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Audit Report & File		



SCOTTISH
FIRE AND RESCUE SERVICE

FIRE INVESTIGATION REPORT

REPORT OF FIRE AT:

Premises:	Mackintosh Building, 167 Renfrew Street, Glasgow				
Post Code:	G3 6PQ				
Occupier:	Glasgow School of Art				
Day of Call:	Friday	Date of Call:	23/05/14	Time of Call:	12:27
Incident No:	21735141	No. of Calls:	37	Grid Reference:	258133, 666052
Appliances first Mobilised	T01A1 Rescue Pump (RP) (Cowcaddens), T01A2 (RP) (Cowcaddens), T04A1 (RP) (Yorkhill)				
Incident Commander (First Attendance):	Watch Commander Stockton				
Other Appliances attending:	T02D1 Arial Rescue Pump (ARP) T02A2 (RP) (Maryhill), M04A1 Support Pump (Milngavie), M04L1 Forward Control Unit (FCU) (Milngavie), V05A2 (RP) (Calton), VO4D1 (ARP) V04A2 (RP) (Polmadie), V01A1 (RP) (Govan), V04A2 (RP) (Polmadie), V05A1 (RP) (Calton), M01K1 Major Incident Unit (MIU) (Clydebank), T02D1 (ARP) (Maryhill), T06D1 (ARP) (Springburn), 554 Fire Investigation Unit (FIU) (Livingston)				
Incident Commander (Overall):	Assistant Chief Officer Goodhew.				
Method of Extinguishing fire:	Six jets and three ARP's in use as water towers.				
Audio Visual Officers:	Frank Kelly John Hannah				

OTHER SERVICES ATTENDING AND CONTACT DETAILS

Police Liaison Officer:	Inspector Wright H179 Police Incident Officer
Police:	Detective Inspector (D.I) Nicola Burnett 290842, Detective Sergeant (D.S) Phil McLauchlan G6019, Detective Constable (D.C) Christopher Sneddon G6238, G/ Division CID, Aikinhead Road Police Station, Glasgow.
Ambulance Service:	Ray Currie (Glasgow South) 07833483780
Doctor / Police Surgeon:	N/A
Police Photographer:	Robert Smith (Easterhouse) 5012198
Forensic Scientist:	Alison Marven Gartcosh.
Procurator Fiscal Contact:	N/A
Gas:	Attended No Details.
Electricity:	Attended No Details
Others:	N/A

FI-WH-GC-006-14 – 21735141 - MACKINTOSH BUILDING, 167 RENFREW STREET, GLASGOW, G3 6PQ (REDACTED)

SIGNED:

DATED:

This report has been compiled by the undernoted officer who has been duly authorised in writing by the Chief Officer or his/her Deputy or Assistant Chief Officer to carry out the functions and exercise the powers as detailed within Section 29 of the Fire (Scotland) Act 2005.

Reporting Officer:	Graeme Warnock	Age:	
Role:	Watch Manager (WM)	Service:	24
On-duty Contact:	As Above	Telephone:	01506 442489
Email:	Graeme.warnock@firescotland.gov.uk	Fax:	01506 438152
Address:	Fire Investigation Unit, East Service Delivery Area, Craigshill Fire Station, Craigshill Road, Livingston EH54 5DT.		
FI Attendance Details:	<p>WM's Warnock and McDevitt attended the scene at 14:00 on Friday the 23rd of May. They liaised with Group Manager Wright who was appointed as Fire Investigation Officer as this was a level three incident.</p> <p>WM's Peacock and O'Neill from FIU West assisted by obtaining witness statements from the fire crews who attended the incident.</p> <p>WM's Warnock and McDevitt returned to conclude their physical investigation of the scene on Saturday the 24th of May 2014.</p> <p>WM's Warnock and Steel returned on Saturday the 23rd of August to obtain further information for the report.</p>		

Fire Service Terminology

To ensure safe operations whilst using breathing apparatus (BA), appropriate and recognised control measures are used. Stage I (one) is used to apply control procedures to meet the demands of small or limited incidents and Stage II (two) is used to apply control procedures which meet the demands of larger and more complex incidents. Stage II introduces additional control measures to monitor the safety of breathing apparatus BA wearers and was implemented in this instance due to the large number of BA wearers being deployed to various locations within the building.

Incident command is categorised from levels one to five, with five being the highest. Each category has a pre-set level of resources attending. For example, a level two incident will result in five pumping appliances attending. Each level response from Level 2 onwards, increases the attendance by an additional three pumping appliances, along with specialist resources as required.

FIRE INVESTIGATION REPORT – NARRATIVE**SEQUENCE OF EVENTS:**

At 12:27 on Friday the 23rd of May 2014, the Scottish Fire and Rescue Service Operations Control Johnston received a call stating there was an automatic fire alarm activation at 167 Renfrew Street, Glasgow. This was the Glasgow School of Art, Mackintosh Building. The control room mobilised the Pre-Determined Attendance (PDA) of TO1A1, TO1A2 and TO4A1. This initial call was followed by a number of repeat calls starting at 12:34 confirming that this was a building alight.

TO1A1 with Watch Commander (WC) Stockton in charge arrived on scene at 12:31 and began assessing the situation and gathering information. At 12:42 WC Stockton sent an informative message stating there was a fire in the basement of a three storey building (sic) and that there were persons unaccounted for within the building. This is known as 'persons reported.' They were at work with one high pressure hose reel (HRJ) and four breathing apparatus (BA). He also made this a level two incident.

Group Commander (GC) Goodlet assumed the role of Incident Commander (IC) at 12:51 and at 13:02 an assistance message was received at control raising the incident level to three.

Fire Investigation from the East Service Delivery Area were mobilised as this was now a level three incident. Fire Investigation from the West Service Delivery Area was attending another incident and therefor unavailable.

At 13:04 GC Goodlet sent an informative message stating the incident was being sectorised and sectors one and four were being set up. He also stated there were ten BA, two main jets, two HRJ's and an Aerial Rescue Appliance being set up.

At 13:19 Assistant Chief Officer (ACO) Goodhew assumed the role of IC. At 13:40 an assistance message was received at control raising the incident level to four. An informative message was sent at 13:43 stating the fire in the basement had spread through voids to the roof space and personnel were at work with ten BA, two ARP's and four jets. At 13:56, a further informative was sent stating thirty percent of the building was well alight and personnel were implementing a firebreak in stairwell to divide building in two.

The Fire Investigation Unit arrived at 14:00 and began the process of investigating the origin and cause of the fire.

At 15:06 a further informative was sent stating stage two BA was in use, four jets and three ARP's also in use. Crews establishing firebreak in roof space, considerable fire spread on all floors and within hidden voids, salvage plan now in operation and light portable pumps pumping water from basements.

A further informative message was sent at 17:25 stating steady progress being made in all sectors. Ten BA, six jets and three ARP's in use.

At 19:24 a further informative message was sent stating that good progress was being made extinguishing hot spots and breaking into voids. Two ARP's being used as water towers and six BA. A total of one hundred and twenty BA sets had been used at this incident so far. Salvage work still being undertaken.

Area Commander (AC) McGhee assumed the role of IC at 19:43. At 20:11 he sent an informative message stating one sector carrying out firefighting operations and one sector carrying out salvage operations. Six BA in use damping down and dealing with hot spots. One team establishing lighting

FI-WH-GC-006-14 – 21735141 - MACKINTOSH BUILDING, 167 RENFREW STREET, GLASGOW, G3 6PQ (REDACTED)

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for night time operations, Safety Officer conducting Analytical Risk Assessment (ARA) for night time operations.

Damping down and extinguishing hot spots continued throughout the night. AC Fairbairn assumed the role of IC at 02:52.

At 10:20 on Saturday the 24th of May a stop message was sent by AC Fairbairn.

AC Tanzilli assumed the role of IC at 10:27.

Damping down and extinguishing hot spots and salvage work in conjunction with staff from the school of Art continued throughout the rest of the 24th of May through to the 30th of May

At 15:15 on Friday the 30th of May, the Scottish Fire and Rescue Service completed operations at the scene and left the incident.

DESCRIPTION OF PREMISES:

The Glasgow School of Art (GSA) is Scotland's only public self-governing art school offering university level programmes and research in architecture, fine art and design.

The building measures 50 metres by 25 metres and consists of ten levels which include mezzanine levels. It was built in two stages, the eastside of the building was built between 1897 and 1899 and the west side between 1907 and 1909. Honeyman and Keppie were the architectural firm commissioned to construct the building from a Charles Rennie Mackintosh design. **See photo's 1, 2 and 3.**

Building Construction

Walls	Sandstone blockwork.
Roof	Combination of roofing including timber pitched roof with covering of slate, glazed pitched roof and lead sheet roofing.
Windows	Single glazed and leaded, ranging from small and basic to ornate stained glass.
Doors	Timber exterior doors, interior doors were mostly timber with decorative glazed panels.
Internal walls	Lath and plaster. Timber cladding to either full or half wall in corridors. Timber stud and plasterboard walls between some studios on second floor.
Ceilings	Lath and plaster
Floors	Concrete floors, timber floors strengthened with Rolled Steel Joists.
VOIDS	Multiple voids running vertically and horizontally throughout the building carrying services such as pipework and electrical cabling.

Heating and ventilating system consisted of brick lined vertical shafts, timber lined vertical shafts and horizontal timber ducts. This original system was obsolete and non-operational.

Description and uses of each floor

The building consists of 10 different levels which include basements and mezzanine levels (M).

Sub-basement	Used for storage/plant and only found in west side of building.
Basement	Range of studios and offices. The studios have skylights/glazed roofs which look out just below pavement level.
Basement (M)	Offices.
Ground Floor	Offices, administration and studios.
Ground Floor (M)	Offices.
First Floor	Studios, Directors Offices and library.
First Floor	Library. Library Balcony
First Floor (M)	Offices and storage.
Second Floor	Studios. Professors Studios and offices.
Second Floor (M)	Storage.

DESCRIPTION OF DAMAGE:

Vast majority of fire damage was confined to the west side of the building.

Sub-basement	Water and smoke damage.
Basement	Water damage, smoke damage to studios and offices. Severe fire and heat damage to studio 19.
Basement (M)	Water damage, smoke damage to offices.
Ground Floor	Water damage, smoke damage. Severe fire and heat damage to void areas and ceiling level in studio 31. Severe fire and heat damage throughout studio 32.
Ground Floor (M)	Water damage, smoke damage to offices.
First Floor	Water damage, smoke damage to studios 43, 44, 45 and offices. Severe fire and heat damage to library.
First Floor Library Balcony	Water damage, smoke damage, severe fire and heat damage to library.
First Floor (M)	Water damage, smoke damage, severe fire and heat damage to library, offices and storage.
Second Floor	Water damage, smoke damage, severe fire and heat damage to studios 57, 58, Professors Studios, Hen Run and offices. Majority of roof construction destroyed, this was close board timber and lead sheet roofing.
Second Floor (M)	Smoke damage, severe fire and heat damage.

