have sides and ends detachable, and held by screws to give easy access to the clusters or coils for repairs at any time.

The heating surface allotted to each flue must be separated by tight metal (tin or galvanized iron) divisions to insure the proper distribution of heat. These divisions will extend 6″ or 8″ below the bottom of the "radiators," or coils, and be closed by metallic horizontal distributing diaphragms, perforated with apertures to control the flow of air upon and over the entire heating surface, and also to intercept some radiant heat from the cooler air below the diaphragm, from which the cool air for regulation of temperature of the ventilated rooms above is to be taken. The entire height of the chambers, therefore, will be about 1·8″ to 2·0″ below, and 8″ to 1·0″ above the clusters or coils.

In some and most instances, trunk connections between the air duct and the heating chamber, may be required, when not otherwise herein specified. These will not be considered by the contractor to be over 6 ft. in length, on the average of those not specified. These trunk connections will be rectangular boxes of suitable areas of cross-sections for the volumes of air to pass them, as may be designated by the architect, and will be made of sheet galvanized iron No. 20 or 22 W. G. The provision for attachment of ducts to chambers or ducts will be given by the builders of the ducts.

Beside the heating surfaces in chambers, there will be many places where direct radiating surfaces will be required; in such places any form of radiator (subject to the approval of the architect for efficiency, suitability and appearance) may be used. If box coils, or radiators in clusters, they must be screened with ornamental screens having marble tops. If Nason radiating vertical tube coils, they must be neatly covered by marble or perforated iron slabs. If return bend coils, they must be bronzed and have plain ornamented supports.

There will be required in ..... rooms, where designated, heated floor plates of cast iron for warming the feet, after the following description: These floor plates will form the cover or lid of a cast iron box or trough 8, 10 or 12 feet long, by 10 or 12 inches wide, by 5 inches deep, all dimensions being taken on the inside—the length and width as designated on the plan. The boxes or troughs will have a flange around the sides and ends 1 inch wide, to which the floor plates will be secured by $\frac{3}{8}''$ stove bolts and nuts. The upper surface of the plates will be finished with fine diamond work and will be set level with the floor, and the whole will be supported by the floor joists, the box as dropping between two of them, and being secured by wood screws through the flange. Within each of these boxes will be placed a coil of four lengths of 1″ steam pipe with close return bends—the pipes being supported by three stands so as to give a fall of $\frac{1}{2}$ inch to 10 feet of length to the

coil within the box. A $\frac{1}{2}''$ pipe connection from steam main and to return main with valve on each and an air or test cask, all to be operated in the cellar or room below the warmer, is to be furnished for each. The boxes will be filled with sand, iron ore or other suitable conducting material, either completely, or so far as may be necessary to convey from the steam pipes to the floor plates a modified degree of heat, say about 100° temperature, at which shoes will not be injured by contact.

There will also be required in . . . . . rooms, where designated, surface radiators for warming, by radiant heat, any persons coming into the room cold, which may be either vertical pipes, return bend coils or cast iron surfaces without projections; 4, 6, or 8 feet long by 2′ 8″ to 3′ 0″ high, as designated in the plan. These will be placed against the walls and encased at the back and ends, and covered at the top, so as to prevent loss of heat by ~~conversion~~ convection to the air and to induce the largest emission of radiant heat to be obtained from the low temperature of the source. These coils will be connected to steam and return mains by $\frac{3}{4}$ and $\frac{1}{2}''$ pipes and valves, as is most suitable for sizes or locations. The valves to be placed in the rooms where the radiant surface is located, to be operated at will.

All coil pipes, which are not vertical, in coils of every kind, must have an inclination, preferably of about $\frac{1}{2}$ inch fall in 10 feet length, so that the flow of steam will occur in the same direction as the current of condense water. All radiators must have shut-off valves on both flow and return, and also air or test cocks.

In the base of each aspirating shaft, where designated on the plans, will be placed an hour glass spiral coil (of the length marked on the plan) of 1″ pipe, to induce the discharge of vitiated air in such shaft.

As most of the heating surface, in rooms or shafts, will be above the level of the flow mains, provision must be made to

drip the flow into the return main in every case. For instance, in the case of spiral coils, they will be connected at both ends with a vertical $1\frac{1}{2}''$ pipe, which shall extend from the top of the spiral coil to the level of take-off of return branch. This $1\frac{1}{2}''$ pipe will have a diaphragm of $1\frac{1}{2}''$ (or $1\frac{3}{8}''$) hoop iron, from $3''$ from the top to within $3''$, from or, above the bottom end, and the steam or flow pipe will enter behind the diaphragm. Return bend coils, both box and other kinds, can be connected in the same way. In the case of the spiral coils or others, the upright pipes, when exposed in any room, must be clothed, to prevent radiation of heat.

