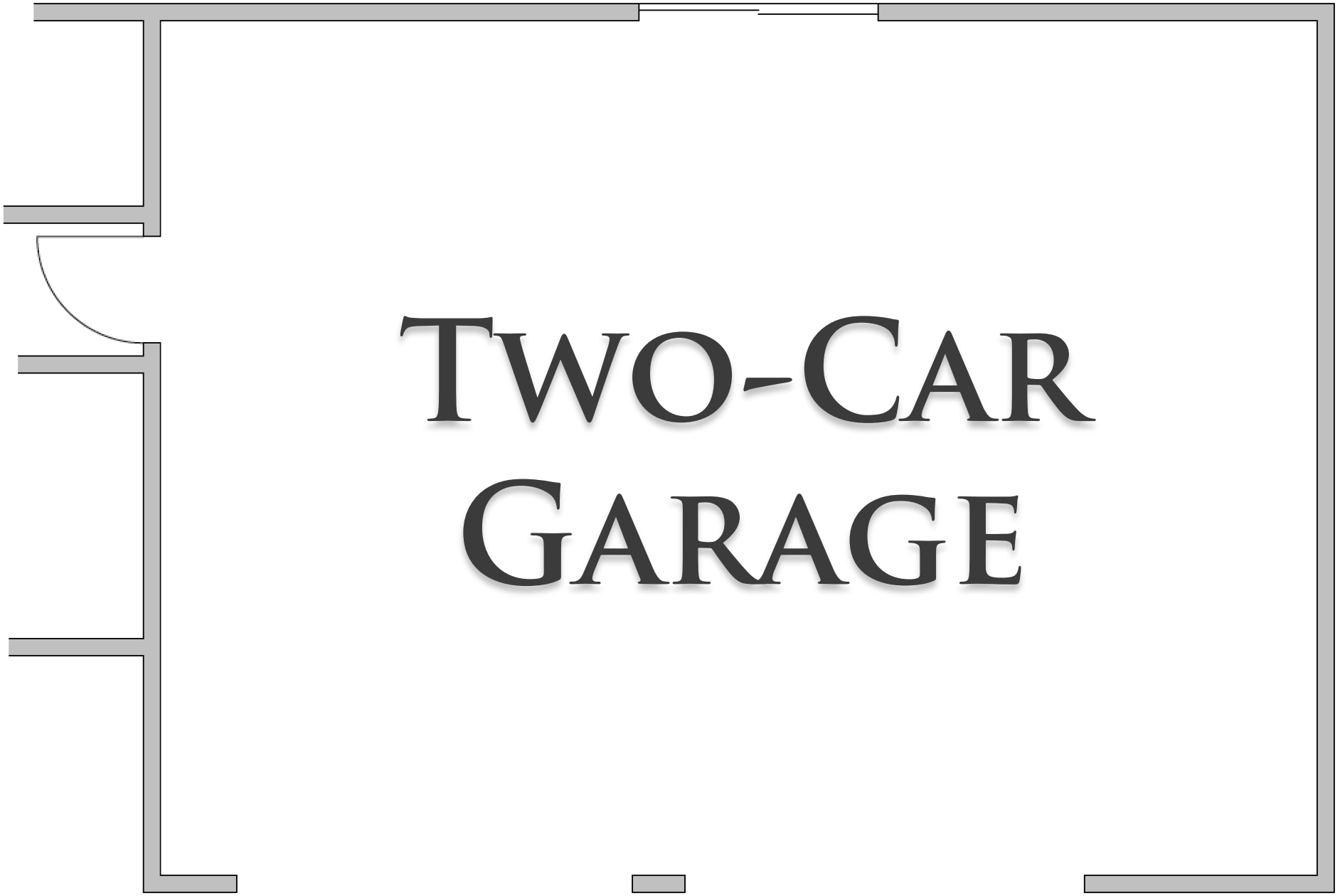
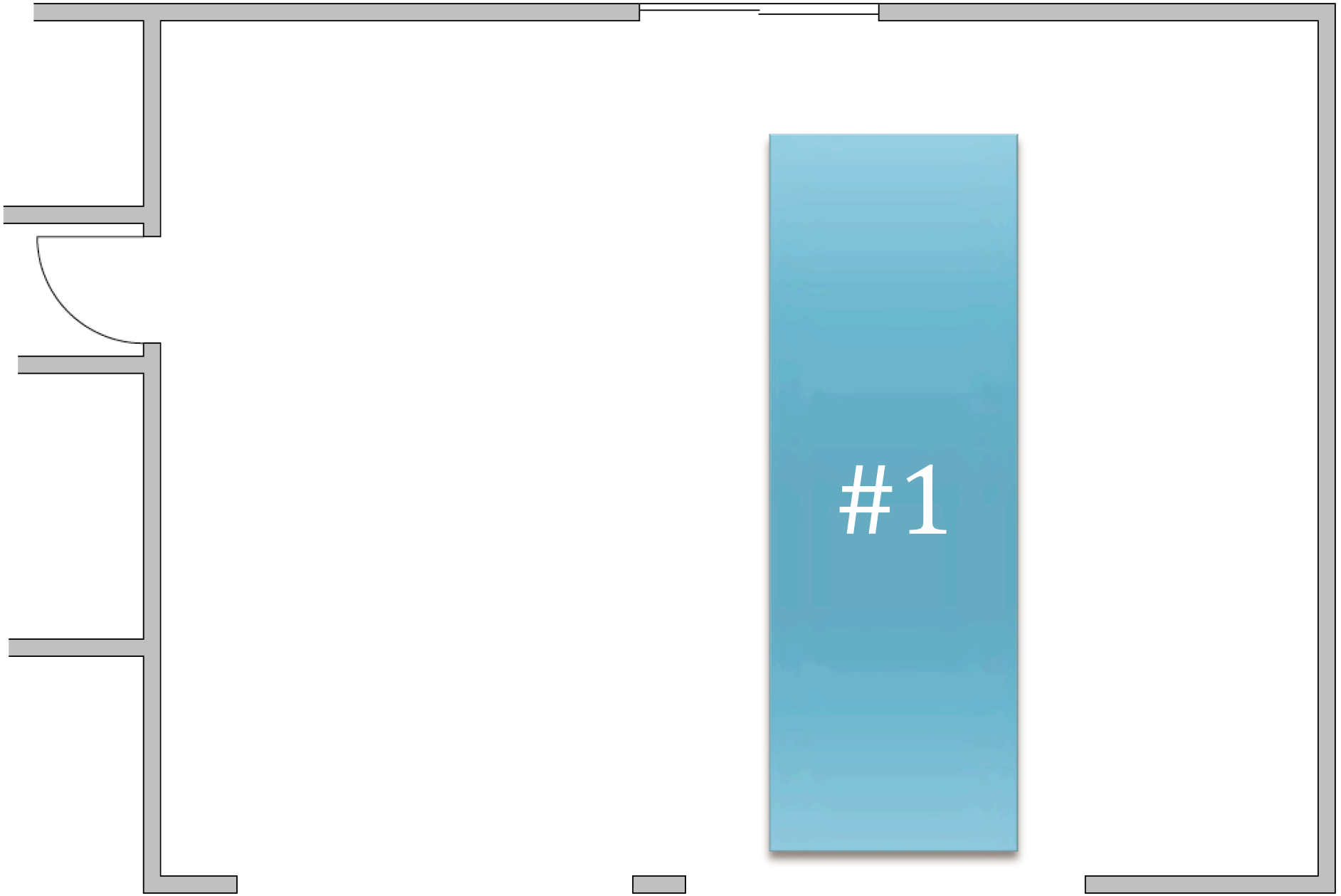
Adventures
in
Residential
Electrical Wiring
or
Why You Should
Hire an Electrician