FI-WH-GC-006-14 – 21735141 - MACKINTOSH BUILDING, 167 RENFREW STREET, GLASGOW, G3 6PQ (REDACTED)

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DEVELOPMENT OF FIRE:

A major contributory factor for the fire spreading throughout the building was the number of timber lined voids and obsolete ventilation ducts running both vertically and horizontally throughout the building. The vertical ventilation ducts consisted of both brick lined, located within the walls and timber ducts mounted on the wall surface. The brick lined ducts were formed within the structure of the walls. Horizontal ducts were timber and in some instances sheet metal. See plan drawing Numbers 1, 2 and 3 showing architect plans.

The fire originated in the vicinity of the projector which was located in the student display area of studio 19 which was in the basement in the west side of the building. **See photos 4, 5, 6 and 7.**

As the fire grew in size flames impinged onto the expanded foam panels positioned behind the projector. These foam panels were installed as part of the students work and were attached to the walls in the display area. Fire would have spread laterally around the foam lined room as well as vertically towards ceiling level. Flames would have travelled up the wall directly behind where the projector was positioned.

This wall area was lined with timber panels – Canadian redwood pine, which formed the outer covering of a vertical service void. An area slightly to the left of the projector had some panels removed allowing access for ongoing maintenance **See photo 8.** This void ran the entire height of the building to roof level. **See photo 9.** This timber lined void acted like a chimney and allowed flames, hot gases and smoke to travel vertically.

As flames and hot gases reached ceiling level of studio 19 they spread horizontally igniting further timber panelling and when these failed flames, hot gases and smoke entered further voids on the same wall but on the other side of the doorway of studio 19.

Flames then travelled through these voids in to studio 31 on the ground floor, directly above studio 19. Fire spread vertically either side of the doorway and also horizontally behind the timber panelling in a westerly direction in studio 31. **See photos 10, 11 and 12.** At least four voids run vertically through studio 31 and these allowed unchecked fire spread to areas above as well as on the same level.

One of these voids allowed lateral access to studio 32 at ceiling level. **See photo 13.**

From studio 32 fire spread through voids to the Mackintosh library above. **See photo 14.**

The construction, layout, and high fire loading which included timber furniture, panelling and books meant the room contents became totally involved in fire. **See photo 15.** From the library fire spread vertically via voids to the library storage space above and then into studio 58 via these same voids. **See photo 16.**

Returning to the ground floor within studio 31, fire then spread via all four vertical voids to the first floor studios above, 43, 44 and 45. It achieved this by breaking through timber panelling which covered the voids, allowing access into the corridor outside the studios. An example of fire spread via the voids in studio 44 on the first floor to the second floor above is shown in **photo 17.**

Flames then travelled up the walls to ceiling level, traversed across the ceiling and exited at window level. The inrush of oxygen via the broken windows intensified the fire. **See photo 18.**

On the second floor fire spread laterally from the professor studios to studio 57 **see photo 19.** From here, fire also spread into studio 58. In effect, studio 58 was being attacked on two fronts by fire spread from below and from the same floor.

Photo 20 shows the area known as the Hen Run, fire spread to this area from the professor studios which were located on the other side of the wall on the left of the image.

The studios on the north side of the building overlooking Renfrew Street were constructed of timber, glass and lead lined roofs. Once these failed the inrush of oxygen intensified the fire affecting the second floor. **See photos 21 and 22.**

Photo 23 shows fire consuming studio 57 on the north east side of the building and **photo 24** shows firefighting operations on the north side of the building.

Fire spreading within the library and up to studio 58 south can be seen in **photo 25.**

OBSERVATIONS:

Final Degree Show

As part of their final assessment, students were exhibiting their work in the degree show. Fourth year students with help from other students are allocated a specific exhibition area within a studio to display their work.

From the beginning of the week students had been working in their areas preparing their work. Some areas were purely used as exhibiting space where other areas were part of the exhibit, for example material applied to the walls. **See photo 26.**

Studio 19

Studio 19 is a room located in the basement of the west part of the building on the north side. Access is gained from a corridor running east to west. It has a partial glazed roof at the front that looks out onto Renfrew Street at pavement level. It is rectangular and measures approximately 8 metres wide by 16 metres long by 6 metres in height.

There is a set of doors leading to studio 20 and an exit door leading to a small basement courtyard. Studio 19 contained three temporary structures designed to compartmentise the studio and allow separate areas for students to prepare and display their work. Entering the studio from the corridor the area on the immediate left contained the structure where the fire originated.

Student Exhibition Space

The temporary structure that formed the display area measured 6m x 2.5m x 2.4m. **See photo 27.** The walls were constructed of chipboard and wooden studs and the ceiling was of stretched polythene. This particular display area had panels of high expansion foam approximately 50-75mm in depth fastened to three of the walls. The other wall was blank to receive the projected image from a shelf mounted projector on the opposite wall.

The foam panels were made out-with the school and brought in by the students. When fastened to the walls there were gaps visible. These gaps were filled in by applying foam directly from the can. Foam was also sprayed between gaps around the shelf where the projector was positioned. The projector was on and had been running for two to three hours.

Expanding Foam

The trade name of the expanding foam was "No Nonsense Expanding Foam Hand Held" It was in a pressurised steel container and contained 750ml of product. This was a polyurethane foam primarily used to fill in gaps during building projects for example to fill gaps in irregular holes and around pipework. In this instance it was being used for its artistic effect. In total some fifty cans of foam was used to produce the panels.

This foam is classed as a hazardous product. It is extremely flammable and harmful to health. The foam is in a liquid form within the can and is known as polymethylene polyphenyl Isocyanate. When expelled from the can and allowed to dry it is extremely flammable. We could find no evidence to suggest that this product failed to perform to the standards specified by its manufacturer.

Projector

The projector was an Epson EMP-TW680. **See photo 28.** Purchased by the school in 2008. While operating it consumed 240 watts and its lamp source contained a 170 watt ultra-high energy (UHE) bulb.

The projector was Glasgow School of Art (GSA) property and was loaned out to the student. On the day of the fire it had been switched on at around 9am and had been running constantly with the exception of a few minutes when it was turned off to install a RCD adaptor between the wall socket and plug. It was connected to a DVD player on an adjacent shelf and was projecting an image onto the opposite wall.

The projector generates a large amount of heat when operating and a built in fan entrains air from the surrounding areas which is blown across the internal parts of the projector and lamp assembly to dissipate heat and keep it from overheating. This bulb has a surface temperature in excess of 200 degrees Celsius and was contained within the lamp assembly. The filament will easily have a temperature in excess of 1000 degrees Celsius.

The projector was maintained by the Technical Services department of the school. It was subject to an inspection, clean and test prior to being loaned out to students. It was subject to portable appliance testing (PAT) which was carried out in December 2013.

Students are advised when they take out equipment to make sure that air intake & outlet are not covered and if required to make holes in boxes/plinths to allow the air to circulate properly. They are also informed not to use them in dusty environments.

FI-WH-GC-006-14 – 21735141 - MACKINTOSH BUILDING, 167 RENFREW STREET, GLASGOW, G3 6PQ (REDACTED)

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In previous years there is only one record of a projector failing and this was due to a blown light bulb. This occurred when the projector was in a very cold room and the invigilators ignored user instructions and unplugged it at the mains, without allowing the light bulb to cool down after use.

A check was made of the UK-AFI and electrical safety first web sites to see if a recall was in force for the projector. These web sites are dedicated to publicising and recalling faulty, defective and dangerous products. Epson's own web site was also checked for recalls.

There was no record of recall of the projector due to faults or defect. No previous records or reports were found of this type of projector being responsible for a fire. We could find no evidence to suggest that a fault occurred within this product which caused the ignition of the flammable gases.

Ignition

The foam is expelled by a propellant which is a mixture of three highly flammable gases. They are propane, isobutane and dimethyl ether.

They all form an explosive and flammable mixture with air even at low concentrations. All three gases are extremely flammable and should not come into contact with naked flames or hot surfaces.

Isobutane, propane and dimethyl ether are all heavier than air and will gradually drop to floor level before dissipating into the atmosphere through natural air circulation and ventilation. In this instance the canister of foam is being held upside down and the propellant expelled just below the projector at a height of approximately 1.7 metres from floor level.

Hot surfaces can cause ignition of the flammable gases/air mixture either directly or indirectly. Therefore two causes of ignition could be considered, namely;

Direct ignition. This will occur if the hot surface is at a temperature above the auto ignition temperature* of the propellant gasses expelled from the canister. In this case the auto ignition temperature of propane, isobutane and dimethyl ether are 470°, 462° and 350° degrees Celsius respectively. It's unlikely that the surface temperature of any internal part of the projector other than the sealed bulb filament were at these temperatures.

Indirect Ignition. The projector is not intrinsically safe** and when it is energised and operating normally the electrical equipment within often creates internal tiny sparks in switches, motor brushes, connectors etc. Therefore flammable gases passing across electrical equipment are likely to come into contact with an ignition source. The minimum ignition energy required to ignite propane and isobutene is 0.25 millijoules and dimethyl ether is 0.26 millijoules***. This level of energy can be created on the surface of a printed circuit board.

Due to the level of destruction of the projector, it's not possible to state for certain exactly what caused the flammable gases to ignite. Consideration was given to the hot bulb cracking and either the filament within igniting the gases or the electric spark created by the filament breaking would be a sufficient ignition source but the bulb is unlikely to fracture just because cooler flammable gases are passing over it.

Therefore, indirect ignition from an electrical spark is the most likely cause for the flammable gases igniting.

*The *Autoignition Temperature* - or the minimum temperature required to ignite a gas or vapour in air without a spark or flame being present.

**Intrinsic safety (IS) is a protection technique for safe operation of electrical equipment in hazardous areas by limiting the energy available for ignition.

***Minimum Ignition Energy can be referenced from Babrauskas, V (2003) Ignition Handbook.

Fire Discovered

At approximately 12:25 on Friday the 23rd of May, a fire occurs within one of these allocated display areas. There are students and staff in the immediate area who witness the insipient stage of the fire developing within and around the projector.

Attempts are made to extinguish the fire with a carbon dioxide fire extinguisher however, this has little effect due to rapid fire growth involving the foam covered walls. The alarm is raised and staff ensure all persons in the immediate area evacuate from the basement.

External

CCTV shows a number of views externally and internally. Prior to appliances arriving thick black smoke can be seen pouring from a door at basement level which leads to studio 19. This lasts for around two minutes then reduces to very small amounts. As appliances arrive, fairly light smoke can be seen drifting across Renfrew Street. Internally a camera on the first floor Mack Gallery records light and then thick black smoke which can be seen rising up the central stairwell and very quickly the upper floors are smoke logged. CCTV data shows the alarm sounding at 12:26:10. By 12:28:00 smoke is visible and by 12:30:00 thick black smoke has filled this area. From the fire alarm sounding to this area being completely smoke logged is less than four minutes. The entrance reception area also shows signs of smoke as students and staff are evacuating.