All valves and cocks for manipulation of the heating surfaces are to have non-conducting wheels or handles, of rubber, black walnut, or other suitable material.

§ MAINS.—The steam and return connections, by branch or direct mains to each cluster, coil, or other radiator, must have the equivalent of one circular inch of sectional area for the steam or flow connection (equal to a $1''$ pipe, nearly) for every 500 square ft. of *effective* steam surface exposed; enlarged to twice this dimension for 400 ft. distance from the ~~boilers~~, and ~~proportionately~~ increased for less or greater distances. The condense water, or return connections, will follow the same rule, with the equivalent to a half of a circular inch of sectional area for the same surface (equal to a $\frac{3}{4}''$ pipe, nearly).

The aggregate area of the great mains, however, will be taken at half way between the total sums of corrected areas and the aggregate areas computed as expanding, trumpet form, from the ~~boilers~~. Thus, 500 square ft. of surface, at 400 ft. from ~~the boilers~~, will take one circular inch area at the boilers, and two circular inches at the surface which imparts heat. The area of main to supply this will be taken at $1\frac{1}{2}$ circular inches at ~~the boilers~~; while at 200 ft. distance ~~from the boilers~~, the ~~area of~~ main allotted to supply the same 500 square ft. (at 400 ft. distance), will have $\left(\frac{2+1\frac{1}{2}}{2}\right) = 1\frac{3}{4}$ circular inches of area.

After the extent of surfaces is concluded, it will not be found difficult to apply this rule.

The flow mains will have a uniform descent of half an inch in 10 ft. of length of main from the boiler room to *every* cluster or coil; no other inclination is to be allowed, but the drop necessary to place the clusters or coils at uniform or desired levels, shall be made at the connection to them.

If in running the lines, this fall or inclination shall bring the flow main below a desired level to supply clusters or coils further on the line, then there shall be placed in the line of main a steam recipient 16″ diameter × 3 or 4 ft. high, which shall be trapped by a check valve into the return main. Such recipients must have air and drain cocks, and a 6″ × 4″ hand-hole, and be securely carried or suspended. At such a recipient, a change of level of the flow main can be made. The connections to return main must have provision for expansion without impairment of joints.

All branch flow mains will be taken from the under side of the greater main, so as to leave no water traps in the lines of the least amount.

The return mains shall have a descent of a half-inch to ten feet horizontal line, to be rigidly preserved from the most remote parts of the distribution, except at the intersection of branches, which shall enter at the top of the greater mains The same rule as to absolute uniformity of all inclination of all horizontal mains, to apply to the return, as well as to the flow main, the sudden *drops*, if necessary, to be made at the connection to the cluster or coils.

Wherever the flow or return pipes (main or branch) are taken through a wall, partition or floor—wall, floor or ceiling plates, with boiler tube ferrule or casing, must be used to protect the opening. The mains, flow and return, are to be suspended by hooks or carried by rollers (with brass pins), so as to be free to expand or contract without straining the joints.

Horseshoe or S loops are to be made in the long lines where requisite to give freedom of expansion; care being taken to preserve the inclination of the line at these curves. There must be a flange joint at least every 50 ft. of continuous length of any size of pipe, and more frequently if convenience for future repair demands it.

All socket joints over 2″, made upon the ground, must have had the sockets stretched in the machine, so that they will fit the taper of the pipe threads, without imposing this labor on the erecting fitter. No running thread joints are to be used in any case; either right and left, union, or flange joints, must be substituted.

§ Ducts and Flues.—The ducts and flues will have a least sectional area based upon the volume of air demanded to pass through them as follows: For each 1000 cubic feet of least (coldest weather) supply to any place of distribution—a sectional area of 1·57 square feet, plus 0·0025 times $(\frac{1}{400}) \times$ distance from the fan, plus also, as a constant, 0·25 square feet. Having thus computed the area of several branches at their extremities, they may be considered as trumpet shaped, or as having expanded from the fan, when summing up the aggregate at any distance from the fan.