Two-Car
Garage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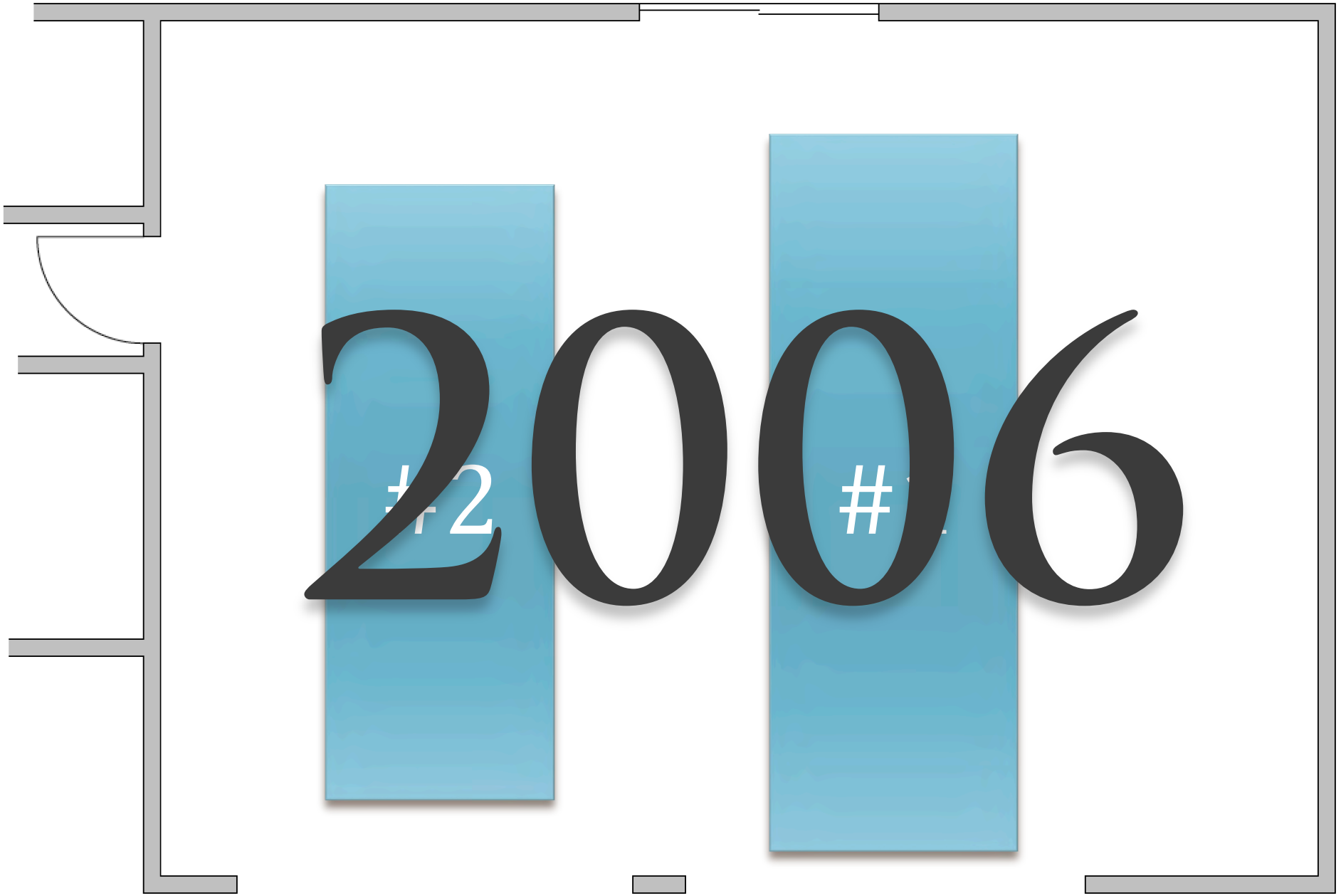
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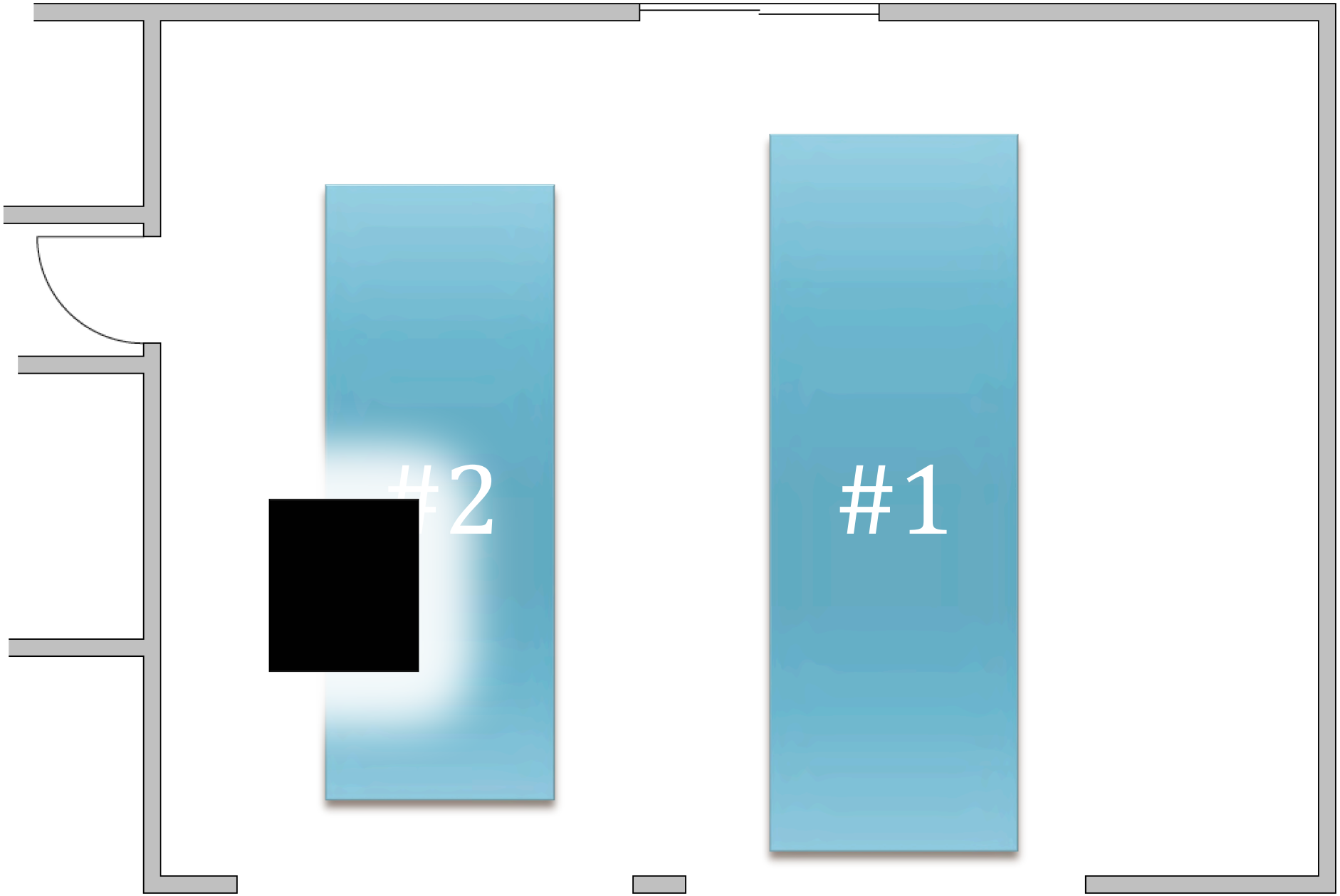
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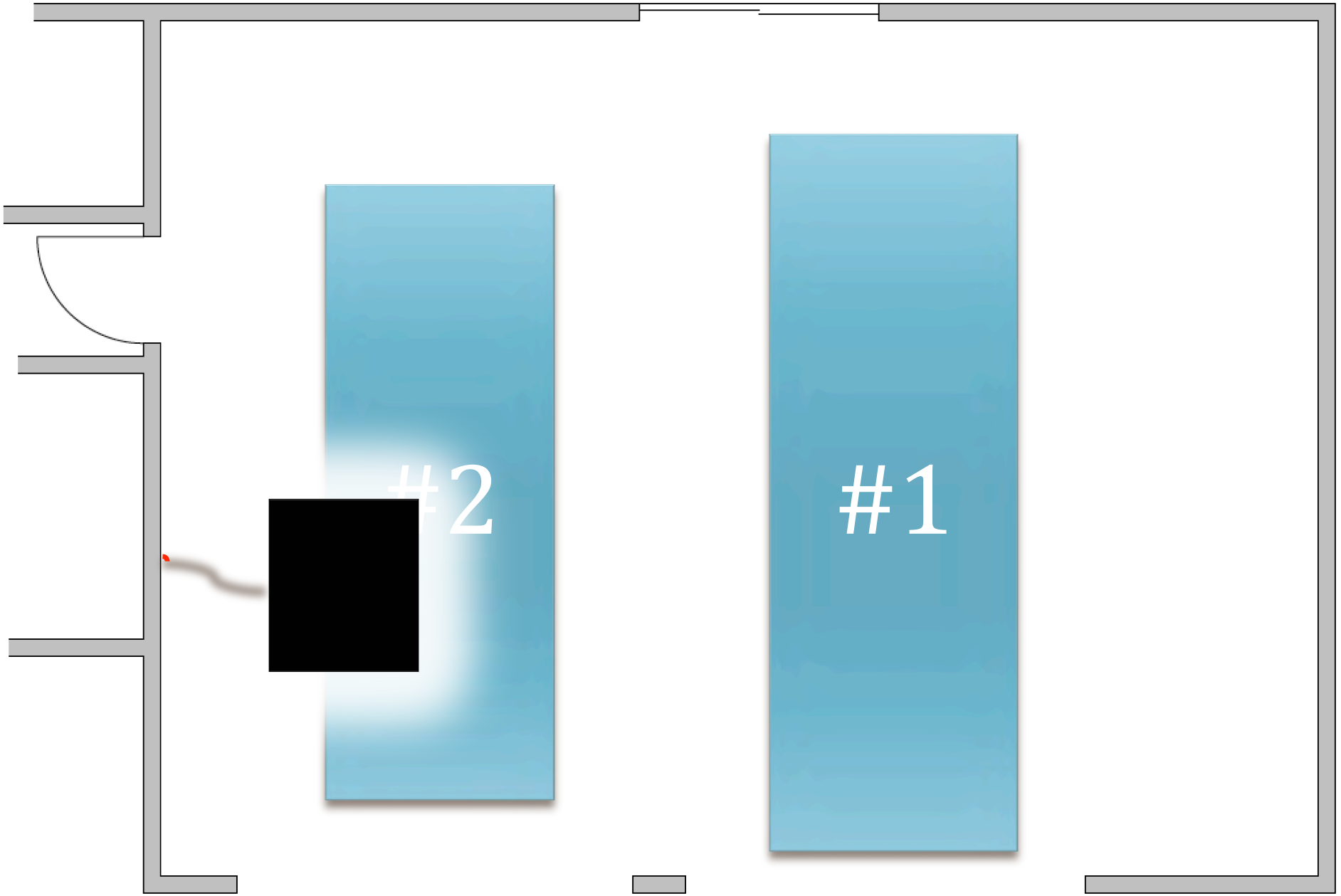
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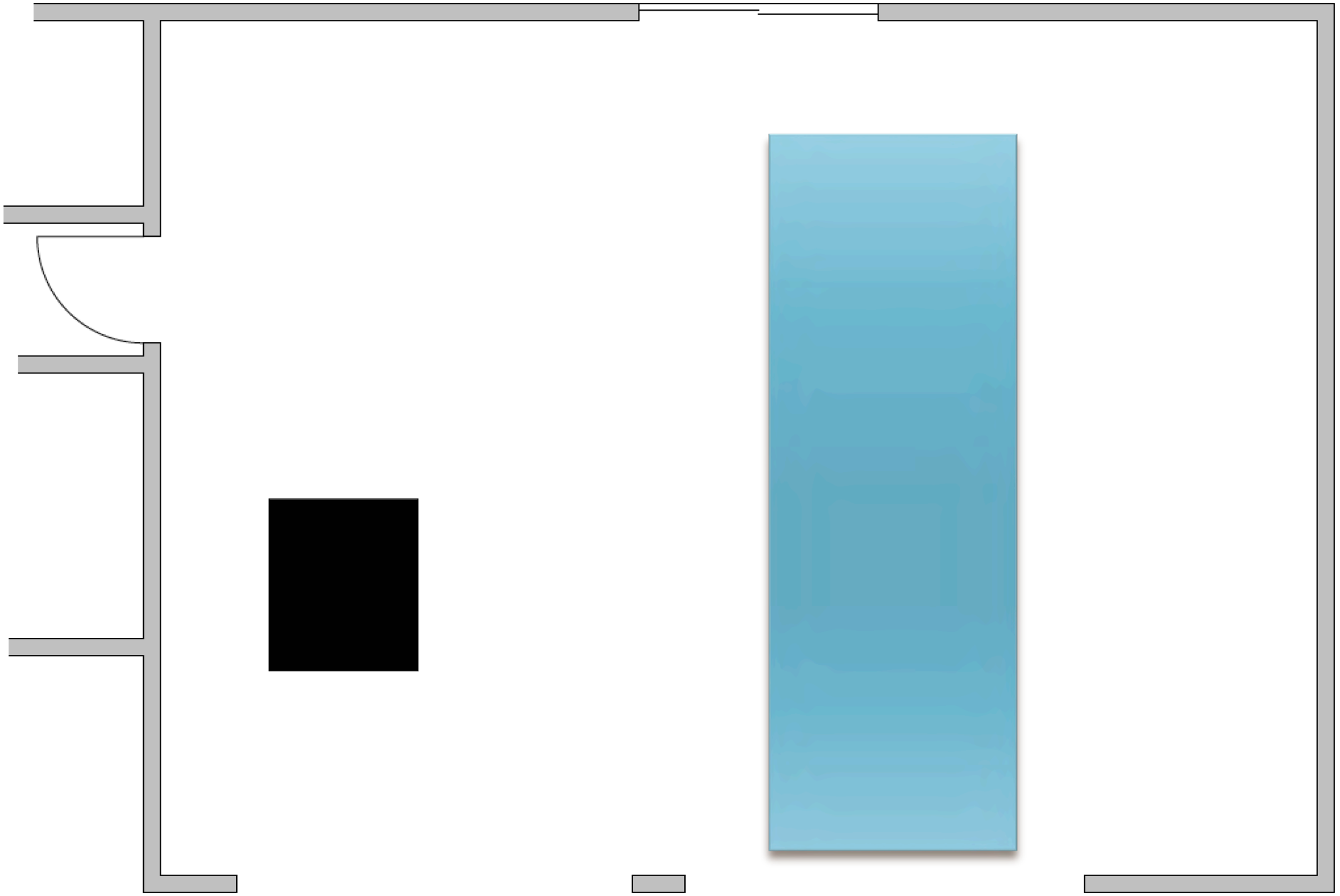
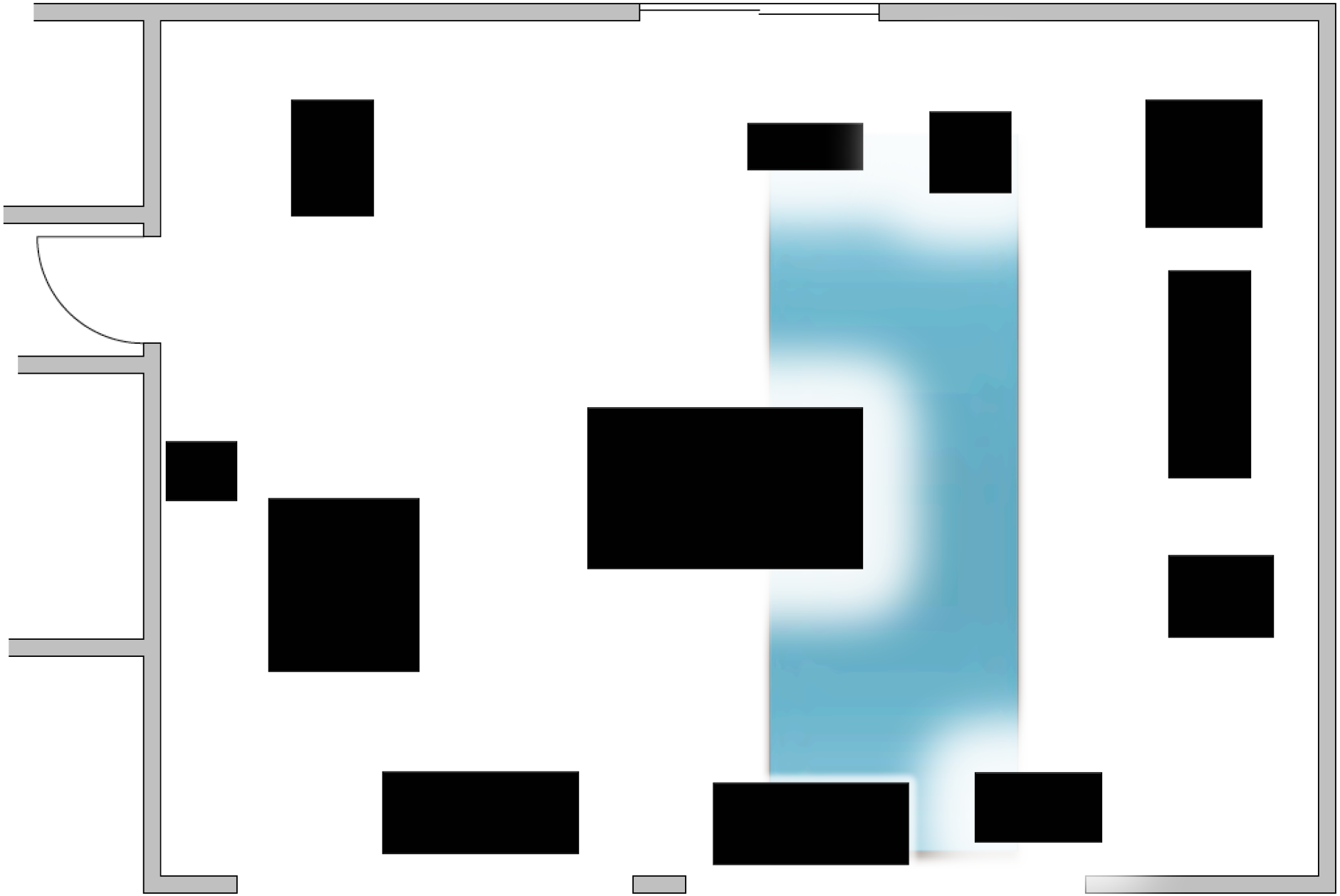
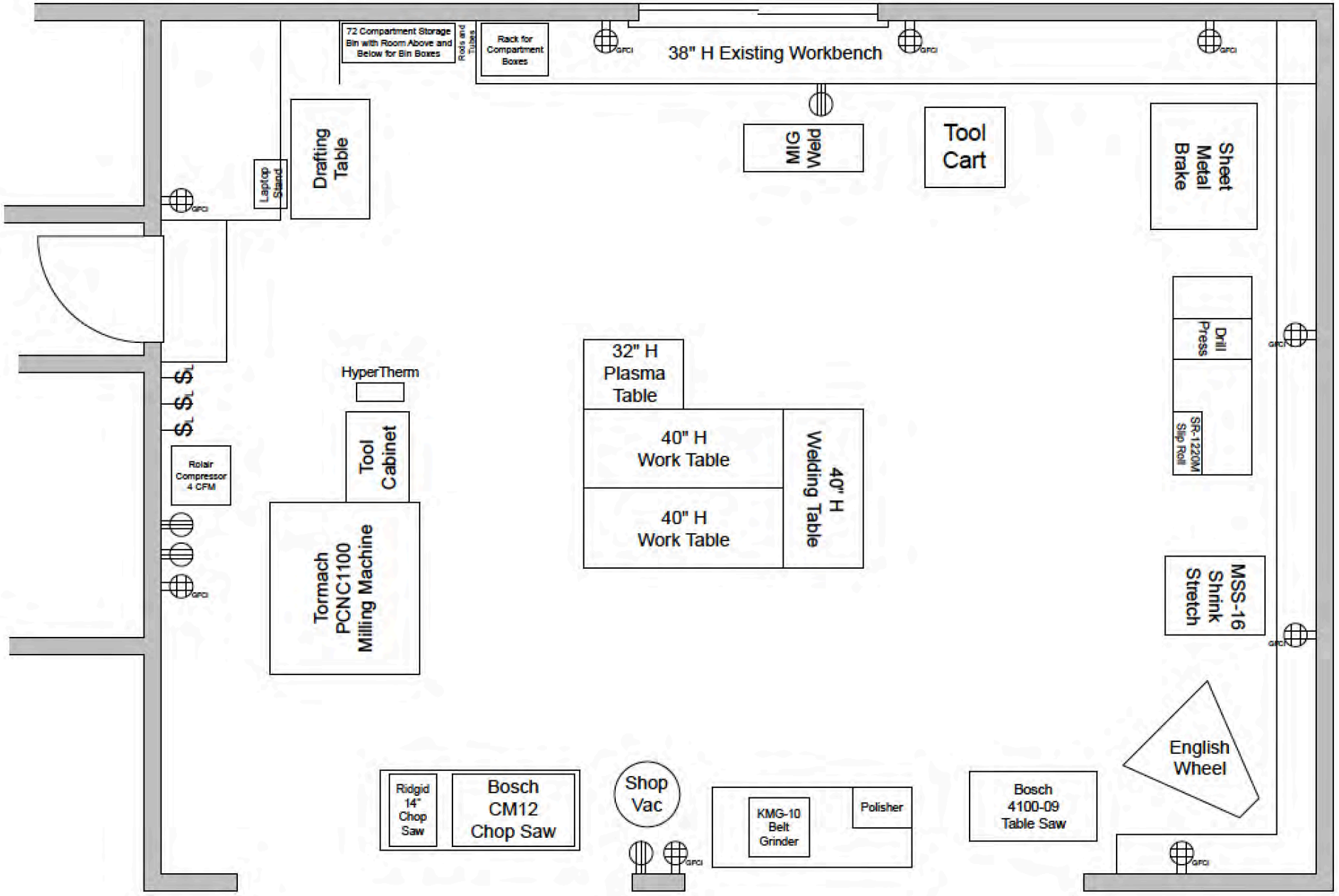
One-Car
Garage