Fire developing within student exhibition space.

The foam lined walls of the space once ignited would burn rapidly. The dangers associated with Polyurethane foam can be summarised as follows:

- (i) Extremely rapid spread of flame across the surface of the material, the speed often being in excess of 0.5 metres per second;
- (ii) Very high temperatures in the order of 1,000°C can be generated during the initial stage of burning;
- (iii) The emission of large quantities of highly toxic gases and smoke.

The ceiling height and large open area of studio 19 would have contributed to a well-ventilated intense fire. As the fire spread to involve all the foam the heat and combustible gases given off would have risen to ceiling level igniting timber panels covering the voids.

Initial Firefighting

Crews are deployed from the main entrance on Renfrew Street and an entrance to the basement on Scott Street. Access is made to studio 19 and the fire extinguished. Crews report that the fire has been knocked down however reports of fire at higher levels and at the rear of the building come in and it is obvious the fire is spreading horizontally and vertically through hidden voids in the building.

Voids and obsolete ventilation system within the building.

There is an obsolete ventilation system running through the building. This consists of a plantroom in the basement that supplied warm air via internal brick lined shafts and timber ductwork running horizontally to studios, offices and corridors throughout the building. This heating and ventilating system is no longer in use. There are also service voids running the entire height of the building that carried pipes and cabling.

Void to the rear of studio 19

On the south wall of studio 19 there is a void that runs upwards to studio 31 above and then to the 1st and 2nd floors. Timber used to cover this void were lengths of Canadian redwood pine. Some of these panels had been removed in studio 19 to allow access to the void in order to run sprinkler pipes. The panels removed were almost directly above the location of where the projector was located.

As fire took hold and developed within studio 19 it spread easily to the studio above rapidly and unchecked via this void.

On the same south wall, fire at ceiling level of studio 19 also broke through timber panelling allowing fire to spread unchecked to the same studio above but on the other side of the entrance door into the studio. In effect flames were entering studio 31 in multiple areas along the south wall.

Fire spread and development within timber ductwork and voids.

As flames travelled within the timber lined voids and ductwork, an intense rapidly burning fire would be the result. This is because the heat from the flames generated further flammable vapours from the pyrolysis* of the timber. This would result in larger more intense flames and the cycle would continue. As the flames were spreading vertically in an enclosed yet well-ventilated area, fire spread would have been rapid.

**Pyrolysis can be defined as the thermal decomposition of organic material through the application of heat without the addition of extra air or oxygen. When pyrolysis occurs, the timber yields flammable vapours.*

Internal Fire Suppression Systems

No water sprinkler or other extinguishing system was installed. A sprinkler system was being installed and was in the latter stages of completion however it was not operational.

CONCLUSION:

After carrying out a full and thorough investigation, which included gathering witness statements, surveying the scene internally and externally, examining physical evidence and studying post fire indicators, it is clear that this fire originated within the projector which was located in studio 19 in the basement. This projector was mounted on a shelf approximately 1.7metres from the ground and located on the south wall.

A number of causes were considered, namely deliberate act, defective appliance and accidental acts.

Deliberate and defective equipment were ruled out due to a combination of further investigations, witness statements and circumstances surrounding the incident.

The fire was caused when flammable gas used as a propellant within a canister of expanding foam was discharged in close proximity to the projector. We could find no evidence to suggest that this product failed to perform to the standards specified by its manufacturer. This flammable gas was drawn into the projector and ignited. Three gases are used as propellant within the canister, namely;

Isobutane, propane and dimethyl ether.

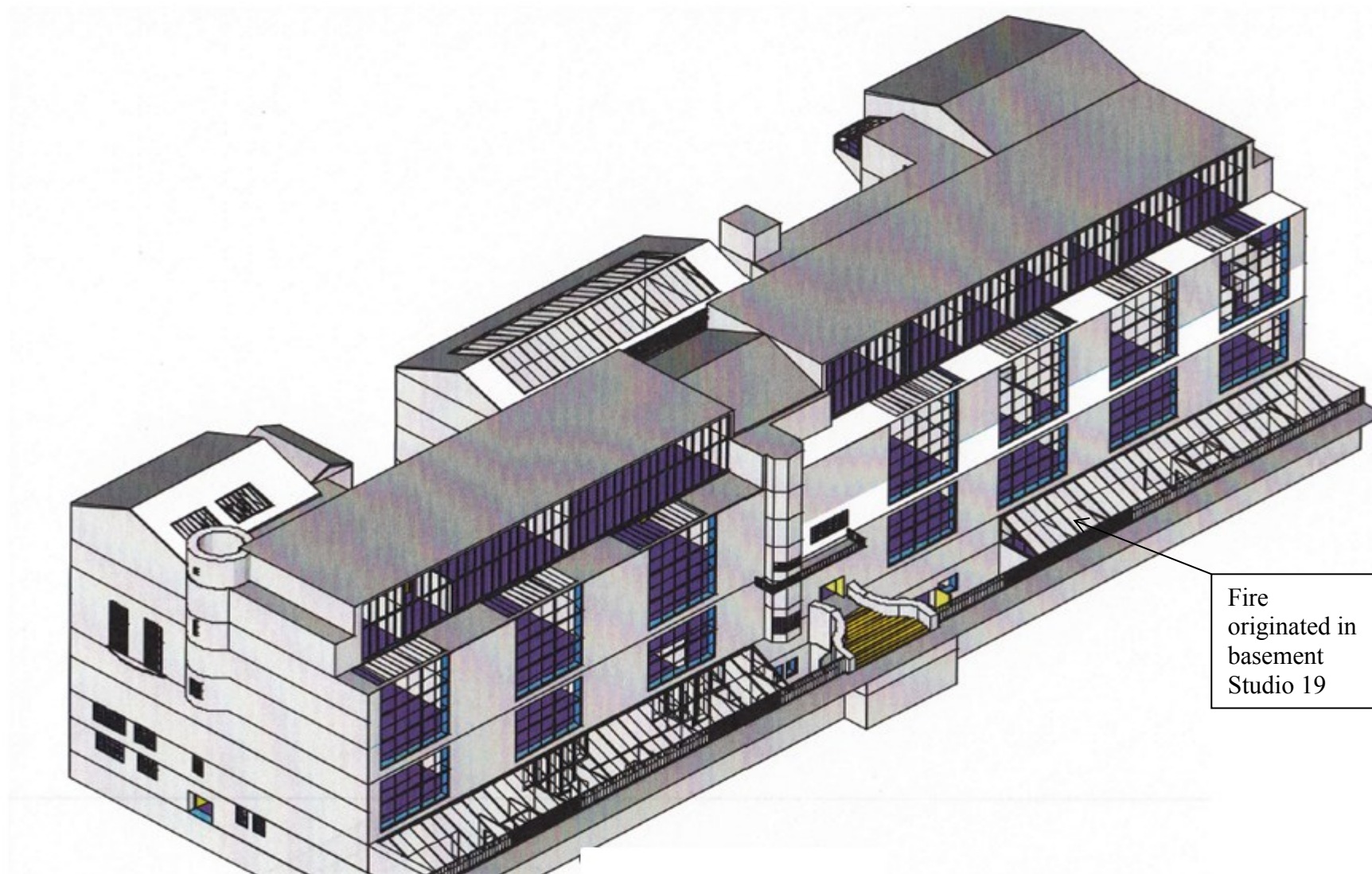
It's highly likely that a combination of all three gases when expelled at approximately 1.5metres from the ground were drawn into the projector via the cooling fan. This gas and air mixture was highly flammable and passed around electrical components before being ignited within the projector.

A number of ignition sources within the projector were considered namely, the lamp assembly and electrical components. Although there is a cooling fan the projector and its components would have been hot as it had been operating for approximately three hours. It is more likely that indirect ignition of the flammable gas occurred as it passed in and around energised electrical components of the projector. We could find no evidence to suggest that a fault occurred within this product which caused the ignition of the flammable gases.

Once ignited the flame front would have grown in size consuming plastic components and the plastic casing of the projector, flames then impinged onto the foam which was placed on the wall directly behind it. The foam then became totally involved in fire producing further flammable gases and thick black carbon rich smoke. The fire would have spread laterally around the walls of foam and vertically towards the ceiling. The timber lined void was directly above the foam lined room and as fascia panels were removed fire, hot gases and smoke would have travelled unchecked up the void vertically and horizontally affecting other floors of the building.

In conclusion, this fire originated within the projector and was caused by flammable gases used as a propellant in the expanding foam canister being drawn into the projector and igniting, most probably by energised electrical components.