The quantity of air of least supply will be derived from two systems: The one depending on the supply for ventilation of session, audience, or largely occupied rooms, where the quantity of air is fixed by the number of occupants, and is largely in excess of the demands for heated air as a means of warming the rooms (in fact in some places the temperature of the air can scarcely exceed 70° or 80° in the coldest weather), and the other where the rooms are to be warmed by the currents in more limited quantity, but of higher temperature (perhaps 110°). (The least quantity will be taken at 30 cubic feet per minute for regular occupant.) In the second case the volume of air will be found by deciding on the extent of heating surface required for any

room, of given exposure and position in the buildings—an extent of heating surface which may vary from one square foot to forty cubic feet of space in the room, to one square foot to one hundred and twenty cubic feet of space in the room; when it may be accepted that there will be needed five cubic feet of air to each square foot of heating surface from which the heat is to be transferred. From these bases the sectional area of flues and ducts can be made to conform to the requirements for air for each room or suite of rooms.

§ Controlling Registers.—At some convenient place between the brick main duct and the chambers containing the heating clusters or coils, will be placed, for every chamber or mouth for passage of air from the ducts, a controlling register, which will consist of two perforated (grid) plates, one of which shall be adjustable upon the other and secured by a screw. Three or four sizes of these registers will be called for, to meet the various dimensions of ducts. It is not supposed that the ducts will be made to conform to requirement for dimension with much closeness, and these registers will be set at *two-thirds* the computed exact area of the ducts, *omitting the constant*, and thus insure the proportionate discharge of air through each or any of them. The openings from the chambers into the flues will be regulated by the sizes of the openings cut in the tin or galvanized iron casing to the chambers, and a provision for a sliding plate adjustment to control the several stories, must be furnished.

§ Supply Registers.—These registers, intended to supply fresh air at or near the floor, must have the wings for control, or some fixed wings, constructed or so placed as, to direct the entering current downwards upon the floor. The area of the register fronts, which must be at least one-half clear unobstructed openings, must be seven times greater than that designated for the flues of supply, without allowance for distance from the fan. This allowance gives a velocity of entering air for largest or double supply, in front of the registers, say 2 ft. of three feet per second, which

velocity is approaching to an appreciable, and if cool, to an objectionable current. The area can be computed directly from the air supply requisite for any room, as derived from the plans or from this specification, by adopting 11 square ft. of total face of register (one-half of which to be clear apertures), per 1000 cubic feet of air per minute, of least ventilation supply (or per 2000 cubic feet of air of greatest or summer supply). The faces of the registers should in no case be over one foot in height, and, if possible, should not be over 3 ft. in horizontal length, so that not above 333 cubic ft. (of least supply) should enter by one register, or proceed from one flue, or branch of a flue. When larger volumes of air are required for any room, two or more places of entrance should be provided to avoid establishment of local currents within the room. All supply registers, of whatever dimensions, should have their height as compared to their width (or horizontal length), as one to three or four. Distributing, diffusing, or baffling plates or screens must be placed behind the register fronts—between the flue mouth, and the fronts—to equalize the flow of air from the flue over the whole surface of the register. The perforations, slits or holes in these plates or screens must be adjusted in size, and the parts disposed to allow the full requisite influx at the same time that they insure the uniform velocity of current over the area of the front. *These sizes and precautions must be followed strictly*, they being indispensable for the introduction of the air with comfort to the occupants. The arrangements requisite to be provided for the manipulation and control of the air supply at these registers, for the admixture of warm and cool air to regulate the temperature, have been described in other parts of this specification, see pages 2, 14, 25, and elsewhere.

Discharge Registers.—These will be the usual Tuttle & Bailey (or of similar and equal) quality and description. They will have one-half the area of front, specified for supply registers, and will be disposed and arranged as described in other parts of this specification, see page 2, and elsewhere.

§ Brief of Method to be pursued in estimating the dimensions of parts of the Heating and Ventilating Apparatus.

Supposing the effective value of such surface as may be used to be equal to that of small steam-pipes placed horizontally in coils, which shall contain steam of not over 30 pounds pressure, the actual quantity of heating surface requisite for any given place can be estimated as follows:

A Table I—will be formed, with several columns in which:

[1st] Each and every room, passage or space—cellars and garrets included, shall be designated.

[2d] A number assumed for each room, etc.

[3d] The story, or floor on which the room is located, given.

[4th] (*a*) length, (*b*) width, (*c*) height, (*d*) cu. contents: (*e*) number of windows, (*f*) height, (*g*) width, (*h*) surface of all.

[5th] The exposure of the room or place to the external air, *N. W.*, *N. E.*, *S. E.*, *S. W.*

[6th] The temperature desired to maintain in each room in the coldest weather.