Zero-Car
Garage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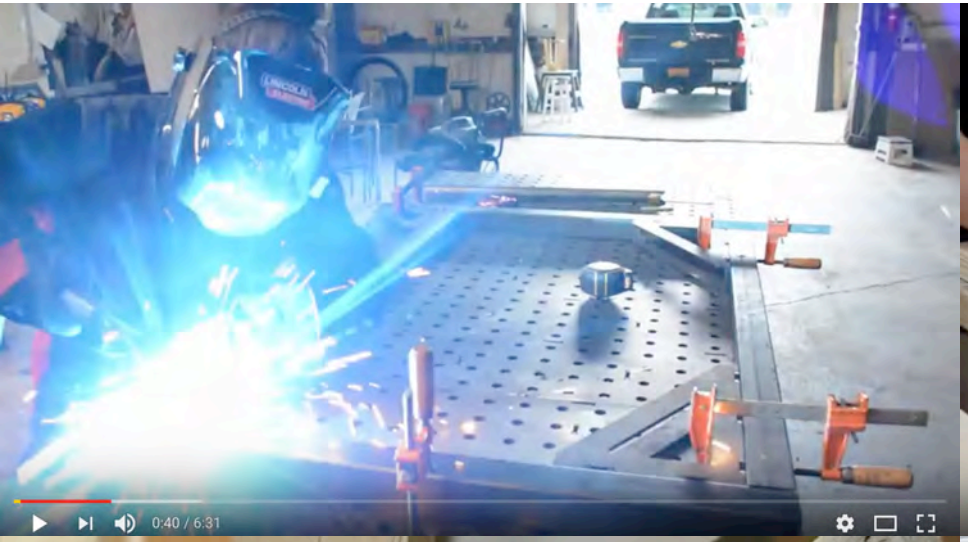
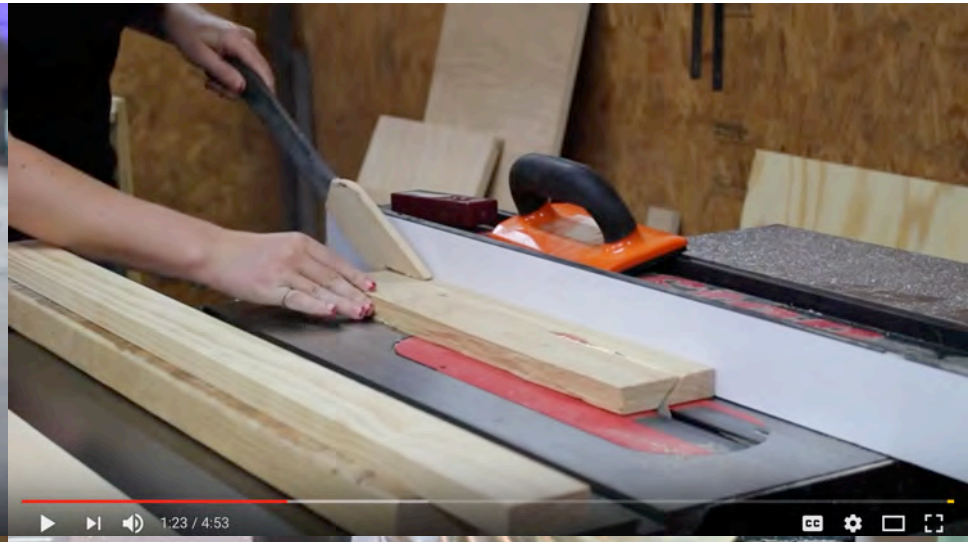
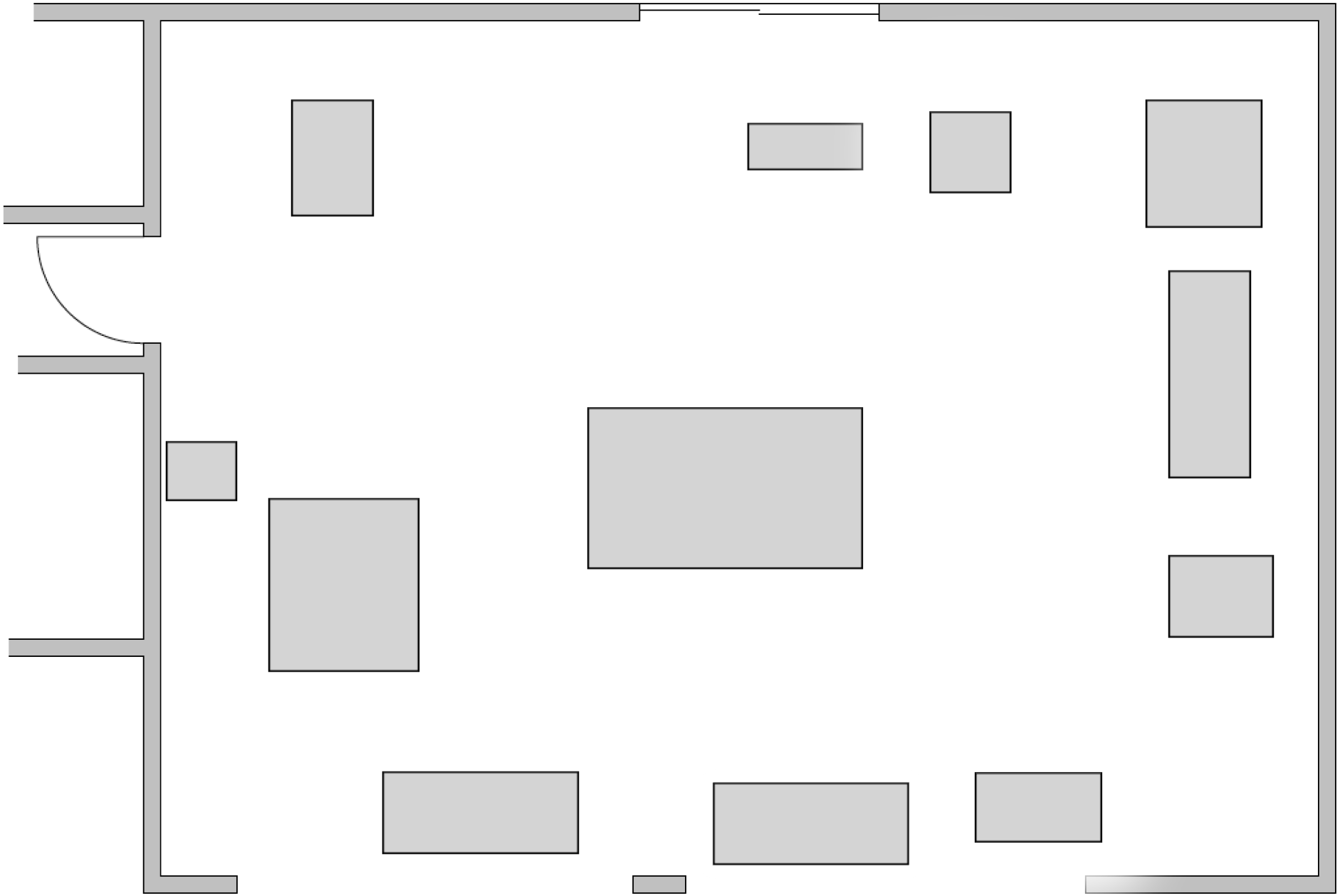
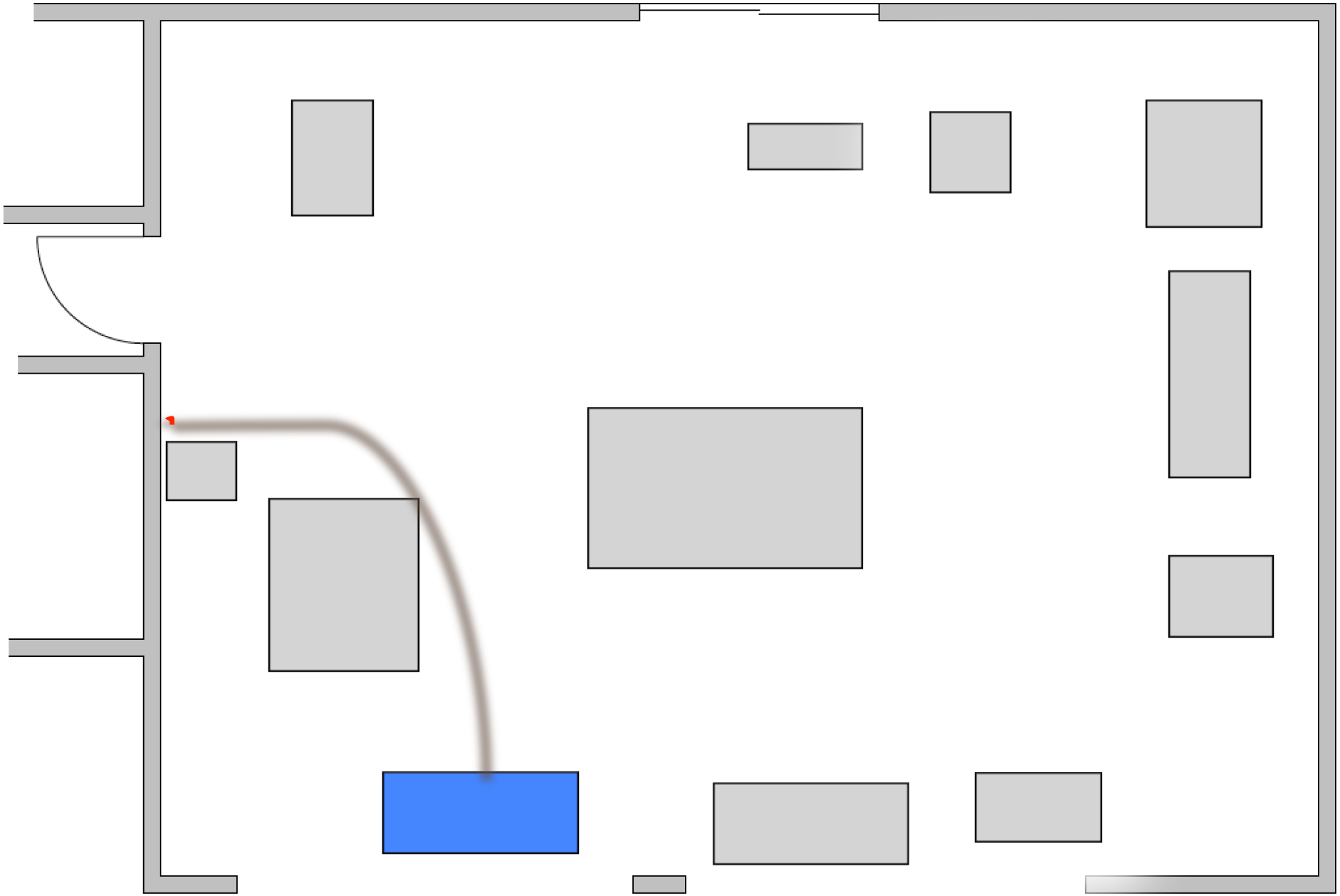
Social media (YouTube) leads to discontent