PLAN 1: MAIN VIEW OF BUILDING

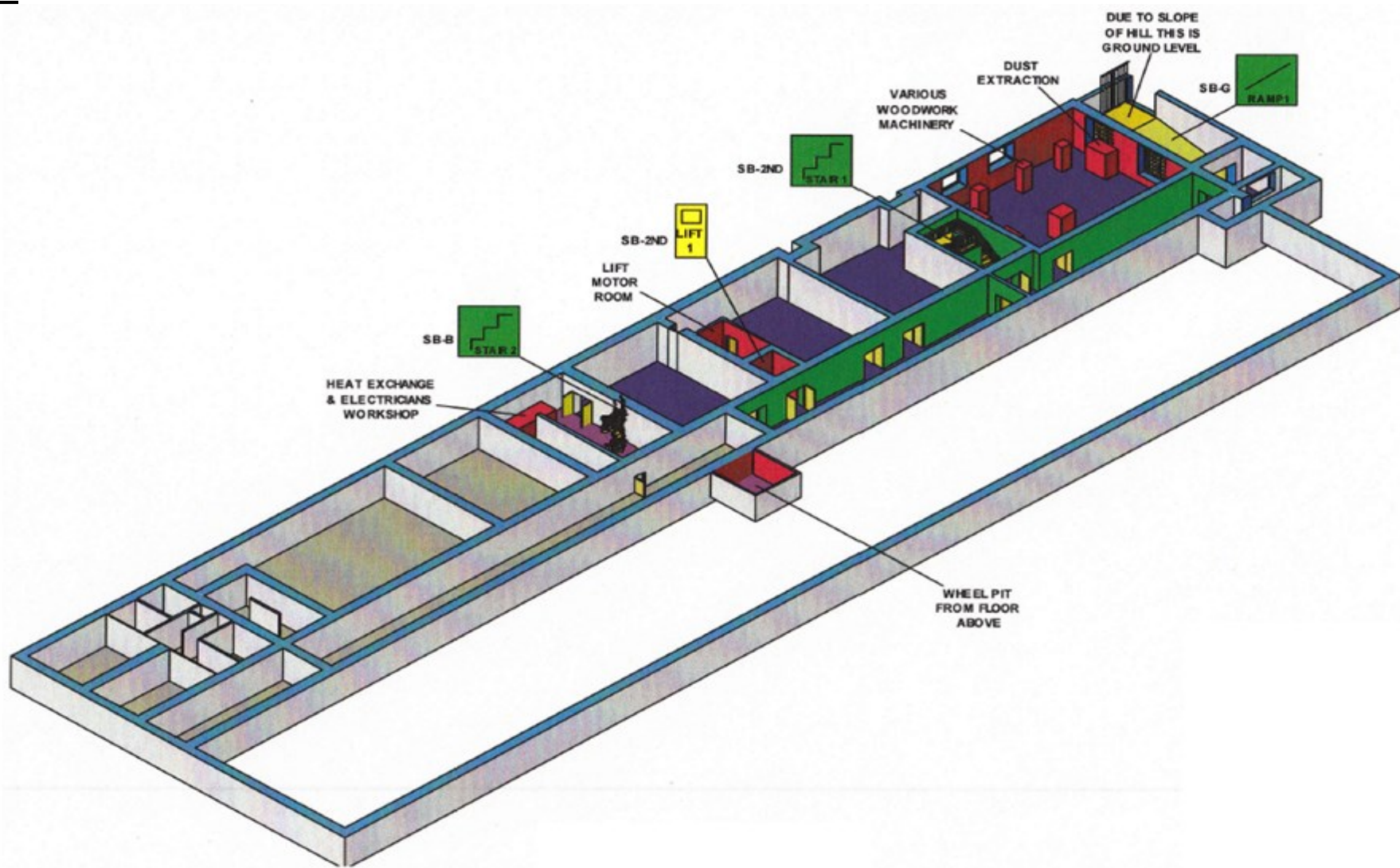


FI-WH-GC-006-14 – 21735141 - MACKINTOSH BUILDING, 167 RENFREW STREET, GLASGOW, G3 6PQ (REDACTED)

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PLAN 2: SUB BASEMENT

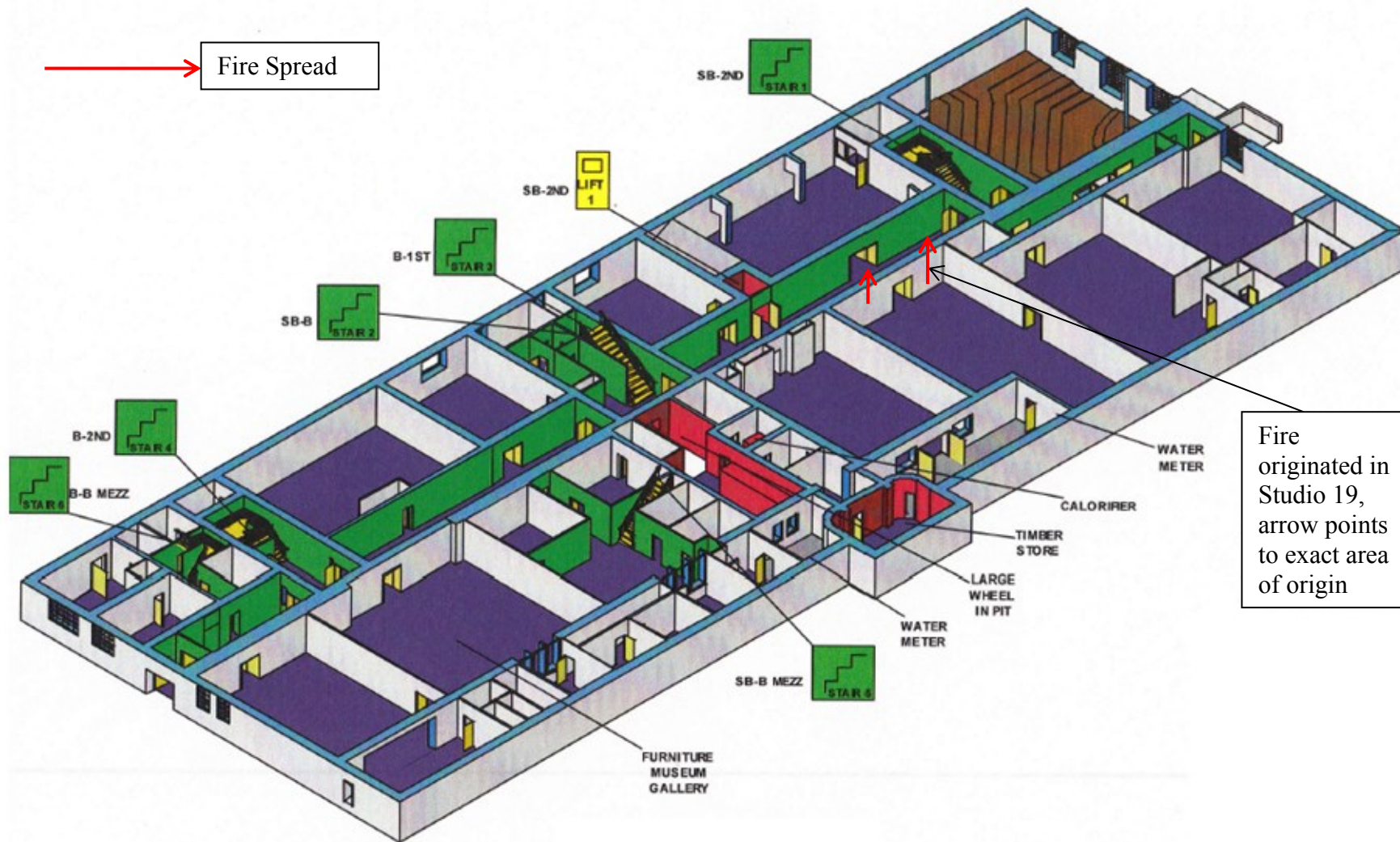


FI-WH-GC-006-14 – 21735141 - MACKINTOSH BUILDING, 167 RENFREW STREET, GLASGOW, G3 6PQ (REDACTED)

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PLAN 3: BASEMENT

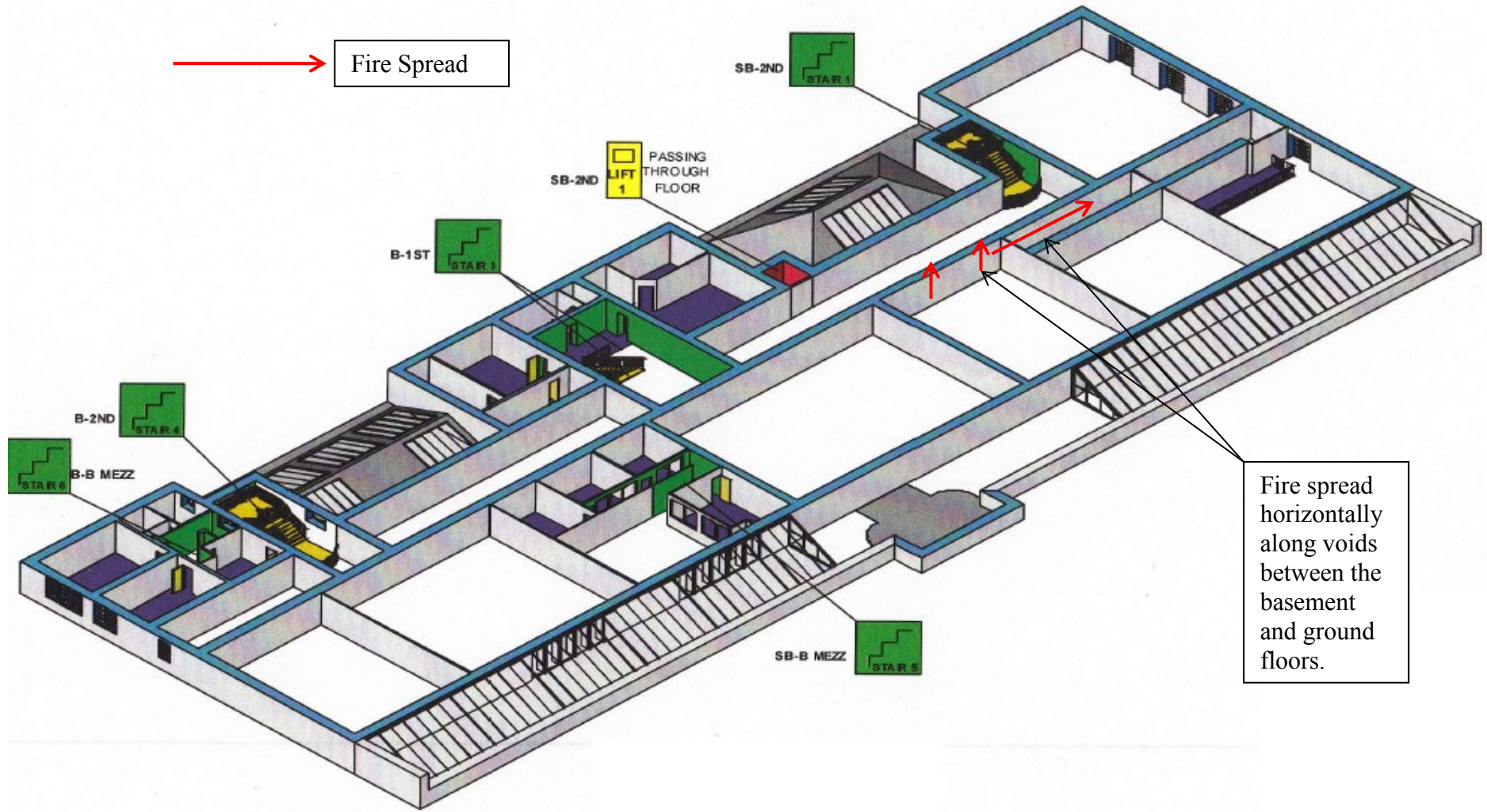


FI-WH-GC-006-14 – 21735141 - MACKINTOSH BUILDING, 167 RENFREW STREET, GLASGOW, G3 6PQ (REDACTED)

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PLAN 4: BASEMENT MEZZANINE LEVEL