[7th] The method of heating as designated by the following letters: *A*, by currents of air for ventilation, where the number of occupants demand volumes of air largely in excess of what would be needed for merely transferring heat; *B*, by currents of air in smaller volumes, as much air at 100° and 110° as will be requisite for heating the room or place; *C*, by currents of air admitted through flues at the temperature of the main duct, *i. e.* 50°, and thus allowed to come in contact with heating surface placed in the room, so that the room may be heated with or without such currents; *D*, by radiating surface in the rooms or places themselves, without any especial provision for supply of air for ventilation of such rooms; *E*, floor plates

for warming feet; *F*, coils for radiant heat for warming persons; *G*, coils for inducing currents in aspirating shafts.

[8th] The volumes of air to be furnished to each room: *A*, as established by number of occupants (at 30 cu. ft. per minute, as the least quantity of air per minute demanded for the purpose of ventilation in the coldest weather, when it becomes expensive to heat large volumes of air); *B* and *C*, volumes of air needed for transferring the heat from the coils to the rooms when heating by indirect or transfer surface in the rooms, to be estimated at five cubic feet of air to each square foot of heating surface which will be established by the (11th) column of the table.

N. B.—An especial provision for supply of air to the school rooms and dormitories in the new pavilions, will be made as follows: each school room on the first floor when in session, is to have 1000 cubic feet of air per minute, and when vacated, 167 cubic feet of air per minute; and each dormitory above such school room, on the second floor, when occupied, is to have 1000 cubic feet of air per minute, and when unoccupied, 167 cubic feet of air per minute.

[9th] Keeping in view that it is proposed to maintain the temperature of the air in the ducts at 50° at all times when the external air falls below that point; with the above data in order on the table, it will be safe to assume for each cubic foot of air demanded as per conditions *A*, one-fifth a square foot of heating surface will be required in the local coil to raise the temperature of the air for ventilation from 50° to 80° or 90°; and for each cubic foot of space within the walls of the rooms or place which is to be heated indirectly, as per conditions *B* or *C*, one-one hundred and twentieth of a square foot of heating surface will be required; and for each cubic foot of space within the walls or place which is to be heated directly

one-eighteth of a square foot of heating surface will be required.

[10th] These quantities in column (9) are to be altered by adding 10 per cent. for the first story or ground floor, and deducting 10 per cent. for each story above the ~~first (or ground)~~ second story when the temperatures are fixed at 70°. By making *judicious* corrections for temperature, less or greater than 70°, and by making further *judicious* corrections for the conditions of exposure and of window surface, and for height of rooms above ~~twelve~~ fourteen feet. The total result of these additions or deductions need not or should not vary considerably from the totals of values in column (9) as the ratios of surfaces given in the paragraph (9) are sufficiently large for supplying heat to the buildings as a whole.

[11th] This column should give the actual heating surface needed under the given conditions for each room or place severally. The surfaces demanded by E and F are to be assumed quantities to be incorporated in this column.

Having Table I in view, Table II will be prepared: On this table will be placed, referring to the cellar and other plans, every coil and surface for heating:

[1st] Designation of locality and descriptive list.

[2d] Numbering a_1, b_1, c_1, d_1, etc., a_2, b_2, c_2, d_2, etc., for similar coils in 1st and 2d Pavilion; and A, B, C, D, etc., for coils in centre Pavilion and Infirmary or Chapel.

[3d] Number of rooms to be supplied with heat or air.

[4th] Separate surface of coil obtained from table (I) from all the rooms.

[5th] Total surface of coil obtained from table (I) from all the rooms.

[6th] Separate volume of air obtained from table (I) from all the rooms.

[7th] Total volume of air obtained from table (I) from all the rooms.

[8th] Distance of Location of Coil from Boilers or Fans measuring the entire length of ducts or passages.

[9th] Areas of steam supply and return water pipes of coils, in circular inches, as given by rule in the specification, under the head of "Mains."

[10th] Areas of air duct to coil, as given by rule in the specification, under the head of "Ducts and Flues."

[11th] Ratio of correction at enlargement of one-four hundredth part for each foot distance from boiler and fan.

[12th] Corrected area of steam supply and return water pipes of coils.

[13th] Corrected area of air ducts at coils or flues in walls.

Having prepared Tables I & II, Table III can be constructed on the same principles, which shall give, in accordance with the rules of the specification under the head of mains, the dimensions of the steam supply and return-water mains at all points in their course.