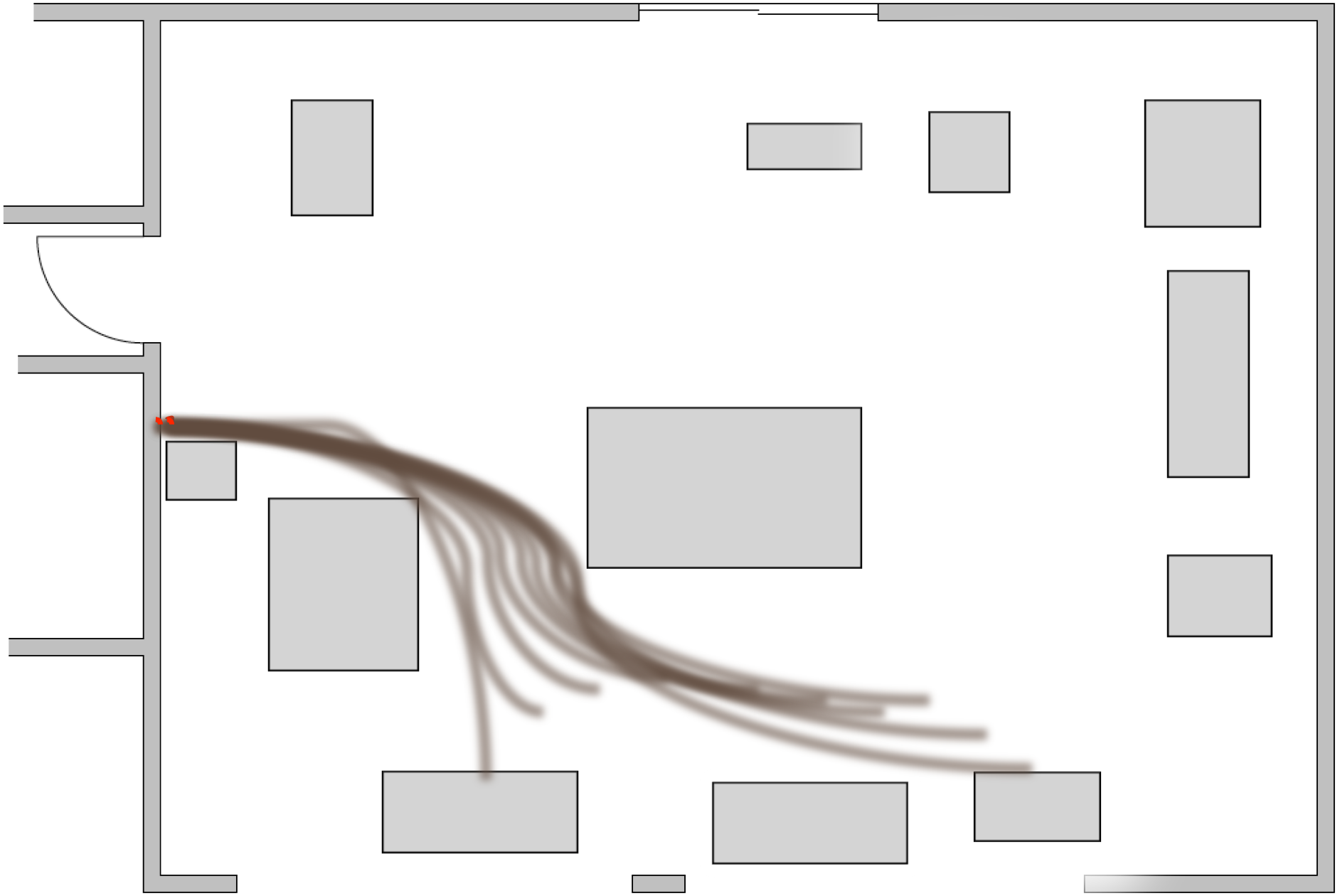


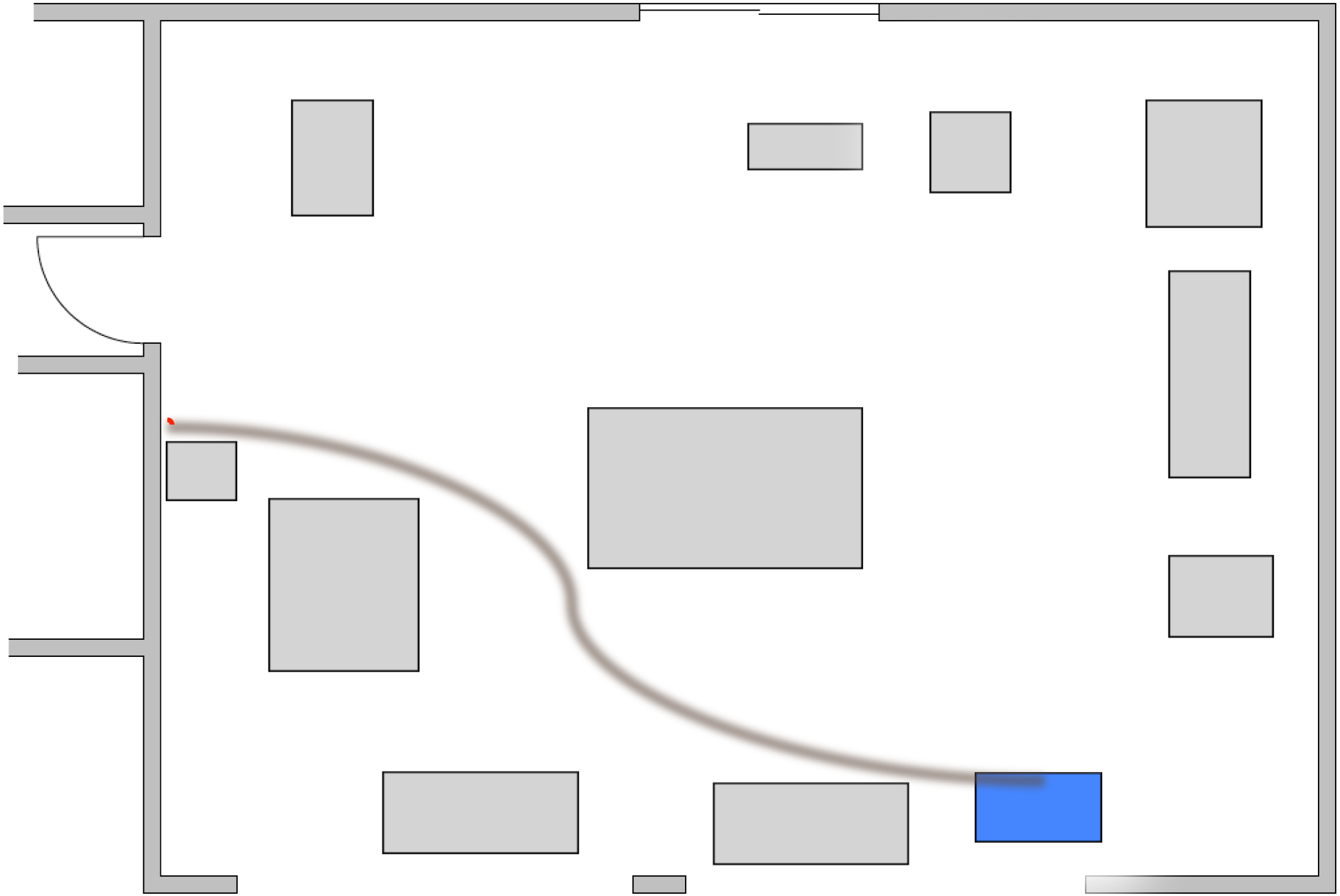


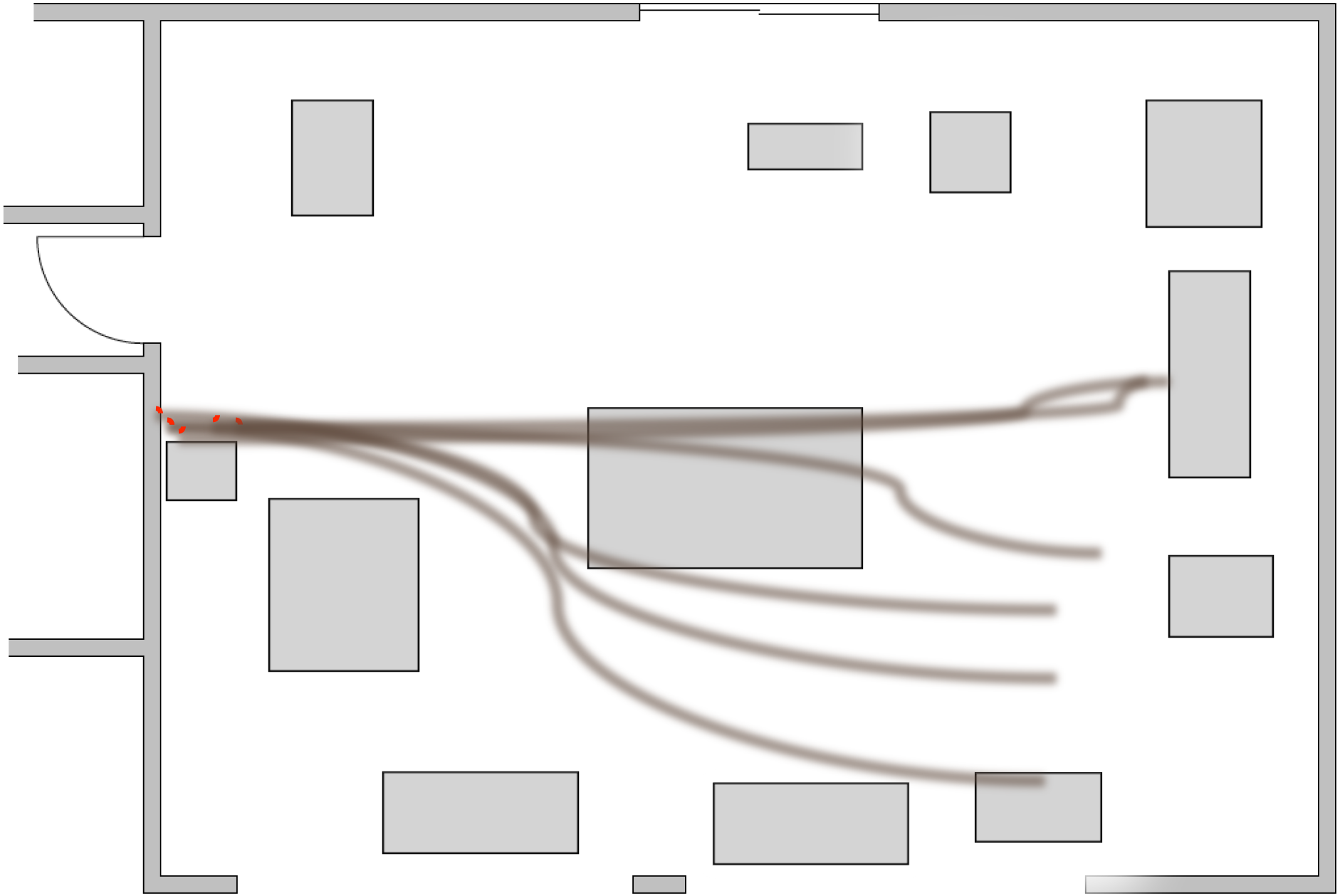
Jimmy Diresta, April Wilkerson, Tested/Adam Savage, Laura Kampf