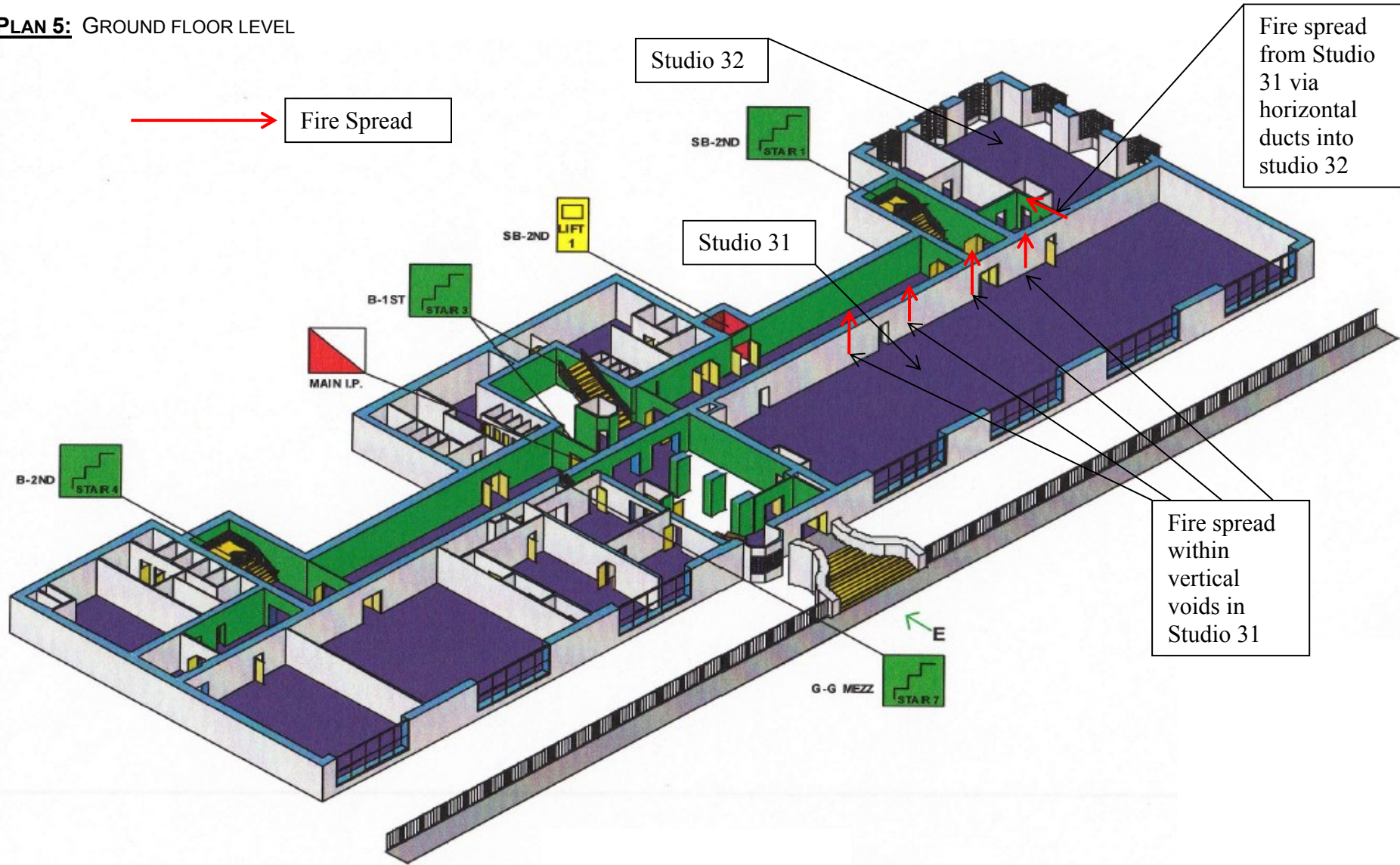


FI-WH-GC-006-14 – 21735141 - MACKINTOSH BUILDING, 167 RENFREW STREET, GLASGOW, G3 6PQ (REDACTED)

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DATED:

PLAN 5: GROUND FLOOR LEVEL

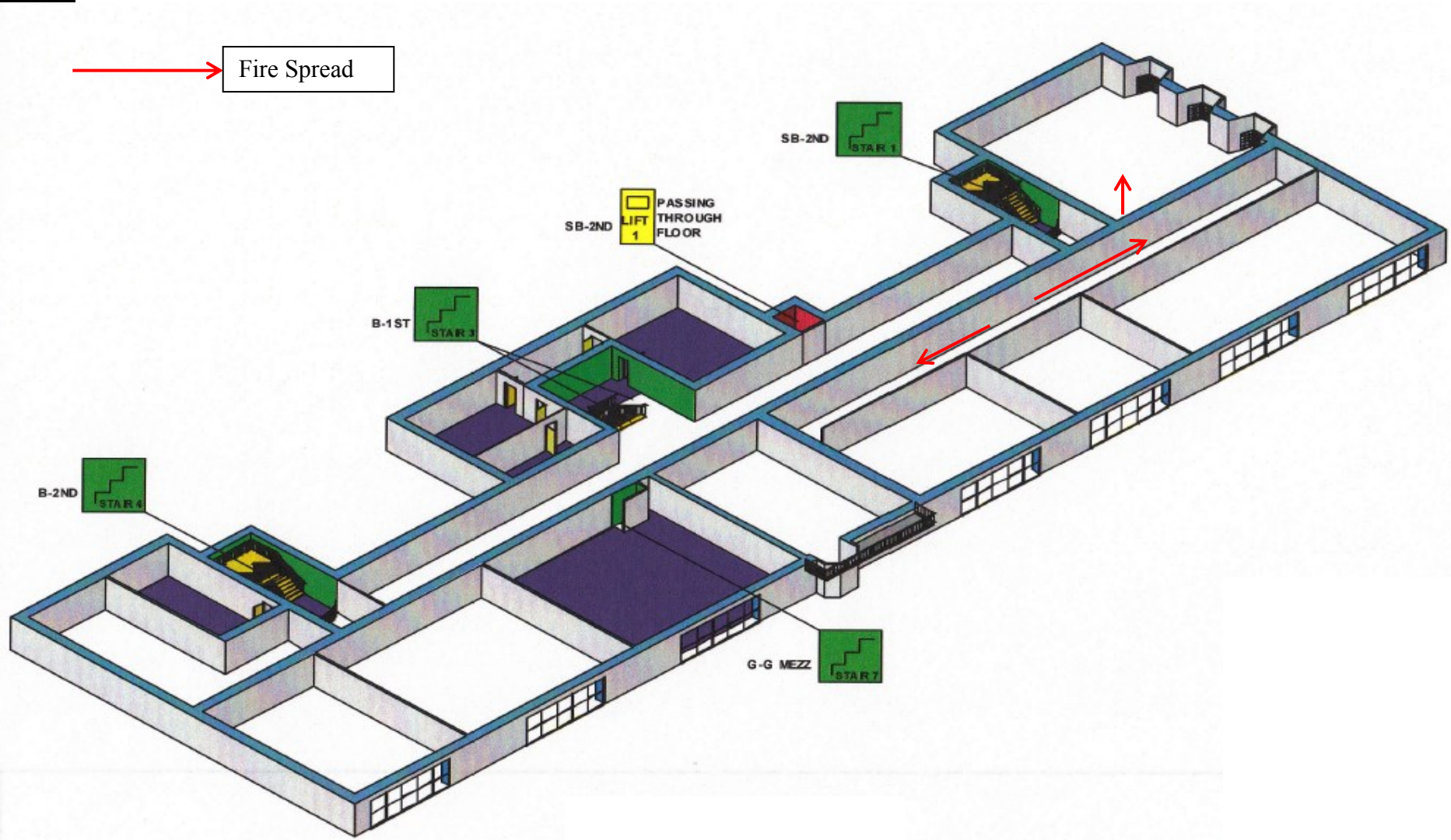


FI-WH-GC-006-14 – 21735141 - MACKINTOSH BUILDING, 167 RENFREW STREET, GLASGOW, G3 6PQ (REDACTED)

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DATED:

PLAN 6: GROUND FLOOR MEZZANINE

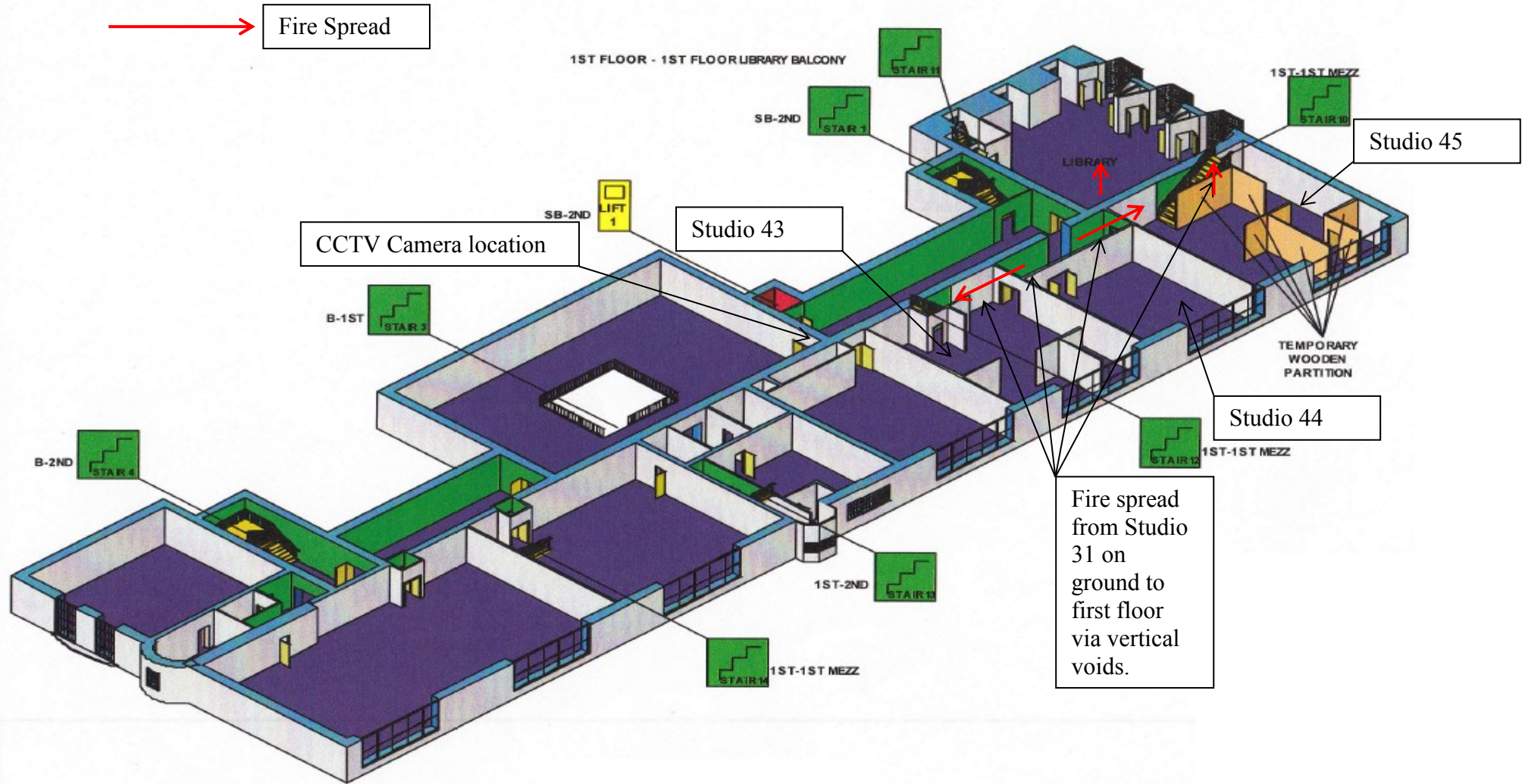


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PLAN 7: FIRST FLOOR

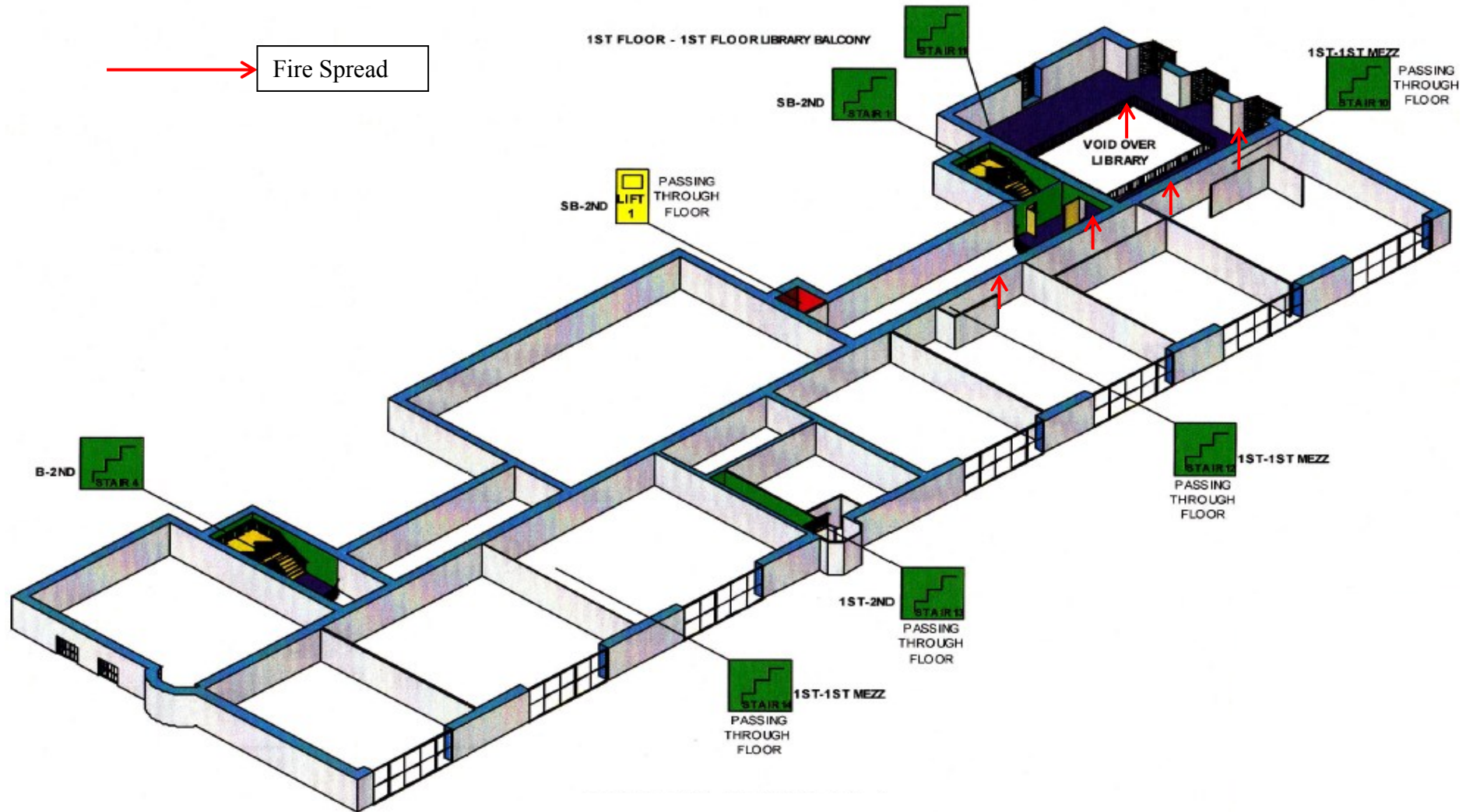


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PLAN 8: FIRST FLOOR LIBRARY

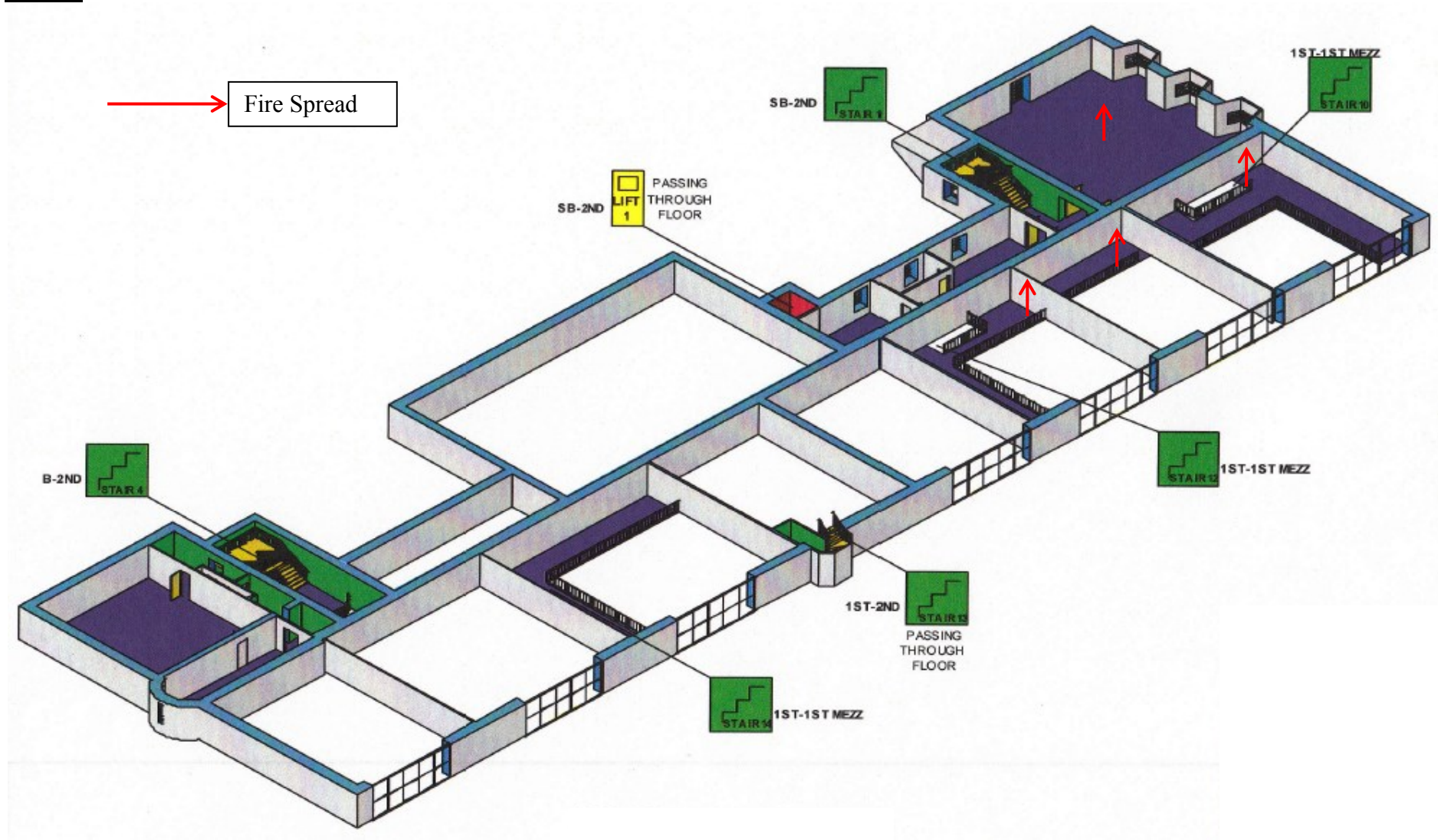


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PLAN 9: FIRST FLOOR MEZZANINE