And the same Tables I & II, will enable a Table IV to be prepared, following the rules of the specification under the head of ducts and flues, showing the areas of the main air duct at any point of the flues for distribution of air from the main duct.

While from the same source of Tables I & II, will be obtained the data to prepare Table V, which will give the areas of the controlling, supply, and discharge registers.

§ Hot-Water Recipient.—The main return pipe will terminate in a recipient, placed in the boiler room or house.

This will be a cylindrical vessel, with domical heads—4 ft. in diameter by 4 ft. height outside of dome heads—the heads will be a segment of a sphere (60°), being 7″ in depth, while the sides will be 2 ft. 10″ wide (or high). In the centre of the top head will be placed a man-hole, a plate of 16″ diameter of opening, with ring $2\frac{3}{4} \times \frac{3}{4}$ to strengthen the hole; the plate of wrought iron, $\frac{1}{2}$″ thick, is to bolt on by $\frac{3}{4}$″ bolts, 3″ *c.* to *c.*, and to have starting handles and screws. The iron of the sides to be C. No. 1, $\frac{5}{16}$″ thick, double riveted; of the head, C. flange $\frac{5}{16}$″ thick, single riveted to sides. It is to be tested to 80 lbs. working pressure (= 107 lbs. test, the same as the boilers). A cast iron stand must be furnished to support this recipient, and raise it about 1 ft. above the pavement of the well or pit in which it will be placed.

The fittings for this recipient will consist of a 3″ brass discharge or blow-off cock, with pipe leading to the sewer, or to 5 ft. beyond wall of buildings; a glass water gauge; a $\frac{1}{2}$″ air cock; and the connections for the main return pipe from the heating apparatus, and for the $2\frac{1}{2}$″ feed pipe to the stand column of the boilers, with $2\frac{1}{2}$″ brass stop valve.

In the line of the $2\frac{1}{2}$″ feed pipe will be placed a 3″ rotary pump, similar in all respects to those specified for the feeding of condense water from the auxiliary coils. This pump will be driven by a line of shaft from the fan engine room, and will derive its motion from the fan engine. There will also be provided an arrangement of shafting and pulleys, to allow this pump to be driven for a time (as may be desired) by the laundry shafting and engine.

§ Clothing of Steam Pipes, etc.—All the steam flow mains and branches, the steam recipients, the hot water heaters, and pipes leading to them, all surfaces, where it is desirable to

prevent loss of heat by radiation, must be covered and protected in the most approved manner. Pipes of all sizes must be shielded by wire work, or a shell of cast or wrought iron, so as to form an enclosed air space next to them, and to preserve the covering from the effect of high heat, after which the whole is enclosed in some good non-conducting fabric or material. The clothed pipes and other objects must present a neat and finished appearance when completed.

§ Hot-Water Heaters.—There will be provided four cylindrical heaters, each 8 feet long by 2 feet 6 inches diameter, with flat heads. Each heater will have 12 $2\frac{1}{2}''$ brass tubes (in two rows of 6 tubes each). The shells will be C. No. 1 iron, $\frac{1}{4}$ inch thick—the heads C. flange iron $\frac{3}{8}$ inch thick. There will be cast iron steam chests at both heads, enclosing the 12 heating tubes. These will be bolted to the heads by a flange joint and be covered by bonnets or plates, bolted to them also by flange joint. The flange joints are all to be faced. The steam-connection for 3 inch pipe will be made to the top side, and the drain connection, for 2 inch pipe, made at the lower side of the one steam chest, in which will be placed a tight (cast iron) diaphragm, separating the upper and lower row of tubes. By this arrangement the steam will pass through the upper row of tubes to the other steam chest and return through the lower row to the first. There will be a hand-hole and plate with clip in front hand as low down as possible, and the 2″ drain connection will not be in the middle of the chest to give access to the hand-hole. The hand-hole will be $6'' \times 10''$ with $2\frac{1}{2} \times \frac{5}{8}$ wrought iron ring. The heads must be stayed by 6 stay bolts above and below the tubes at both ends. The front head will not be flanged, but riveted to an angle iron rim. Bent flanges for $2\frac{1}{2}''$ screwed pipes will be riveted to the shell near both ends, top and bottom.

The heaters will stand in pairs one over the other (1 foot apart), and the lower one be elevated 1 foot from the floor. Cast iron stands and distance stands being furnished.