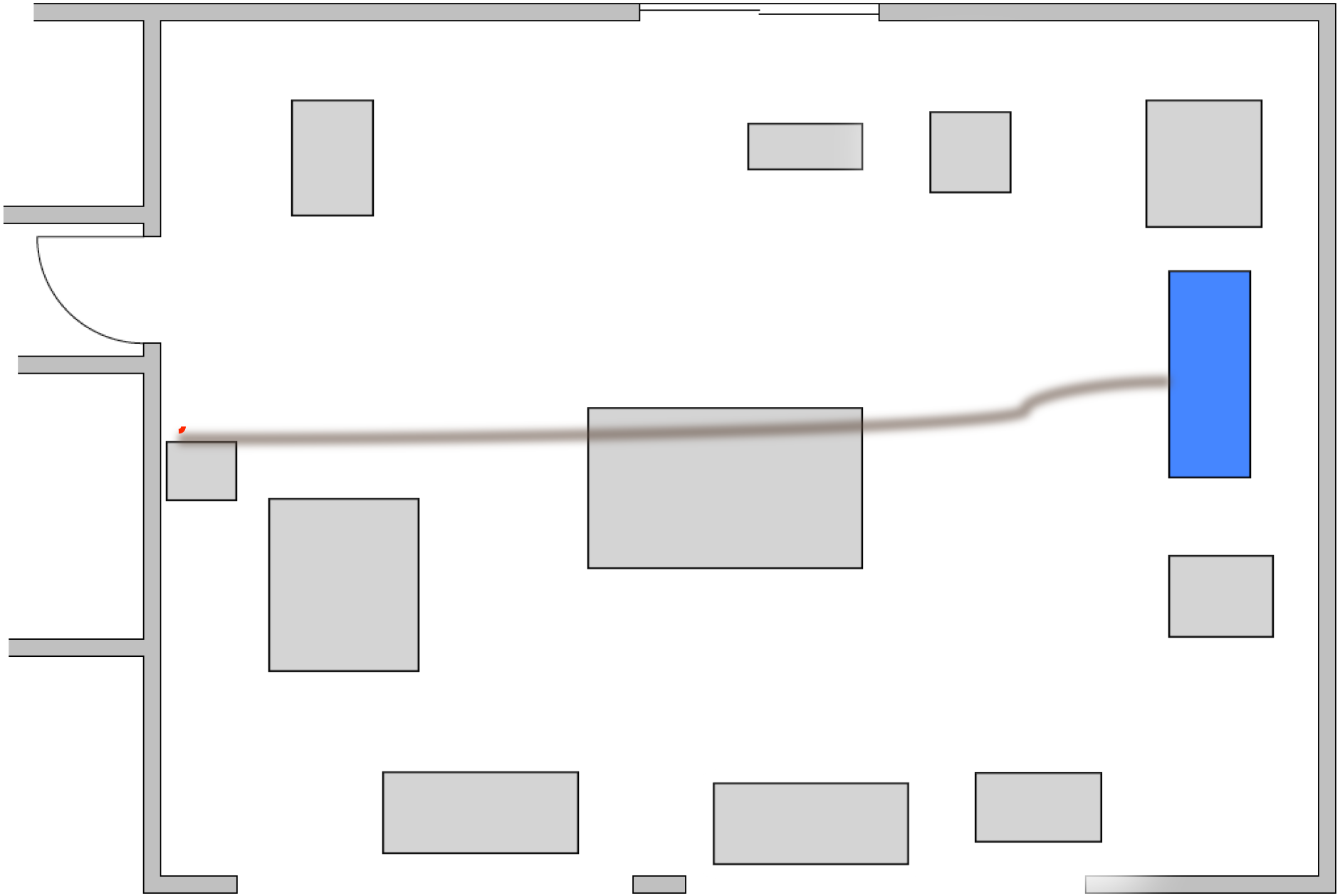


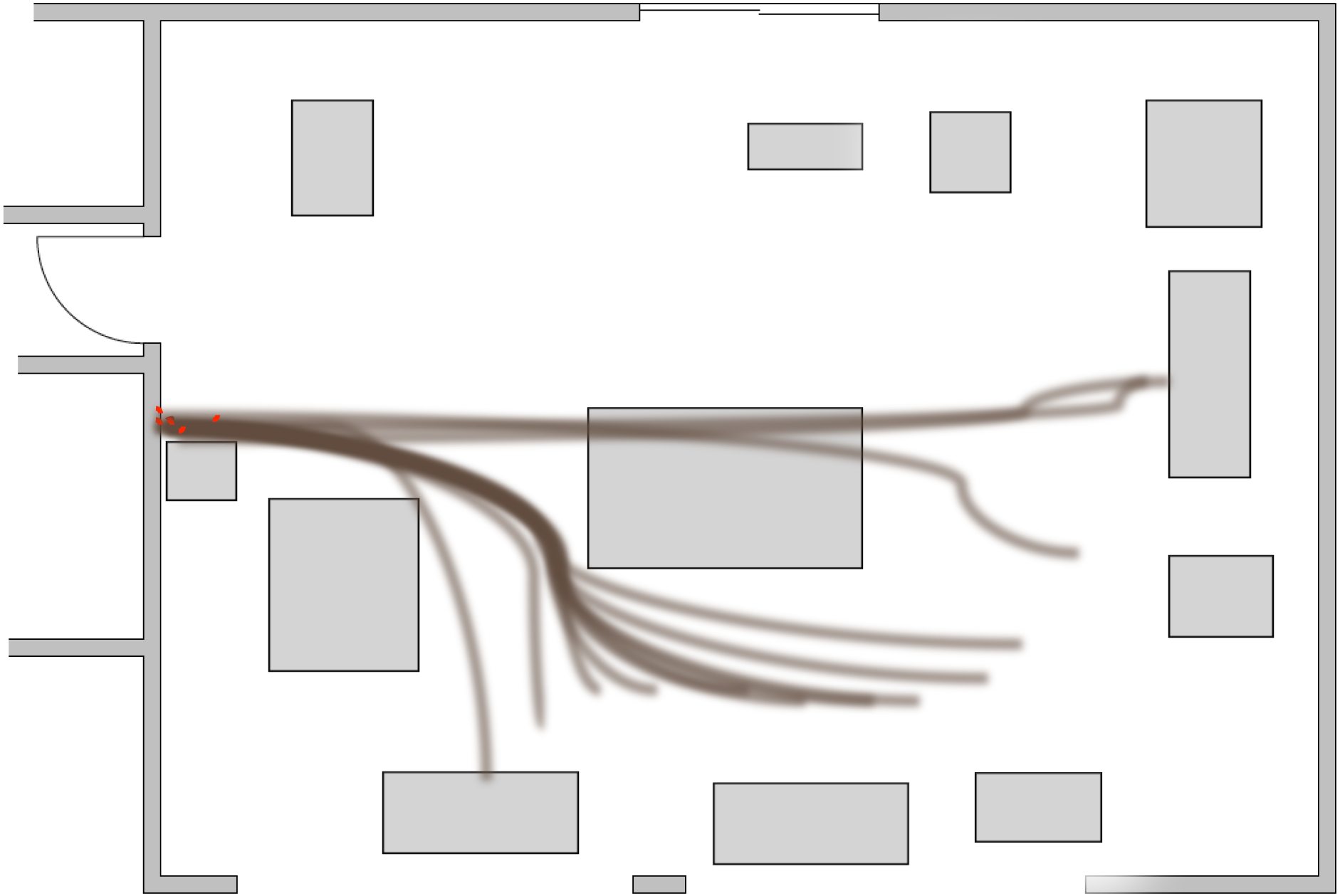


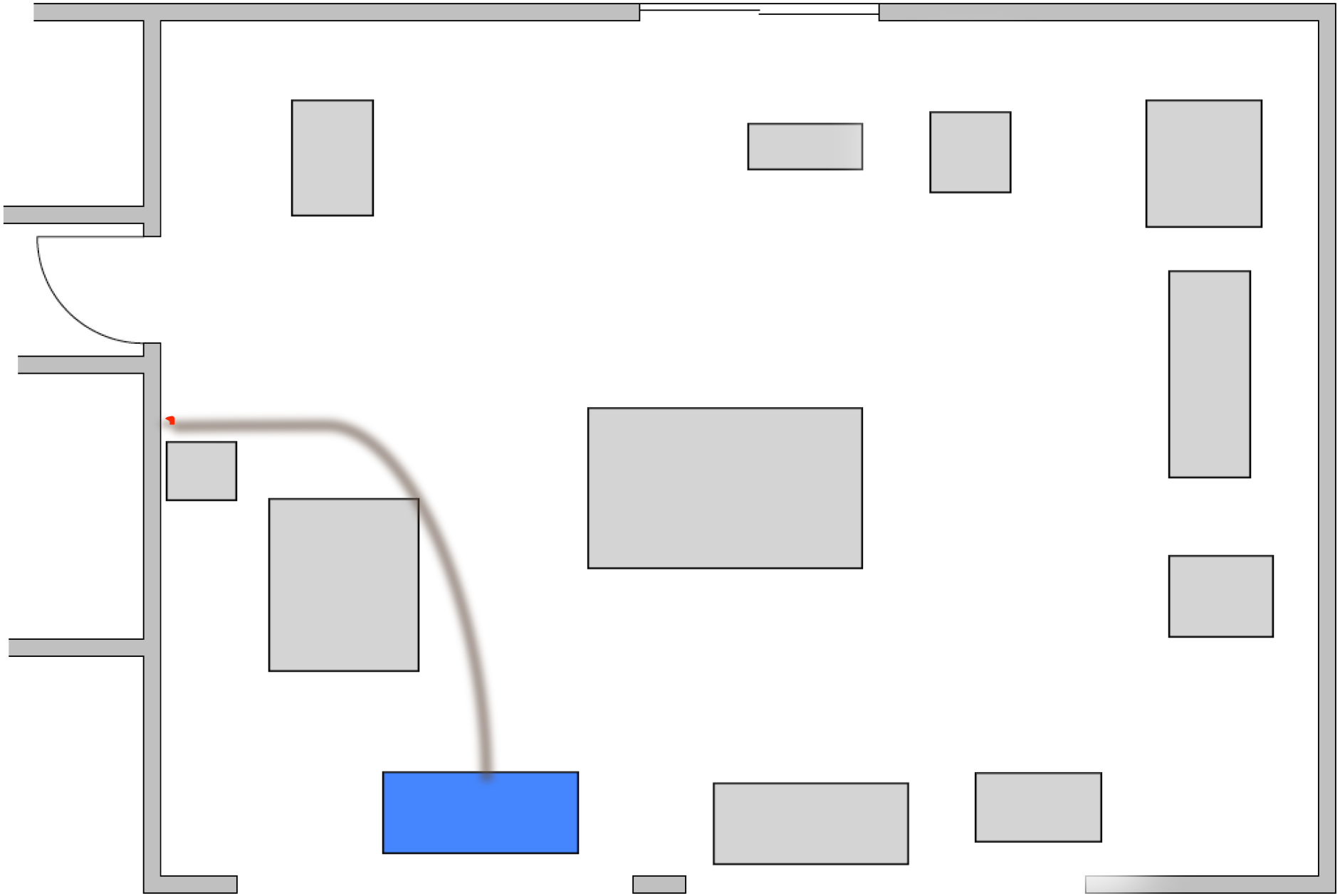


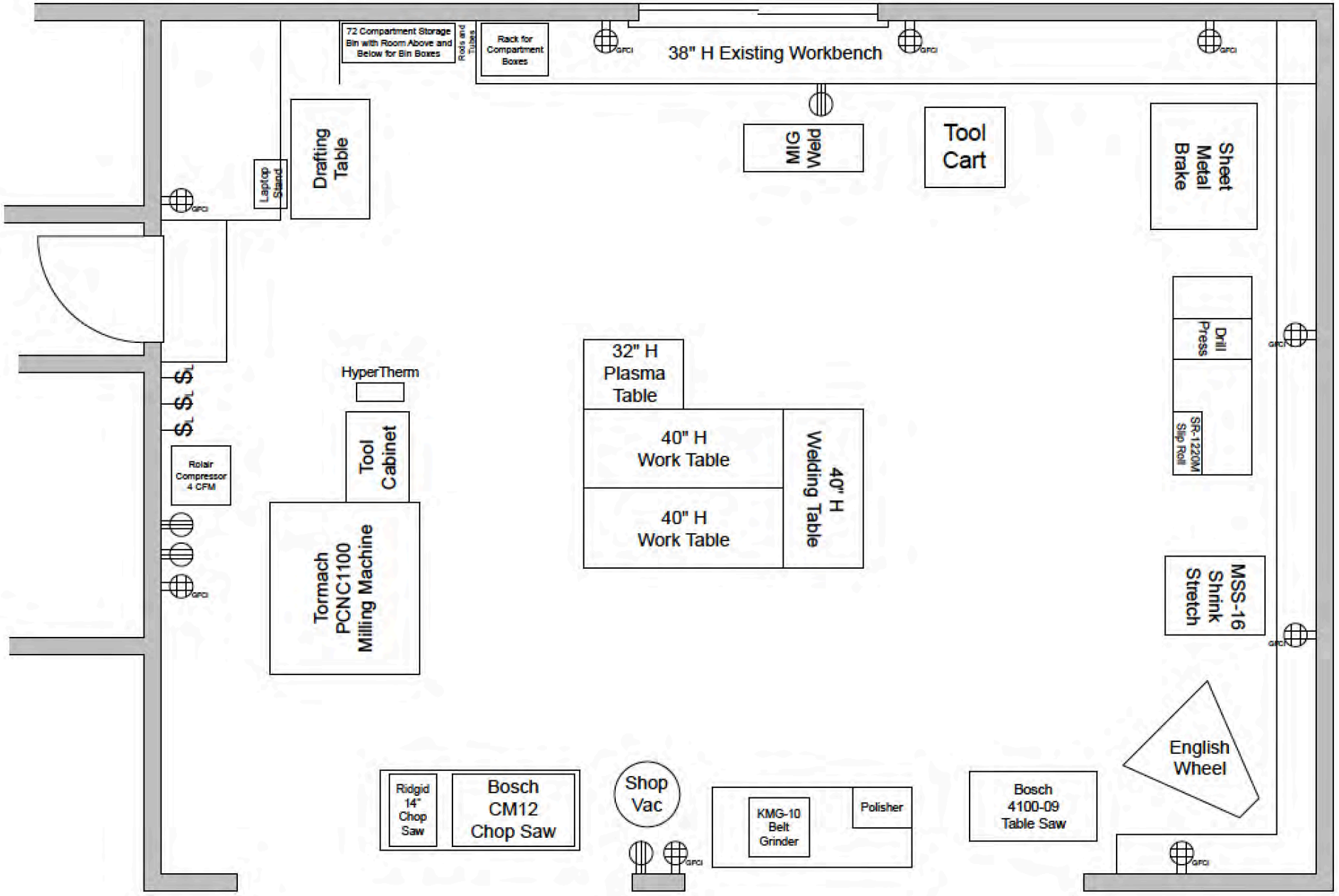








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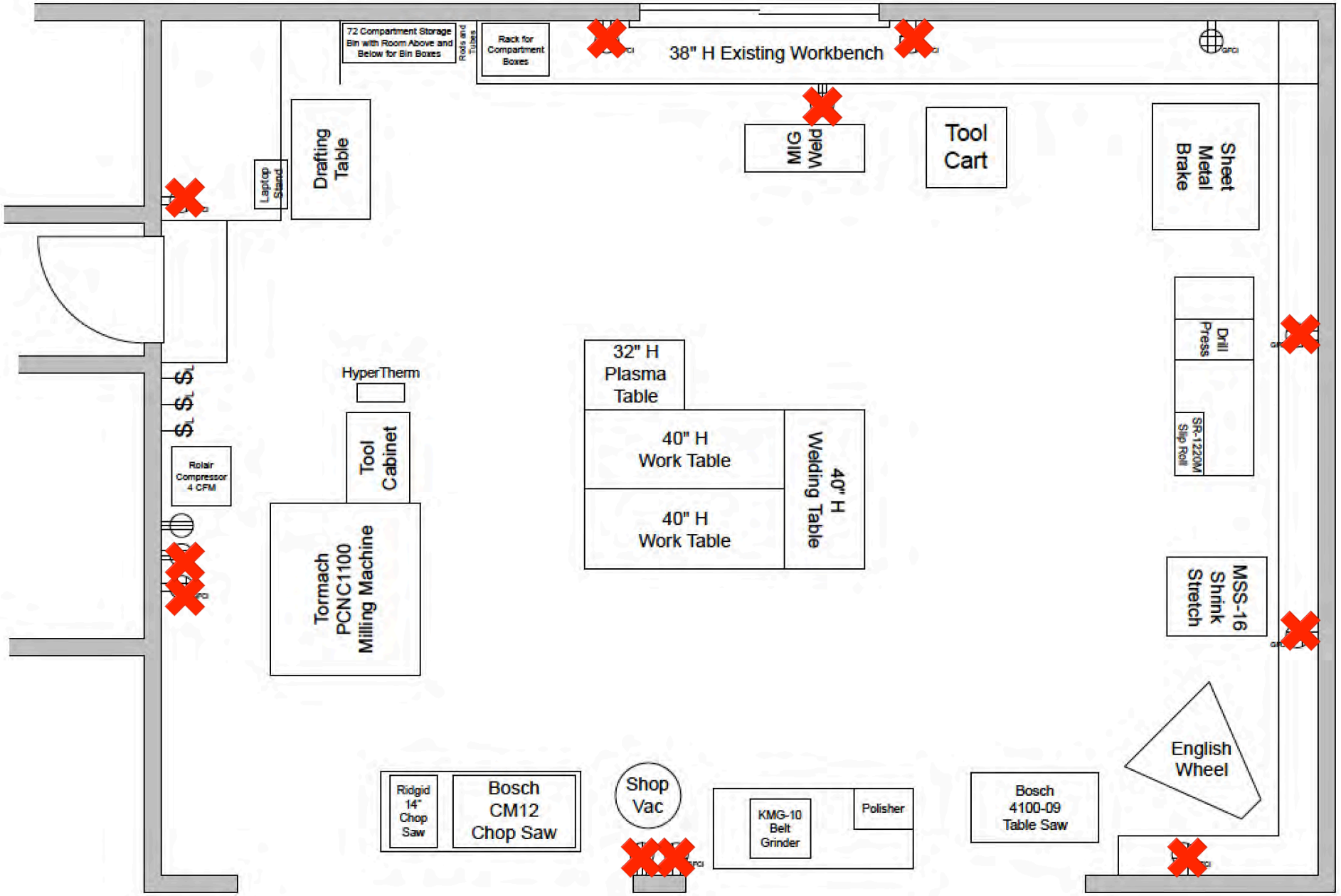
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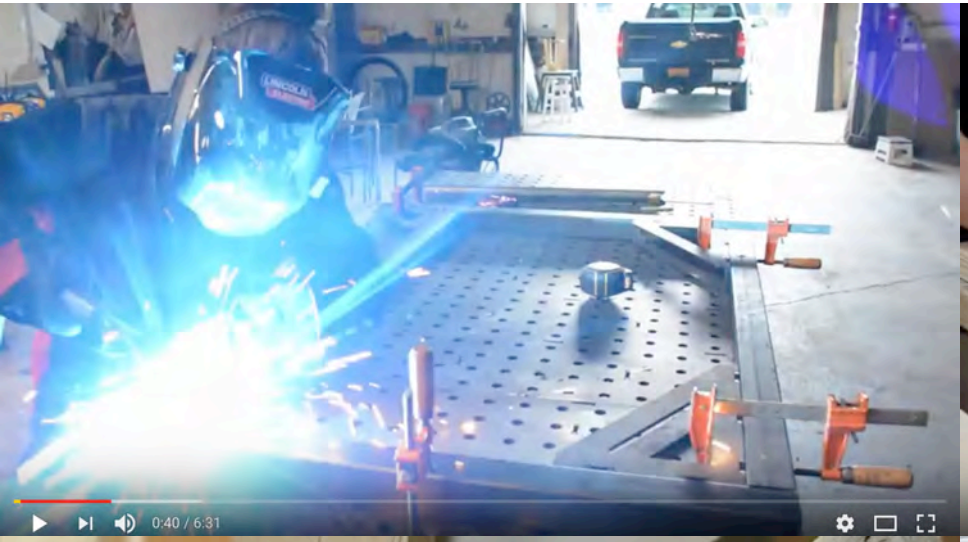