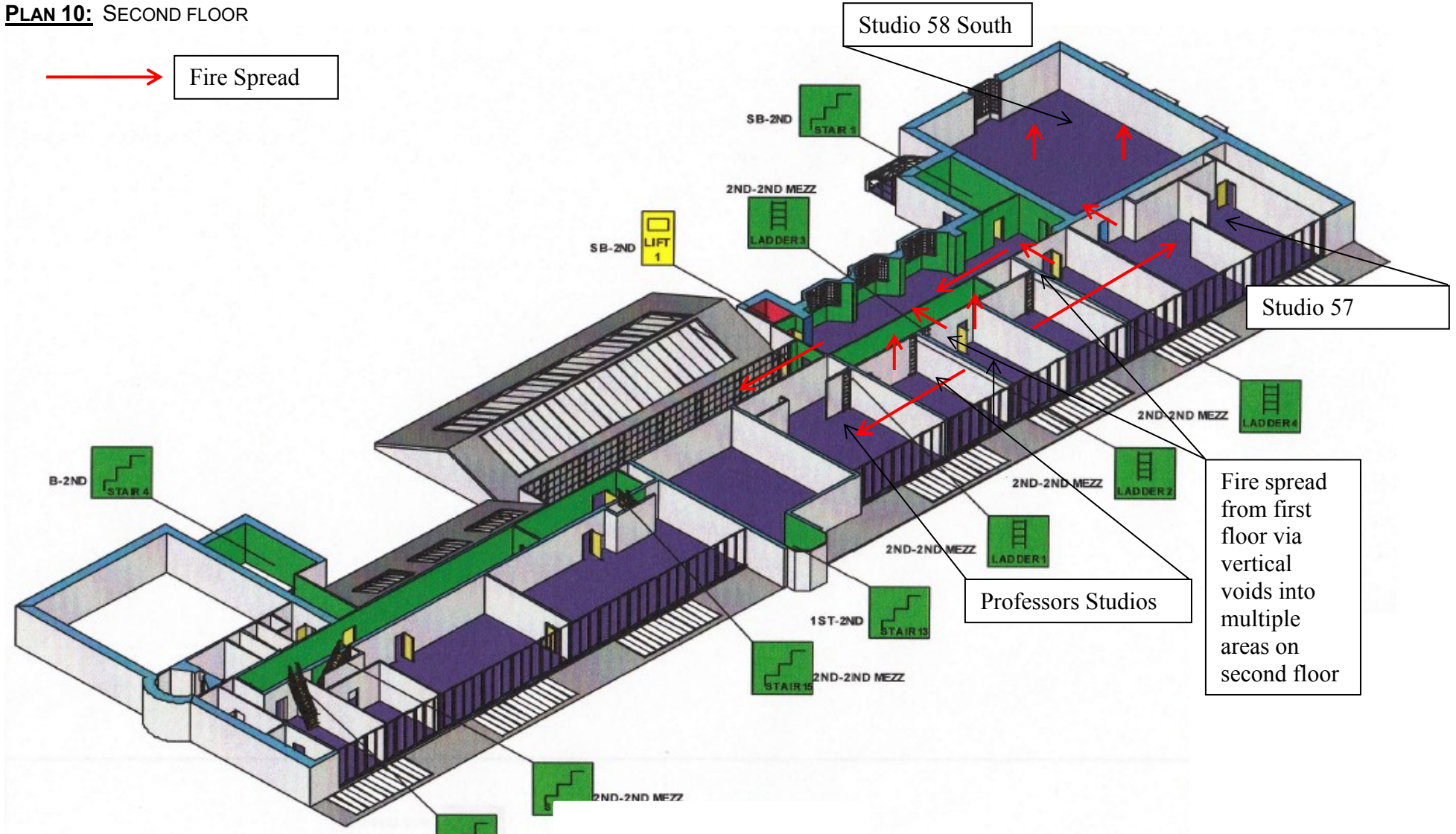


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PLAN 10: SECOND FLOOR

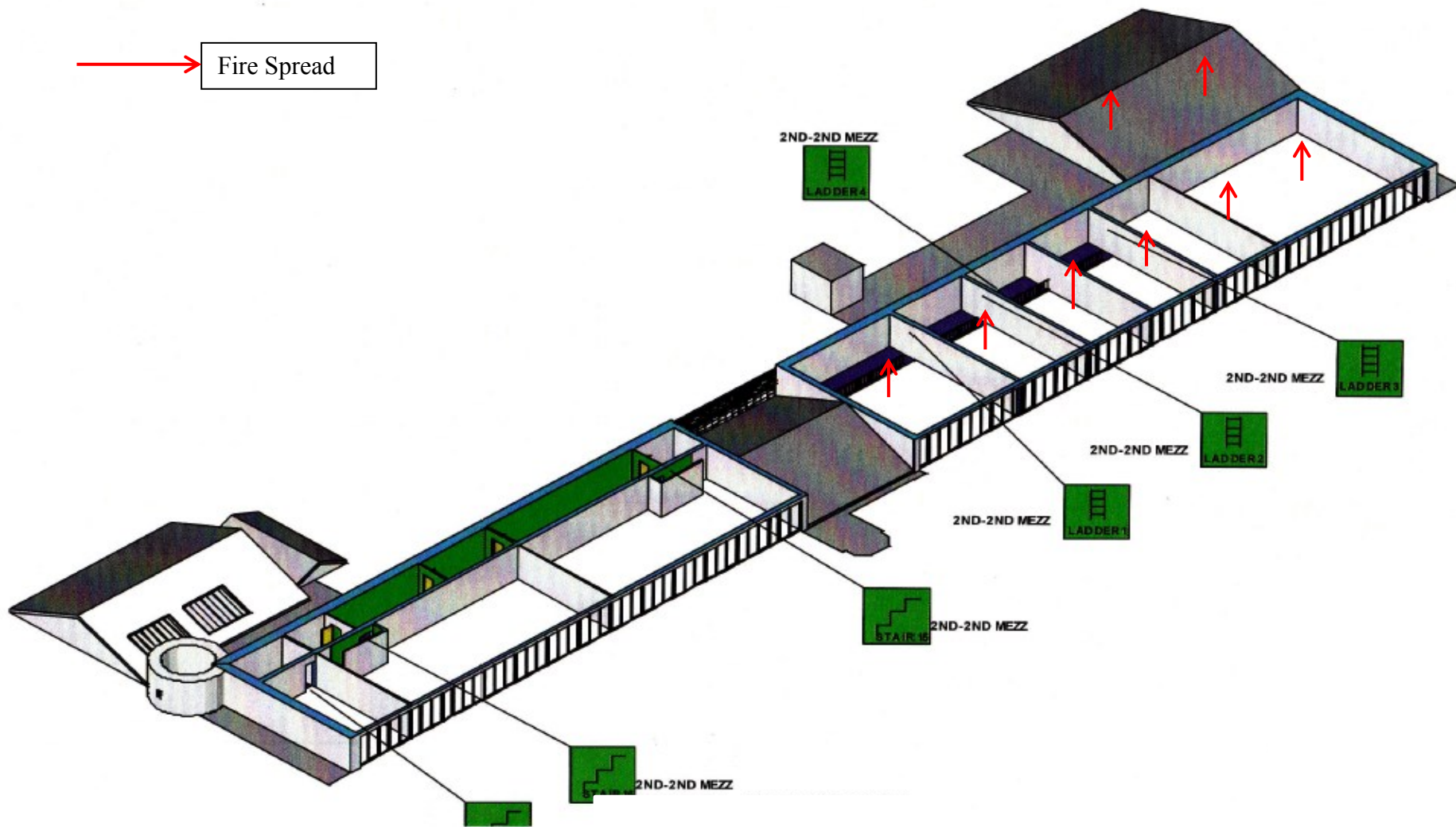


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PLAN 11: SECOND FLOOR MEZZANINE



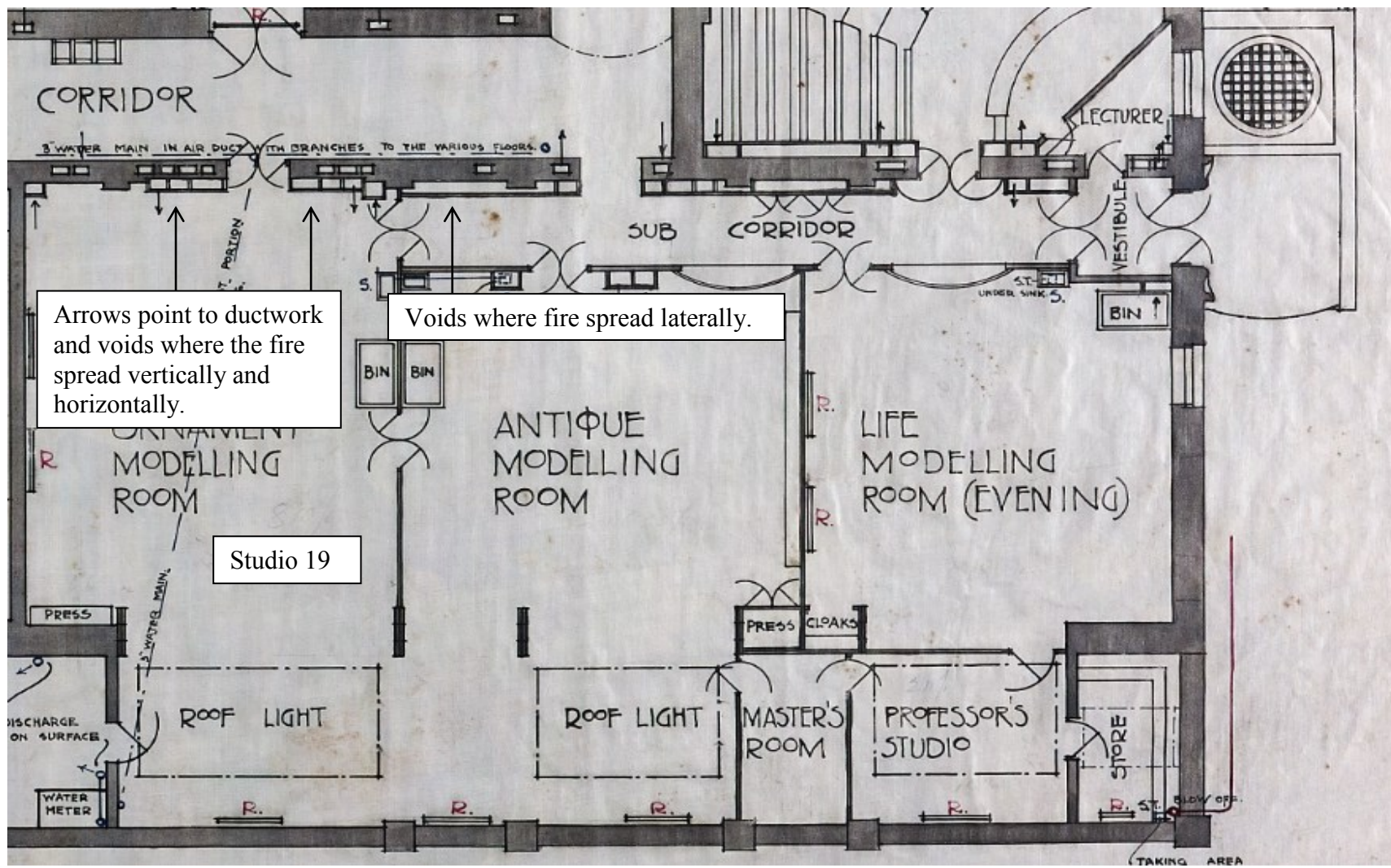
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1910 ARCHITECT DRAWING OF BASEMENT SHOWING HEATING AND VENTILATING DUCTWORK.

DRAWING NUMBER 1.