The pipe from the exhaust steam recipient for the fan engine is to be brought over to the hot-water heaters and connected to the steam chests with two valves at or near the heaters. An independent $1\frac{1}{2}$ inch live steam pipe is also to be brought from the boiler main to supply the exhaust steam pipe with any additional volume needed for heating a given quantity of water. This $1\frac{1}{2}''$ pipe is to have a stop valve at the boiler main and another near the heaters, and also a differential valve to operate at below 2 lbs. pressure.

§ Tool and Store Room and Furniture.—A suitable room will be allotted for use as a tool and store room. In this will be placed a fitter's work-bench (with 3″ ash top) and three lock-up drawers, and a fitter's cabinet with doors to lock. In these drawers and the cabinet all the fitter's tools will be arranged and disposed with a separate place for each. Also a sheet iron and plumber's bench (with 3″ ash top), with two lock-up drawers and two lock-up closets or cabinets for the disposition and use of the tools of the sheet iron and tinman. Also a closet for the smith tools. In all cases a separate place must be provided for each tool. Also shelves, boxes, lock-up drawers or boxes, and racks for storage in convenient and accessible order and for the protection of the valuable stores which are to be supplied. This store and tool room will have a stone hearth or floor 10 ft. square about the forge, and will be finished and arranged for a show place in the mechanical department of the College.

§ Oil Room.—There will also be allotted a suitable room or vault, fireproof, well lighted, with stone floor, to be used as an oil room. In this room will be placed a set of six oil canisters. Four of these will be 18″×18″ sq.×3·0″ high, and two 15″×15″ ×2·6″ high; they will all have hinged lids, made to shut over the top edge on three sides, and so large as to open three-fourths the top of the can. They will be made of No. 10 sheet iron, bottom and covers flanged 2″, and the joints riveted and calked

to be oil tight. They will have $\frac{3}{4}''$ brass cocks, attached by a goose neck to the *bottom* of the canisters. They will be mounted on a frame of angle iron, substantially made, 18″ high, and will stand over an iron drip trough 3 ft. wide by 6″ deep, with partitions 5″ deep for each oil canister. This drip trough is to be made of $\frac{3}{16}$ boiler plate throughout. In each separate part of the drip trough will be placed a strainer made of wrought iron $\frac{1}{4}''$ thick, and perforated with $\frac{3}{8}''$ holes, $1\frac{1}{2}''$ *c.* to *c.*, over the entire surface. These strainers will stand upon six $\frac{3}{4}''$ studs 3″ high. Three iron shelves, on brackets built into the wall, each 6 ft. long by 10″ wide, with three supporting brackets, will be required. These shelves will be like the treads of cast iron steps, only with smooth upper surface. And there will be needed for furniture of this oil room: two sets of copper measures—gallons, quarts, pints and gills; one copper oil pump for emptying a barrel into a canister; and one 20 lb. counter scale, with weights complete; and one iron table 3 ft. × 18″ with sheet metal ($\frac{1}{4}''$ thick) top, and pipe legs.

§ Tools.—There will be furnished a double set of spanner wrenches, fitting all valve stuffing boxes and centre pieces—a double set of monkey-wrenches—a full set of pipe fitter's tools up to 4 inches—pipe tongs—pliers—taps to 1″—dies to 4″—Stanwood cutters—parallel and pipe vises—one heavy wrought iron vise for chipping and forging—hand hammers and sledges—chipping chisels—fitter's chisels and augers—a bench drill—ratchet and breast drills—drills—files, etc., etc.; a portable forge—2 cwt. anvil and block—a set of smith tools for small work with hammers—sledges, etc., with smith bench and tools arranged; hand and bench shears—stakes—punches, etc., for sheet iron work, making a small set of sheet iron worker's tools; furnace, soldering irons, etc., etc, making a small set of tinman's tools; furnace—pots—ladles, etc., making a small set of plumber's tools. The whole of which tools, and such others as may be required for the repairs and maintenance of the heat-

ing and ventilating, water and gas apparatus at the College, shall be supplied, by list or schedule, at a cost of $500, at manufacturer's prices, net wholesale cash rates to dealers, which schedule shall meet the approval of the architect or some person designated by him.

§ STORES.—There shall be left upon the premises at the completion of the work, fittings of all kinds, such as were used in construction and may be requisite for repairs—a few hundred feet of assorted pipes, partly in pieces of desirable length, but mostly in whole lengths—bolts and nuts—rivets—bar and rod iron, sheet iron, plain and galvanized—lead and solder—sheet tin—rubber packing, rings and sheet—cotton yarn packing—hemp packing—gasket—red lead—white lead—oil—brushes, etc., etc., to be supplied by approved schedule at a cost of $200 (valued as provided above for the tools).