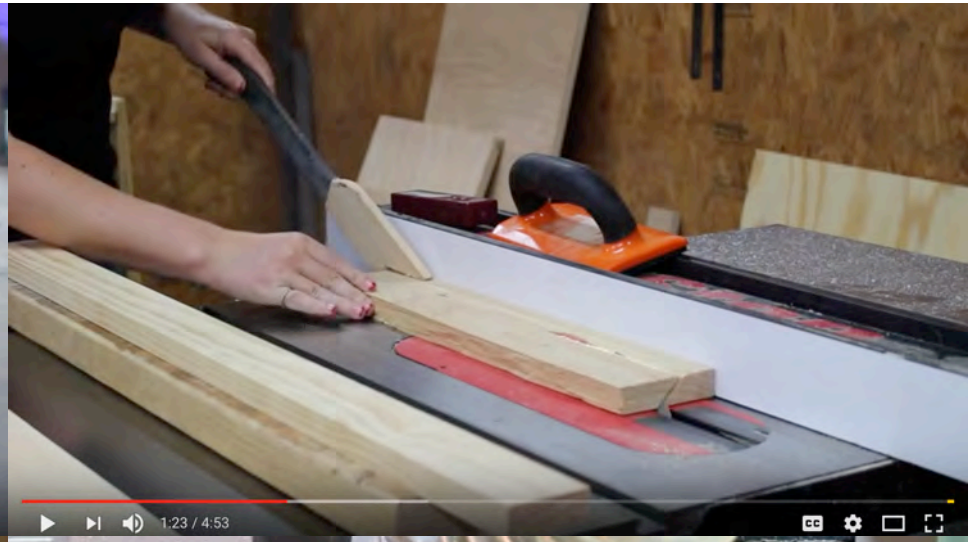

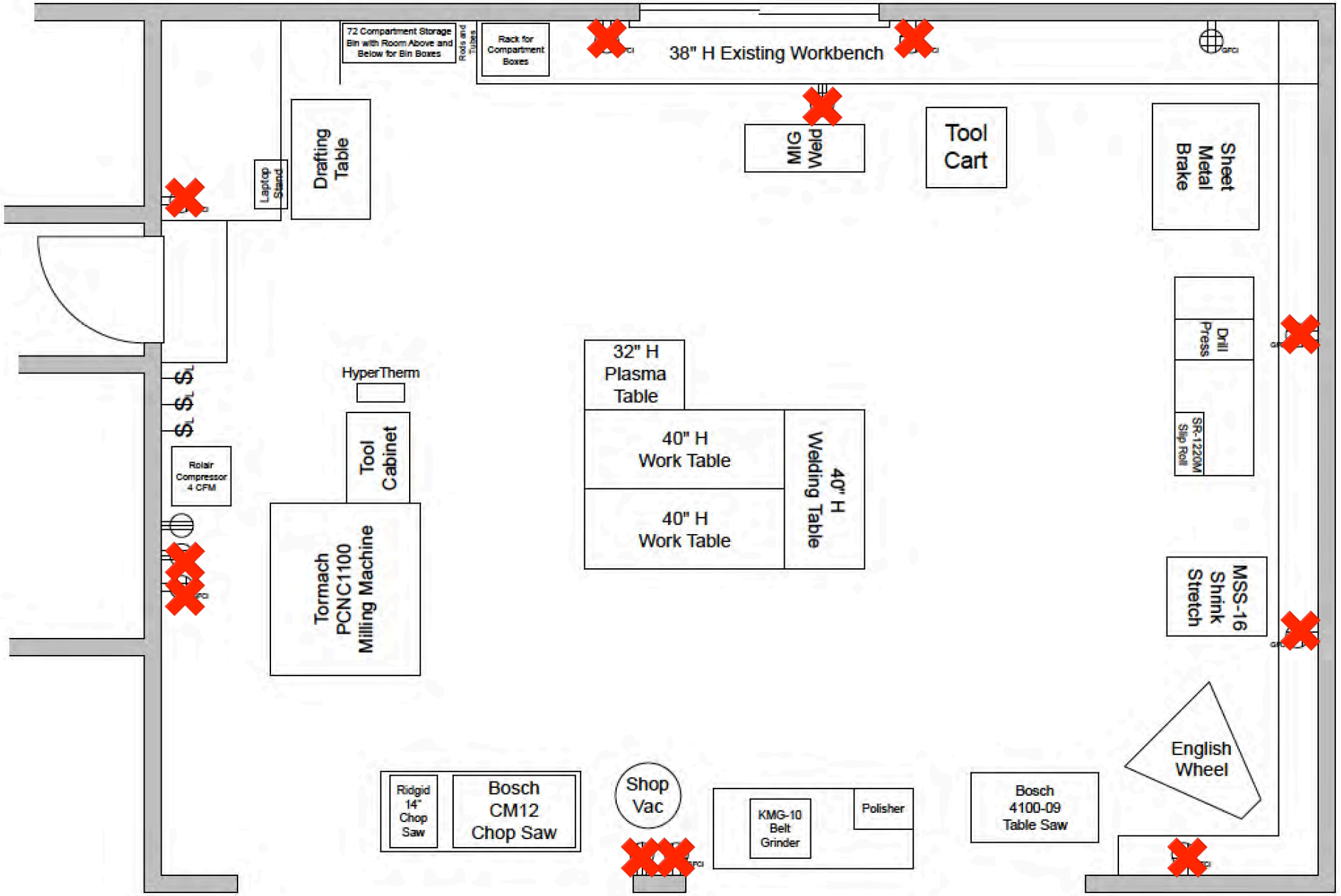
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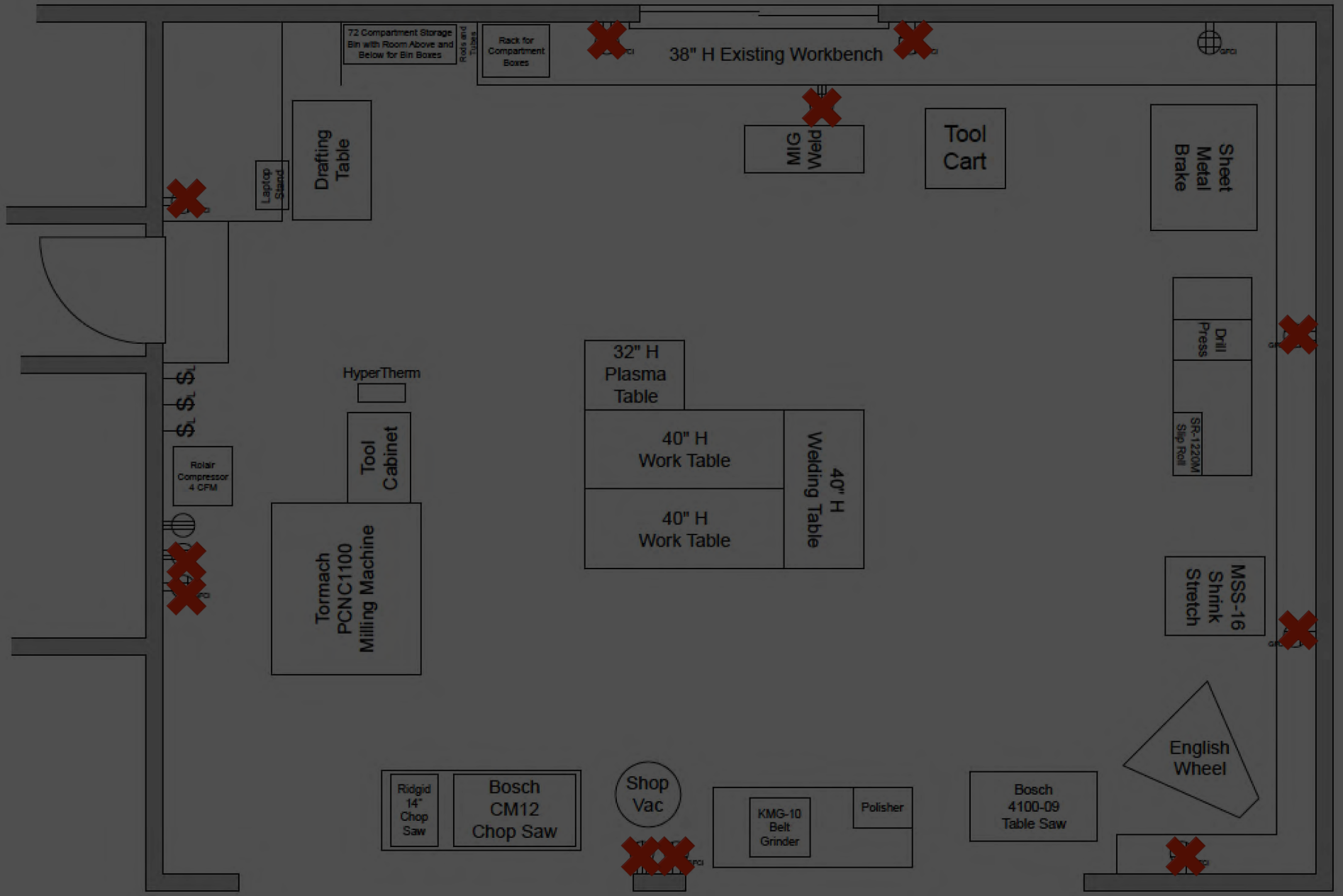
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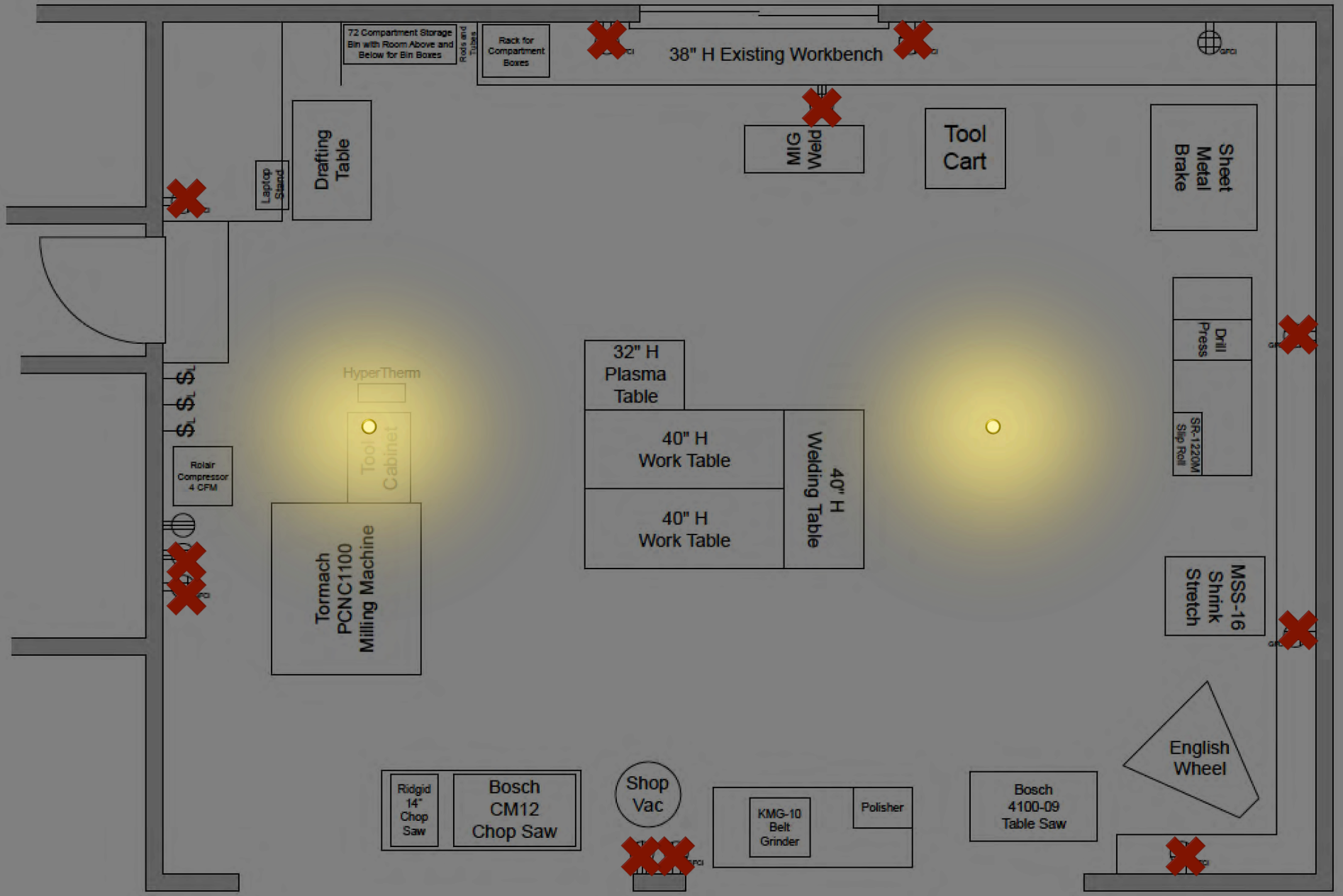
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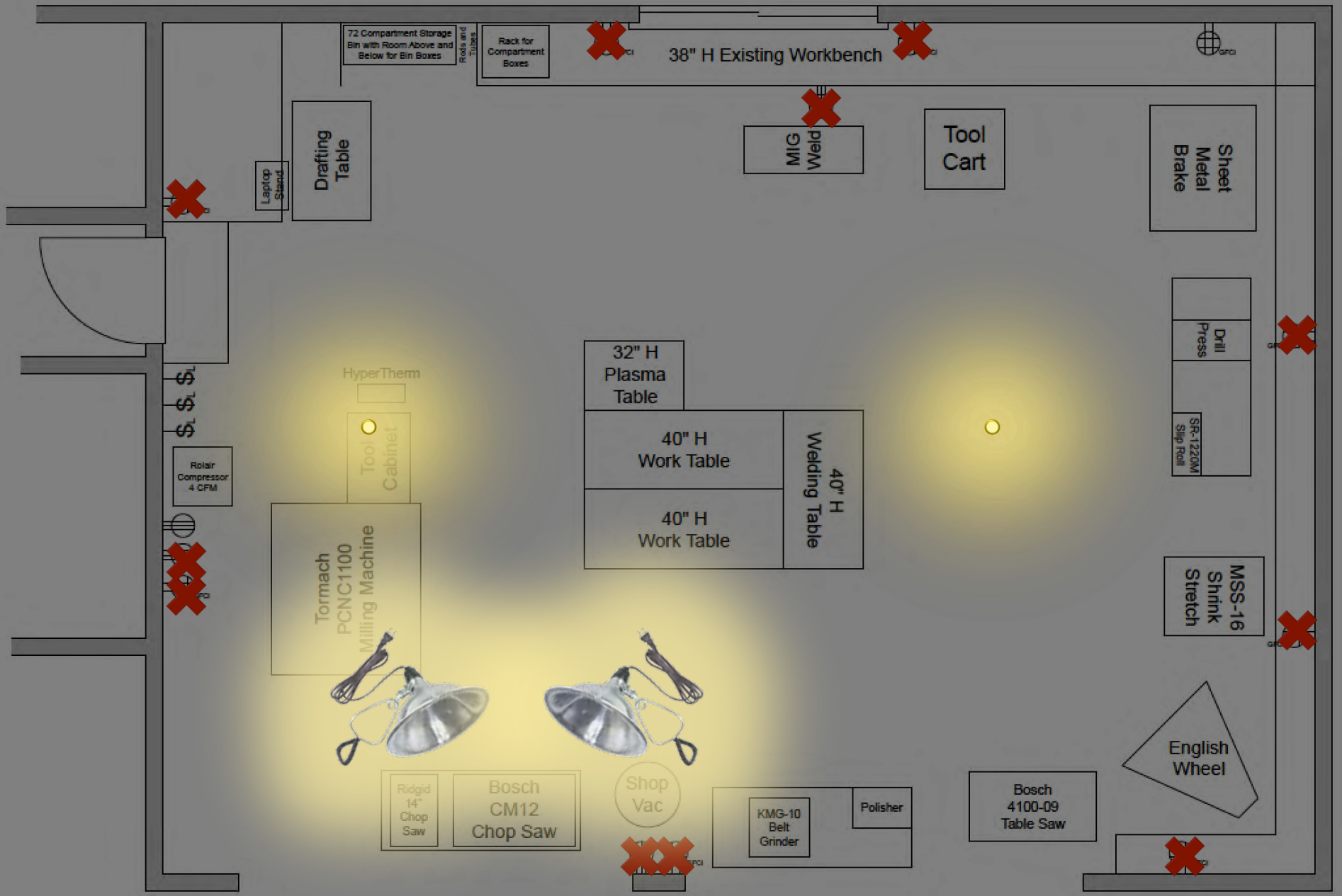
Clamp Lamps

Image attribution: Amazon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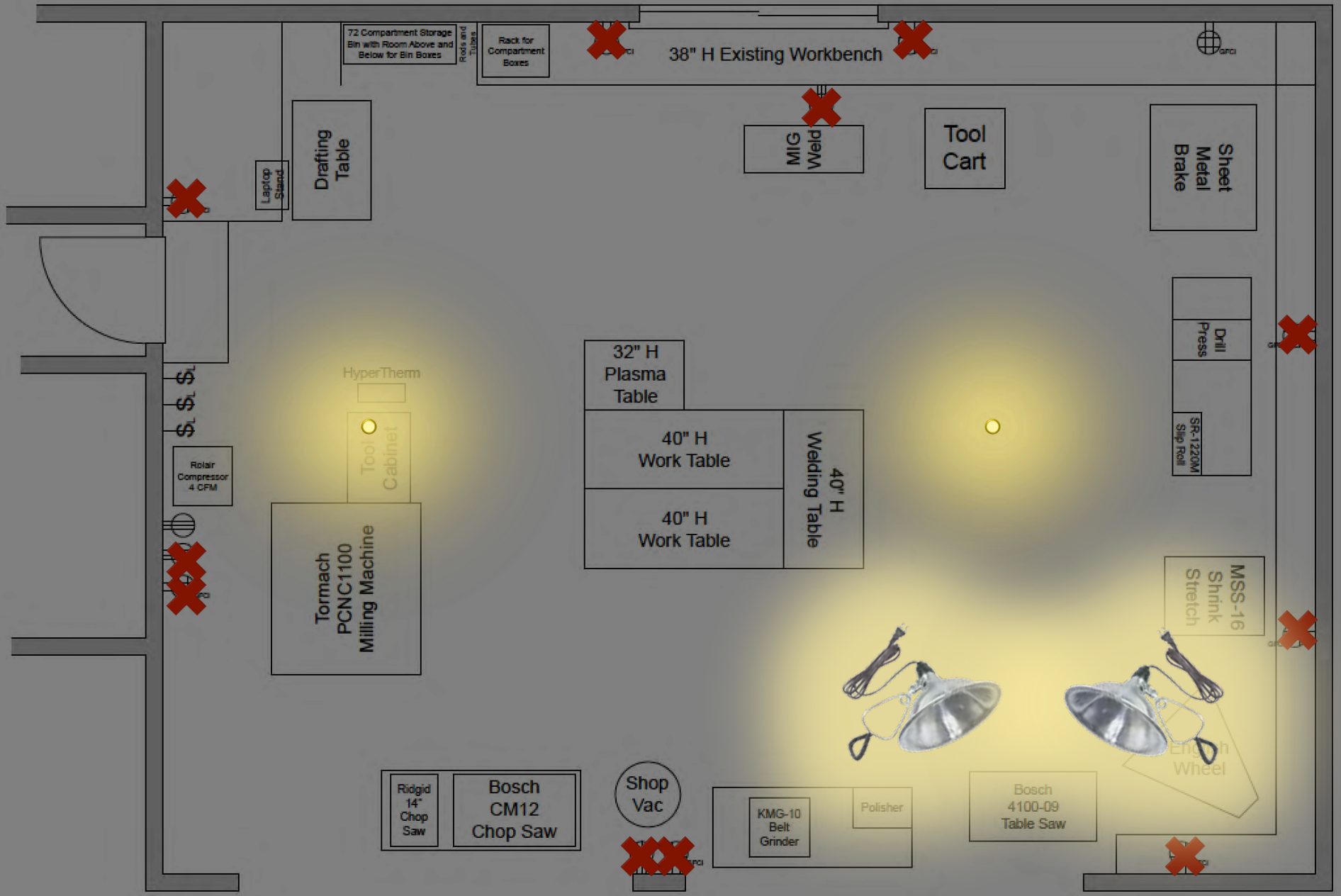
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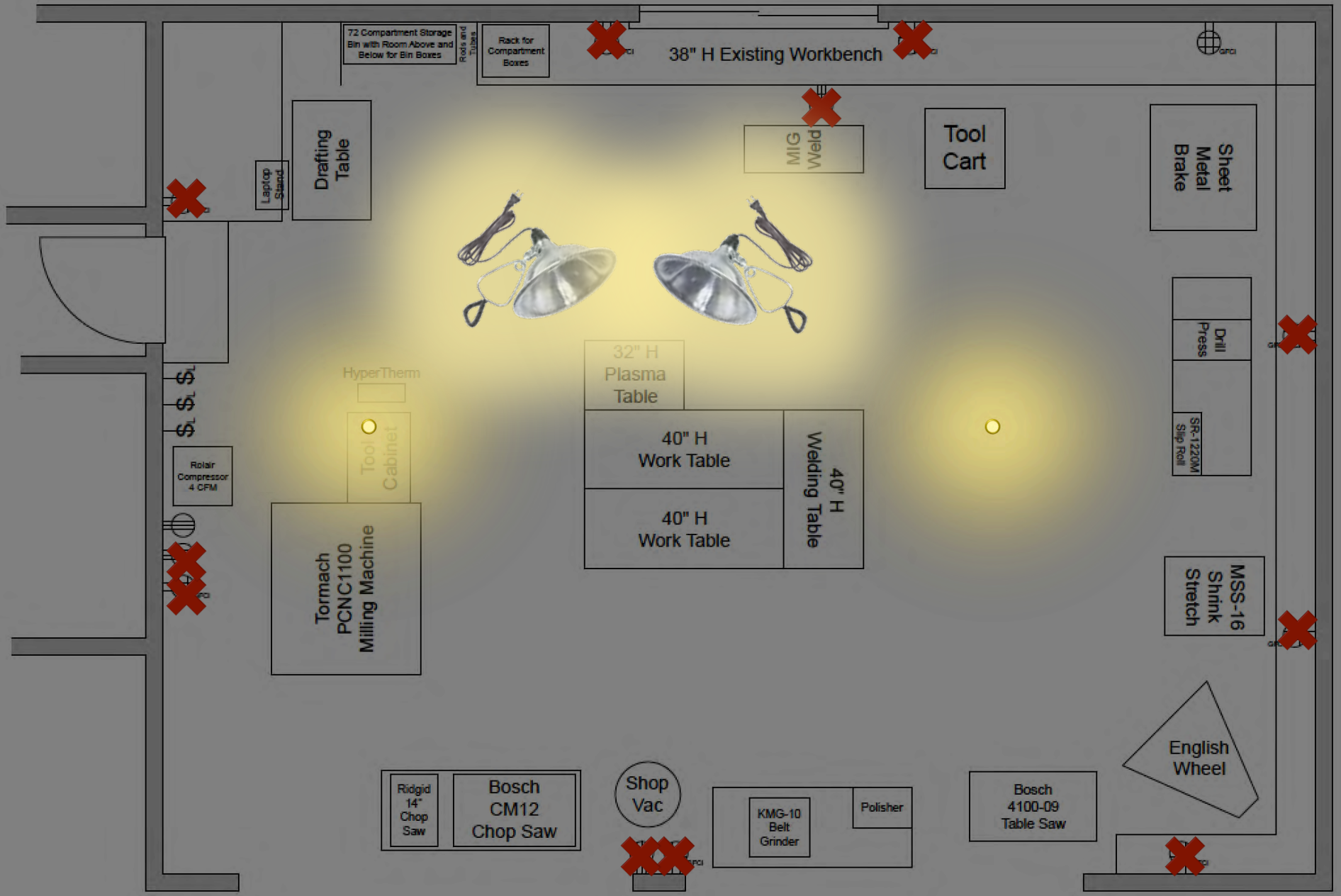
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Objectives