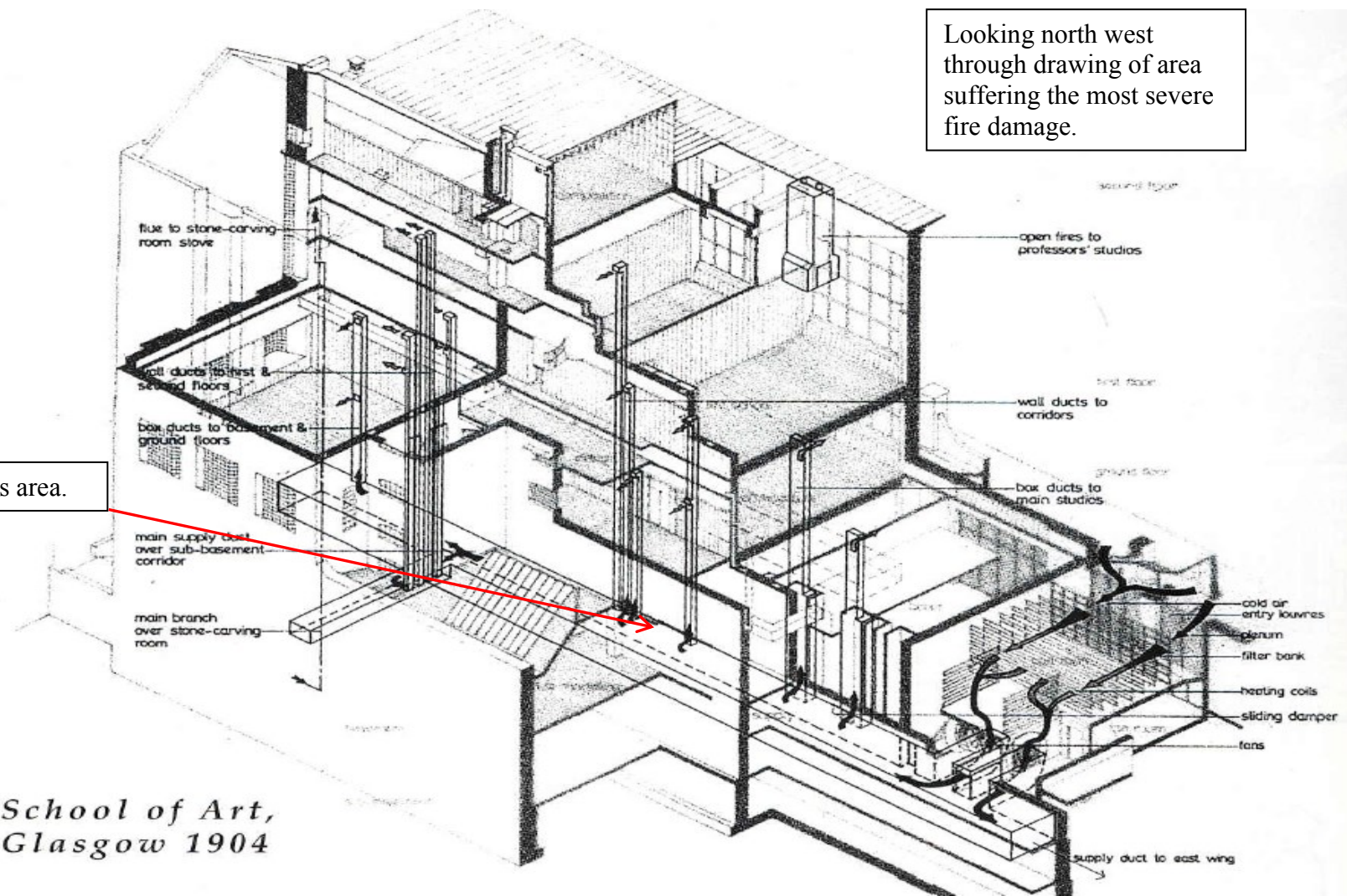
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1904 ARCHITECT DRAWINGS

DRAWING NUMBER 3



Looking north west through drawing of area suffering the most severe fire damage.

Fire originated in this area.

*School of Art,
Glasgow 1904*

SIGNED:

DATED:

ILLUSTRATIVE PHOTOGRAPHY:



Photo 1. North elevation. Main entrance to Glasgow School of Art. Image courtesy of Wikipedia.

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Photo 2. Looking towards east elevation. Image courtesy of google street view.

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Photo 3. Looking towards west elevation. Image courtesy of google street view.

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Photo 4. Within studio 19, the student display area, south wall, projector circled



Photo 5. Close up view of remain of projector.

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Photo 6. North wall of student display area. Projected image appeared on this wall.



Photo 7. External image of student display area. Looking south.

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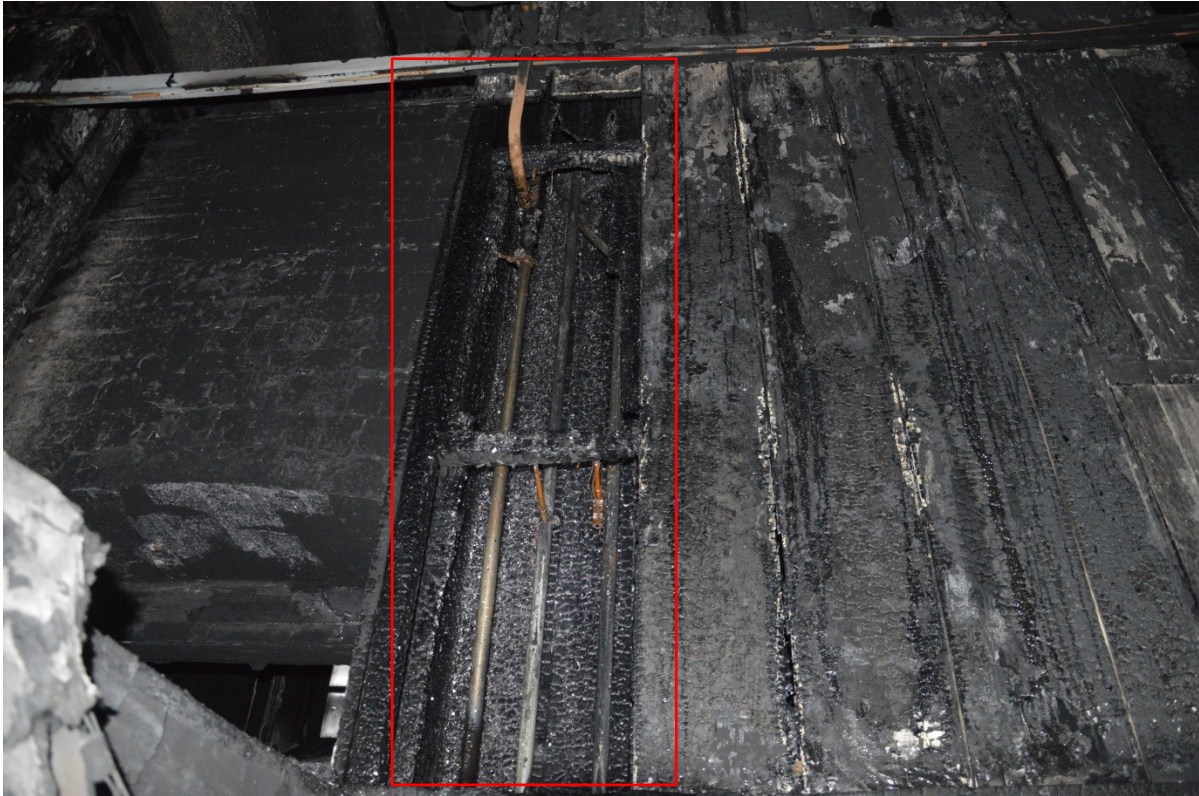


Photo 8. Area above and slightly to left of where projector was located. Note missing void panels highlighted within red rectangle



Photo 9. Void running from basement studio 19 to roof

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Photo 10. Studio 31 Ground floor. Fire spread vertically via voids either side of door. Note V pattern. Less damage in this area as fire spread to floor above at wall/ceiling junction.



Photo 11. Studio 31 Ground floor. To left of door, fire spread to first floor via void area circled.

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Photo 12. Studio 31 Ground floor. To right of door fire spread up vertical void



Photo 13. Ground floor studio 31 west side. Fire spread up each vertical void. Suspect fire spread to these voids horizontally from the left. Circled area horizontal void leads to studio 32.

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Photo 14. Ground Floor Studio 32 looking south west.



Photo 15. First floor Mackintosh Library, looking south west.

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Photo 16. 2nd floor Studio 58 looking south



Photo 17. First floor studio 44. Looking south, fire spread up vertical voids to 2nd floor

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Photo 18. First floor studio 45, looking north onto Renfrew Street



Photo 19. 2nd floor Studio 57 looking north

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Photo 20. 2nd floor Hen run south elevation, looking east.



Photo 21. Professor Studios on 2nd floor north elevation totally involved in fire. Image courtesy of Craig Watson SNS Group.

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Photo 22. North elevation



Photo 23. 2nd Floor north west elevation, studio 57

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Photo 24. Aerial Rescue Pumps at work on north side of building



Photo 25. South west corner of building. Library and studio 58 above.

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Photo 26. Interior image of student display area prior to foam panels being located on walls. Image courtesy of Police Scotland.



Photo 27. Exterior image of the student display area within studio 19. This was taken two to three days prior to the fire. Note the area circled is the pipe void with panels removed. Image courtesy of Police Scotland.

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Photo 28. Catalogue image of projector Epson EMP-TW680. Courtesy of google image.



Photo 29. Top cover removed. Image courtesy of www.cine4home.com

Photo's 29-31 are internal images of a similar Epson model, the TW 600. Layout of components is the same only the specifications vary slightly. The purpose of the photos is to show the internal construction.

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Photo 30. Image with cover removed. Printed circuit board removed. Image courtesy of www.cine4home.com

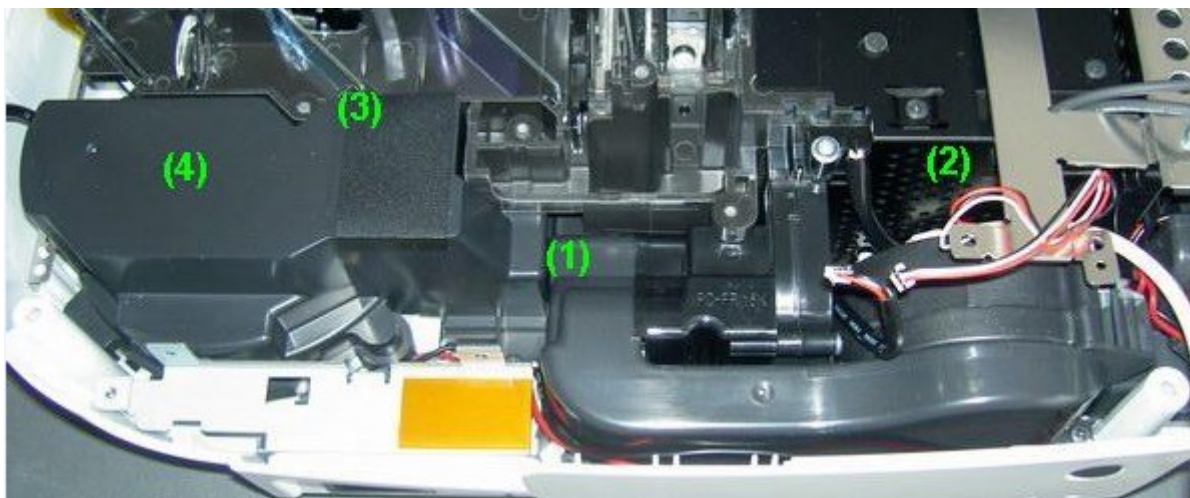


Photo 31. Air intake. Back of projector. Image courtesy of www.cine4home.com

The necessary cooling air is sucked in from the bottom of the machine (1), and the majority is passed directly over to the lamp (2). The remaining part is led towards the optical path (3) where a second fan continues to distribute the air further (4). The "used" air is finally exhausted completely on the front right on the front of the machine, next to the optics.

All photographs and images shown in this report with the exception of numbers 1, 2, 3, 21, 26, 27, 28, 29, 30 and 31 are courtesy of Scottish Fire and Rescue Service.

Three dimensional plan drawings of each level courtesy of Scottish Fire and Rescue Service.

Architect drawings from 1910 courtesy of Page\Park Architects Glasgow.