- More outlets
- More lighting

Strategies

pay someone
or
do it myself

Strategies

Pay someone

or

Do it myself

PAY SOMEONE

PAY SOMEONE

HOUSE PAINTING

LANDSCAPE DESIGN

BACKUP GENERATOR

HARDWOOD FLOORS

PROPANE TANK/LINE

Strategies

pay someone

or

do it myself

DO IT MYSELF

DO IT MYSELF

PLUMBING

KITCHEN TILE

ELECTRICAL WIRING

DO IT MYSELF

PLUMBING

KITCHEN TILE

ELECTRICAL WIRING

ELECTRICAL WIRING

ELECTRICAL WIRING

REPLACE APPLIANCES

NEW BRANCH CIRCUITS

NEW LIGHTING CIRCUITS

ELECTRICAL WIRING

REPLACE APPLIANCES

NEW BRANCH CIRCUITS

NEW LIGHTING CIRCUITS

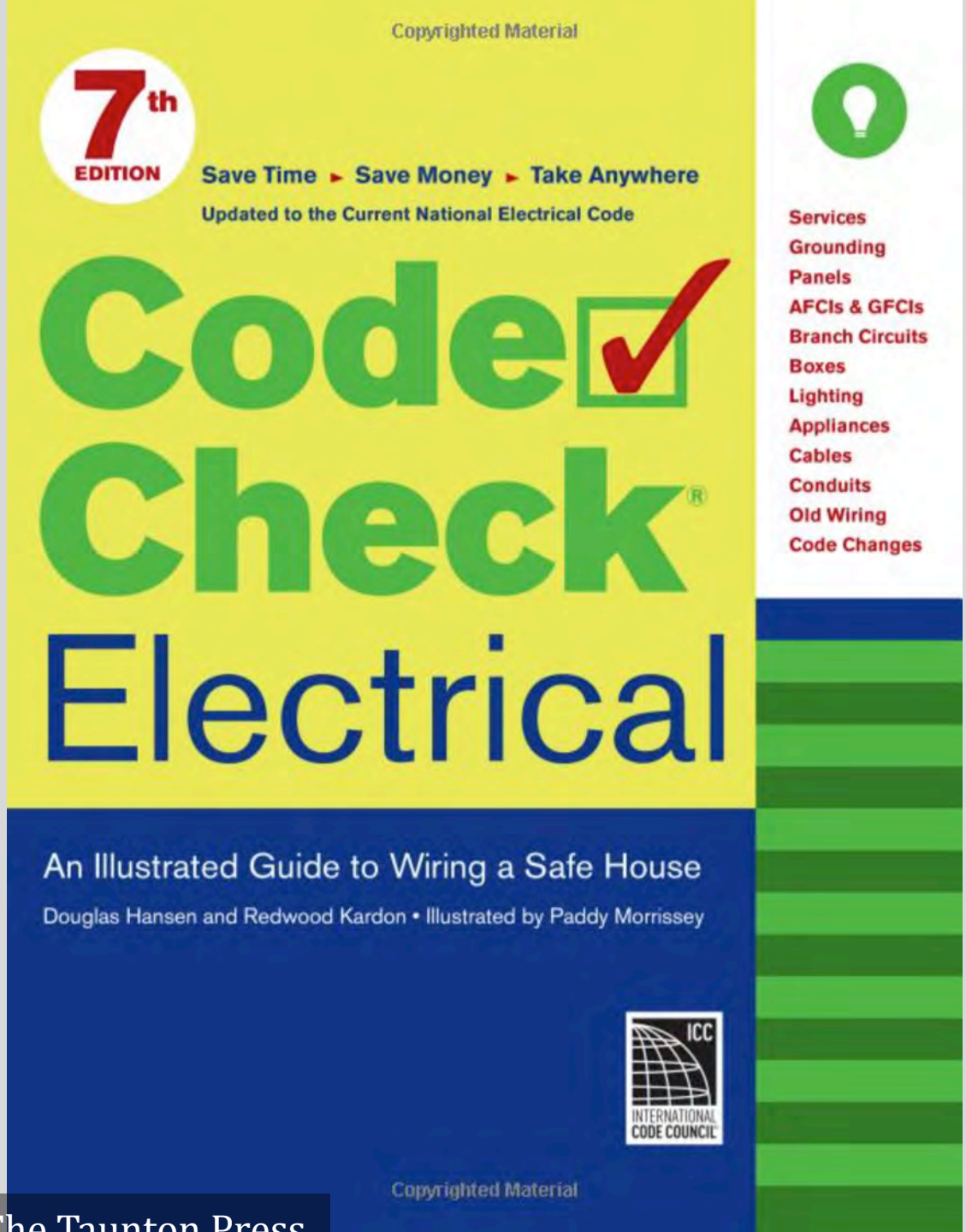
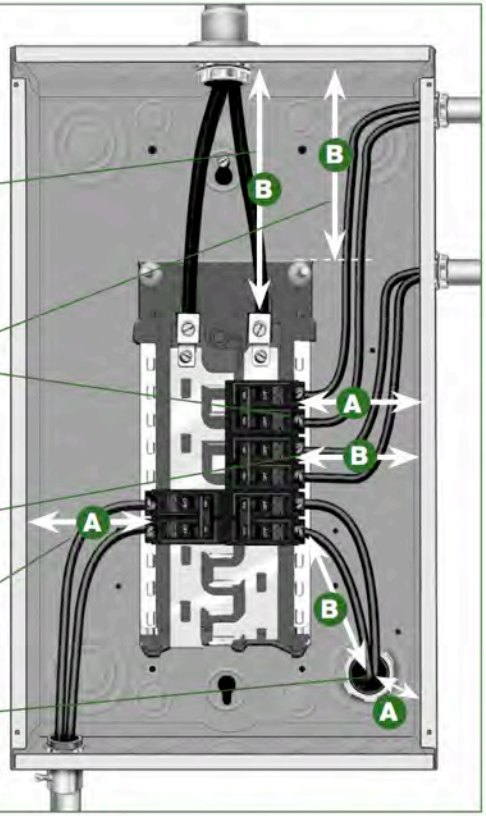


Image attribution: The Taunton Press

FIG. 17

Wire Bending Space

(For clarity, neutrals & EGCs not shown)



Dimension **T8B** from panel wall to lug determines max conductor size

The conductors from this breaker are allowed **T8A** size because they exit the side wiring space to an adjacent gutter that has **T8B** space. The adjacent gutter space is measured from the boundary posts above the main lugs.

Conductors exiting wall opposite terminals limited to **T8B** size

Conductors not exiting wall opposite terminals limited to **T8A** size

Back wall entry conductors limited to **T8A** measured to front panel edge & **T8B** measured to breaker terminal

TABLE 8 MINIMUM WIRING SPACE OPPOSITE TERMINALS

L Bends – Wire not through wall opposite terminal (A)		S Bends – Wire enters or leaves (B) enclosure in wall opposite terminal		
Wire Size (AWG or kcmil)	Required Space (in.)[1]	Cu Wire Size (AWG)	Compact Al (AWG or kcmil)[2]	Required Space (in.)[3]
14 – 10	n/a	14 – 10	12 – 8	n/a
8 – 6	1½	8	6	1½
4 – 3	2	6	4	2
2	2½	4	2	3
1	3	3	1	3
1/0 – 2/0	3½	2	1/0	3½
3/0 – 4/0	4	1	2/0	4½
250	4½	1/0	3/0	5½

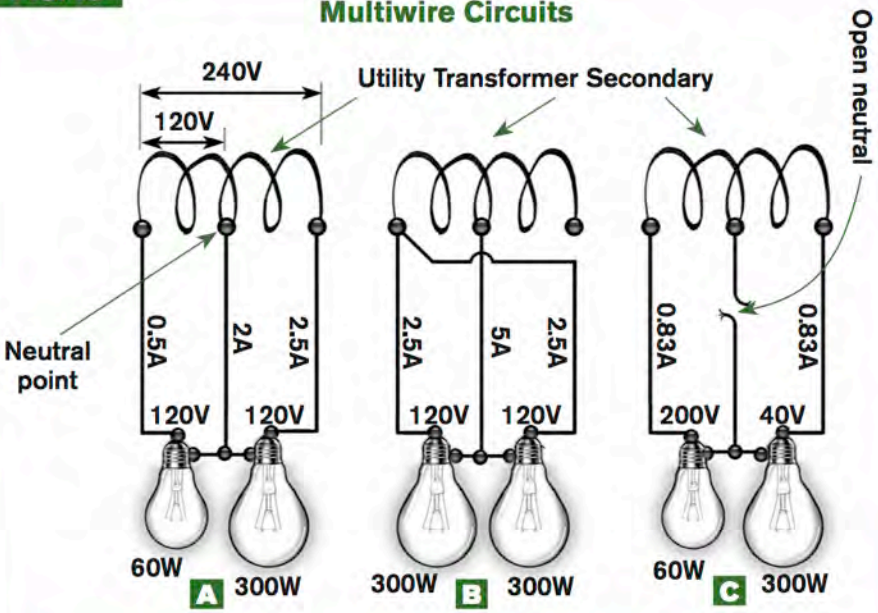
Multiwire Circuits

	12 IRC	14 NEC
☐ Hot conductors must originate from opposite poles	[3501]	{100}
☐ All conductors must originate from same panel	[3701.5]	{210.4A}
☐ Multiwire neutrals may not feed through devices such as receptacles (pigtail lead from neutral to splice in box)	[3406.10.2]	{300.13B}
☐ All multiwire circuits req handle tie or single handle	[3701.5.1]	{210.4B}
☐ All conductors of multiwire circuit must be grouped (wire ties or other means) inside panel EXC **F16**	[3701.5.2]	{210.4D}
• Cable systems where grouping is obvious **F16**	[3701.5.2X]	{210.4DX}
• Where conductors have numbered wire markers corresponding to their circuit numbers	[n/a]	{210.4DX}[15]

Standard electrical services to 1- and 2-family dwellings originate at a utility transformer with two ungrounded "hot" conductors and a neutral derived from the center of the transformer's secondary coil, as depicted in **F18**. The neutral is connected to earth and is referred to as the "grounded" conductor. The neutral limits the voltage on either of the hot conductors to 120V to ground. Not only is the service to the house a "3-wire" circuit, but 120V branch circuits are often installed with shared neutrals, and are then known as multiwire circuits. If the neutral is broken or loose, voltages become erratic, as in **F18 C**. TV sets, motors, and computers don't do well with fluctuating voltages. Signs of unstable voltage, such as incandescent bulbs growing brighter or dimmer as other loads change, could indicate a loose neutral either at a branch circuit or at the utility.

FIG. 18

Multiwire Circuits

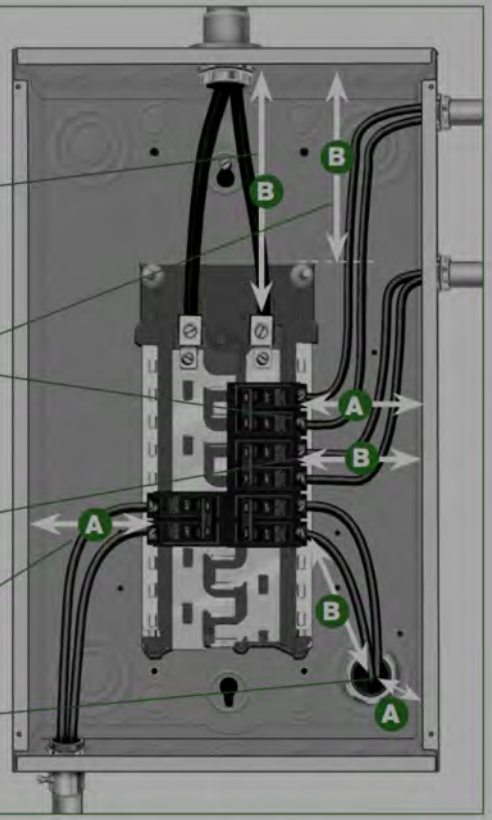


A PROPER CIRCUIT 2 unequal loads are fed by a 3-wire circuit. The

FIG. 17

Wire Bending Space

(For clarity, neutrals & EGCs not shown)



Dimension **T8B** from panel wall to lug determines max conductor size

The conductors from this breaker are allowed **T8A** size because they exit the side wiring space to an adjacent gutter that has **T8B** space. The adjacent gutter space is measured from the boundary posts above the main lugs.

Conductors exiting wall opposite terminals limited to **T8B** size

Conductors not exiting wall opposite terminals limited to **T8A** size

Back wall entry conductors limited to **T8A** measured to front panel edge & **T8B** measured to breaker terminal

TABLE 8 MINIMUM WIRING SPACE OPPOSITE TERMINALS

L Bends – Wire not through wall opposite terminal (A)		S Bends – Wire enters or leaves (B) enclosure in wall opposite terminal		
Wire Size (AWG or kcmil)	Required Space (in.)[1]	Cu Wire Size (AWG)	Compact Al (AWG or kcmil)[2]	Required Space (in.)[3]
14 – 10	n/a	14 – 10	12 – 8	n/a
8 – 6	1½	8	6	1½
4 – 3	2	6	4	2
2	2½	4	2	3
1	3	3	1	3
1/0 – 2/0	3½	2	1/0	3½
3/0 – 4/0	4	1	2/0	4½
250	4½	1/0	3/0	5½

Multiwire Circuits	12 IRC	14 NEC
☐ Hot conductors must originate from opposite poles	[3501]	{100}
☐ All conductors must originate from same panel	[3701.5]	{210.4A}
☐ Multiwire neutrals may not feed through devices such as receptacles (pigtail lead from neutral to splice in box)	[3406.10.2]	{300.13B}
☐ All multiwire circuits req handle tie or single handle	[3701.5.1]	{210.4B}
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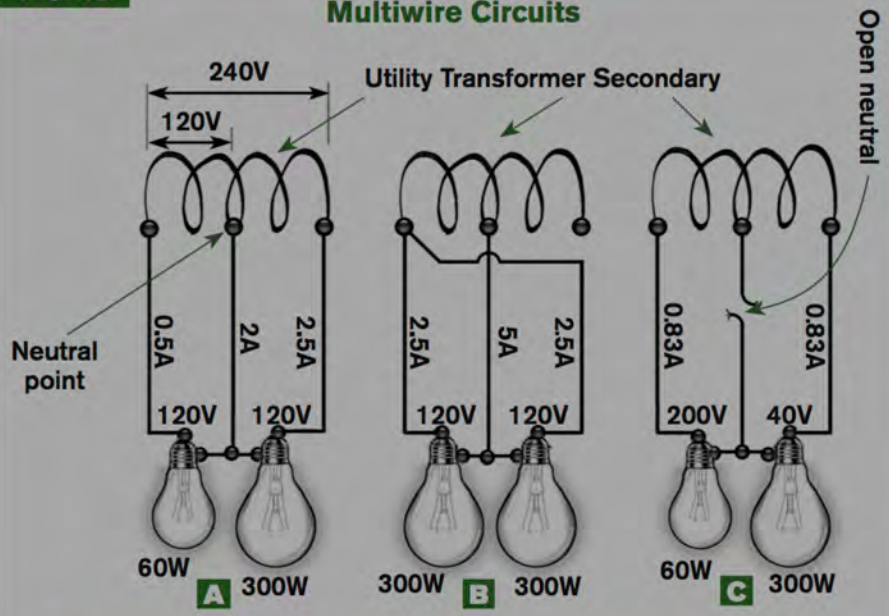
• Where conductors have numbered wire markers corresponding to their circuit numbers	[n/a]	{210.4DX}[15]

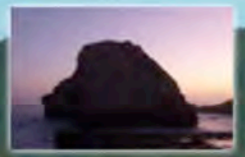
Standard electrical services to 1- and 2-family dwellings originate at a utility transformer with two ungrounded "hot" conductors and a neutral derived from the center of the transformer's secondary coil, as depicted in **F18**. The neutral is connected to earth and is referred to as the "grounded" conductor. The neutral limits the voltage on either of the hot conductors to 120V to ground. Not only is the service to the house a "3-wire" circuit, but 120V branch circuits are often installed with shared neutrals, and are then known as multiwire circuits. If the neutral is broken or loose, voltages become erratic, as in **F18 C**. TV sets, motors, and computers don't do well with fluctuating voltages. Signs of unstable voltage, such as incandescent bulbs growing brighter or dimmer as other loads change, could indicate a loose neutral either at a branch circuit or at the utility.

FIG. 18

Multiwire Circuits



A PROPER CIRCUIT 2 unequal loads are fed by a 3-wire circuit. The

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Kathy Molloy Previsich, Planning Director

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BUILDING AND ZONING COUNTER HOURS

MONDAY THROUGH THURSDAY

MORNING HOURS

8:00 A.M. – 11:30 A.M.

AFTERNOON HOURS

1:00 P.M. - 2:30 P.M.

Accessory Dwelling Unit Study

Housing Element

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County of Santa Cruz California

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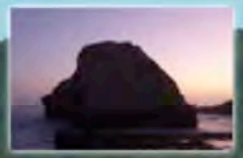


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MONDAY THROUGH THURSDAY

MORNING HOURS

8:00 A.M. – 11:30 A.M.

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Codes

California Building Standards Code (California Code of Regulations, Title 24)

2016 Triennial Edition (effective January 1, 2017)

The 2016 California Building Standards Code (California Code of Regulations, Title 24) was published as of July 1, 2016. The effective date of the 2016 Code is January 1, 2017.

Information Bulletin 16-01 provides detailed information concerning the 2016 publication including changes to the California Building Code (California Code of Regulations, Title 24, Part 2). Chapter 34 - Existing Structures, of the California Building Code has been relocated to the California Existing Building Code (California Code of Regulations, Title 24, Part 10). A cross reference table was developed to assist code users identify the relocated code sections.

Part 1 - California Administrative Code (HTML)

Errata (non-substantive corrections): Effective January 1, 2017 (PDF)

Part 2 - California Building Code

- **Volume 1 of Part 2** (HTML)

Errata (non-substantive corrections): Effective January 1, 2017 (PDF)

Supplement: Effective January 30, 2017 (PDF)

- **Volume 2 of Part 2** (HTML)

Errata (non-substantive corrections): Effective January 1, 2017 (PDF)

Supplement: Effective January 30, 2017 (PDF)

Part 2.5 - California Residential Code (HTML)

Errata (non-substantive corrections): Effective January 1, 2017 (PDF)

Part 3 - California Electrical Code (HTML)

Errata (non-substantive corrections): Effective January 1, 2017 (PDF)

Part 4 - California Mechanical Code (HTML)

Errata (non-substantive corrections): Effective January 1, 2017 (PDF)

Part 5 - California Plumbing Code (HTML)

Errata (non-substantive corrections): Effective January 1, 2017 (PDF)

Part 6 - California Energy Code (HTML)

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- Exterior Elevated Elements (EEE) Subcommittee - Resources
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2016 CALIFORNIA ELECTRICAL CODE

CALIFORNIA CODE OF REGULATIONS TITLE 24, PART 3

Based on the 2014 National Electrical Code®

California Building Standards Commission

2016 CALIFORNIA ELECTRICAL CODE

CALIFORNIA CODE OF REGULATIONS TITLE 24, PART 3

Based on the 2014 National Electrical Code®

California Building Standards Commission

NFPA

Exception: *Where the conditions of maintenance and supervision ensure that only qualified persons service the installations, terminals for grounded conductors shall be permitted to be permanently identified at the time of installation by a distinctive white marking or other equally effective means.*

200.10 Identification of Terminals.

(A) Device Terminals. All devices, excluding panelboards, provided with terminals for the attachment of conductors and intended for connection to more than one side of the circuit shall have terminals properly marked for identification, unless the electrical connection of the terminal intended to be connected to the grounded conductor is clearly evident.

Exception: *Terminal identification shall not be required for devices that have a normal current rating of over 30 amperes, other than polarized attachment plugs and polarized receptacles for attachment plugs as required in 200.10(B).*

(B) Receptacles, Plugs, and Connectors. Receptacles, polarized attachment plugs, and cord connectors for plugs and polarized plugs shall have the terminal intended for connection to the grounded conductor identified as follows:

(1) Identification shall be by a metal or metal coating that is substantially white in color or by the word *white* or the letter *W* located adjacent to the identified terminal.

(2) If the terminal is not visible, the conductor entrance hole for the connection shall be colored white or marked with the word *white* or the letter *W*.

Informational Note: See 250.126 for identification of wiring device equipment grounding conductor terminals.

(C) Screw Shells. For devices with screw shells, the terminal for the grounded conductor shall be the one connected to the screw shell.

(D) Screw Shell Devices with Leads. For screw shell devices with attached leads, the conductor attached to the wires (including the equipment grounding conductor), shall have means to identify the terminal for the grounded circuit conductor (if any).

200.11 Polarity of Connections. No grounded conductor shall be attached to any terminal or lead so as to reverse the designated polarity.

ARTICLE 210
Branch Circuits

I. General Provisions

210.1 Scope. This article covers branch circuits except for branch circuits that supply only motor loads, which are covered in Article 430. Provisions of this article and Article 430 apply to branch circuits with combination loads.

210.2 Other Articles for Specific-Purpose Branch Circuits. Branch circuits shall comply with this article and also with the applicable provisions of other articles of this *Code*. The provisions for branch circuits supplying equipment listed in Table 210.2 amend or supplement the provisions in this article.

210.3 Rating. Branch circuits recognized by this article shall be rated in accordance with the maximum permitted ampere rating or setting of the overcurrent device. The rating for other than individual branch circuits shall be 15, 20, 30, 40, and 50 amperes. Where conductors of higher ampacity are used for any reason, the ampere rating or setting of the specified overcurrent device shall determine the circuit rating.

Exception: *Multioutlet branch circuits greater than 50 amperes shall be permitted to supply nonlighting outlet loads on industrial premises where conditions of maintenance and supervision ensure that only qualified persons service the equipment.*

210.4 Multiwire Branch Circuits.

(A) General. Branch circuits recognized by this article

Table 210.2 Specific-Purpose Branch Circuits

Equipment	Article	Section
Air-conditioning and refrigerating equipment		440.6, 440.31, 440.32
Audio signal processing, amplification, and reproduction equipment		640.8
Busways		368.17
Circuits and equipment operating at less than 50 volts	720	
Central heating equipment other than fixed electric space-heating equipment		422.12
Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits	725	
Cranes and hoists		610.42
Electric signs and outline lighting		600.6
Electric welders	630	
Electrified truck parking space	626	
Elevators, dumbwaiters, escalators, moving walks, wheelchair lifts, and stairway chair lifts		620.61
Fire alarm systems	760	
Fixed electric heating equipment for pipelines and vessels		427.4
Fixed electric space-heating equipment		424.3
Fixed outdoor electrical deicing and snow-melting equipment		426.4
Information technology equipment		645.5
Infrared lamp industrial heating equipment		422.48, 424.3
Induction and dielectric heating equipment	665	
Marinas and boatyards		555.19
Mobile homes, manufactured homes, and mobile home parks	550	

(B) Disconnecting Means. Each multiwire branch circuit shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point where the branch circuit originates.

Informational Note: See 240.15(B) for information on the use of single-pole circuit breakers as the disconnecting means.

(C) Line-to-Neutral Loads. Multiwire branch circuits shall supply only line-to-neutral loads.

Exception No. 1: A multiwire branch circuit that supplies only one utilization equipment.

Exception No. 2: Where all ungrounded conductors of the multiwire branch circuit are opened simultaneously by the branch-circuit overcurrent device.

(D) Grouping. The ungrounded and grounded circuit conductors of each multiwire branch circuit shall be grouped by cable ties or similar means in at least one location within the panelboard or other point of origination.

Exception: The requirement for grouping shall not apply if the circuit enters from a cable or raceway unique to the circuit that makes the grouping obvious or if the conductors are identified at their terminations with numbered wire markers corresponding to the appropriate circuit number.

210.5 Identification for Branch Circuits.

(A) Grounded Conductor. The grounded conductor of a branch circuit shall be identified in accordance with 200.6.

(B) Equipment Grounding Conductor. The equipment grounding conductor shall be identified in accordance with 250.119.

(C) Identification of Ungrounded Conductors. Ungrounded conductors shall be identified in accordance with 210.5(C)(1) or (2), as applicable.

(1) Branch Circuits Supplied from More Than One Nominal Voltage System. Where the premises wiring system has branch circuits supplied from more than one nominal voltage system, each ungrounded conductor of a branch circuit shall be identified by phase or line and system at all termination, connection, and splice points in compliance with 210.5(C)(1)(a) and (b).

Reason #1: Don't let anything catch fire

Image attribution: Wikipedia, “Fire”

Reason #2: Don't let anybody die

Image attribution: http://forums.pelicanparts.com/uploads14/electrocution_Cat1222492681.jpg

The Steps

Review the code

Draw outlet plan

Draw lighting plan

Get building permit

Perform installation

The Steps

review the code

draw outlet plan

draw lighting plan

get building permit

perform installation

7th EDITION

Save Time ► Save Money ► Take Anywhere

Updated to the Current National Electrical Code

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An Illustrated Guide to Wiring a Safe House

Douglas Hansen and Redwood Kardon • Illustrated by Paddy Morrissey

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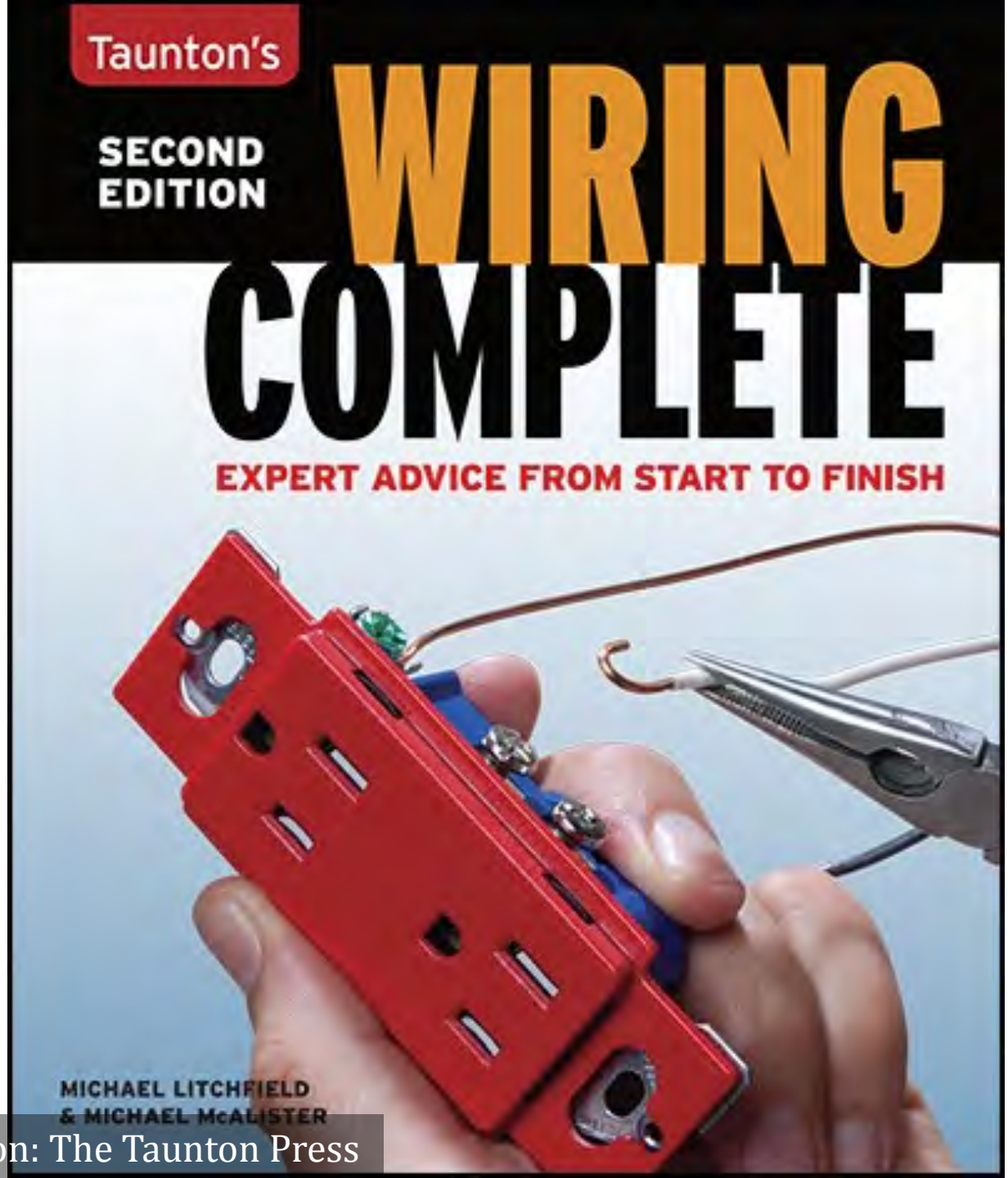

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The Steps

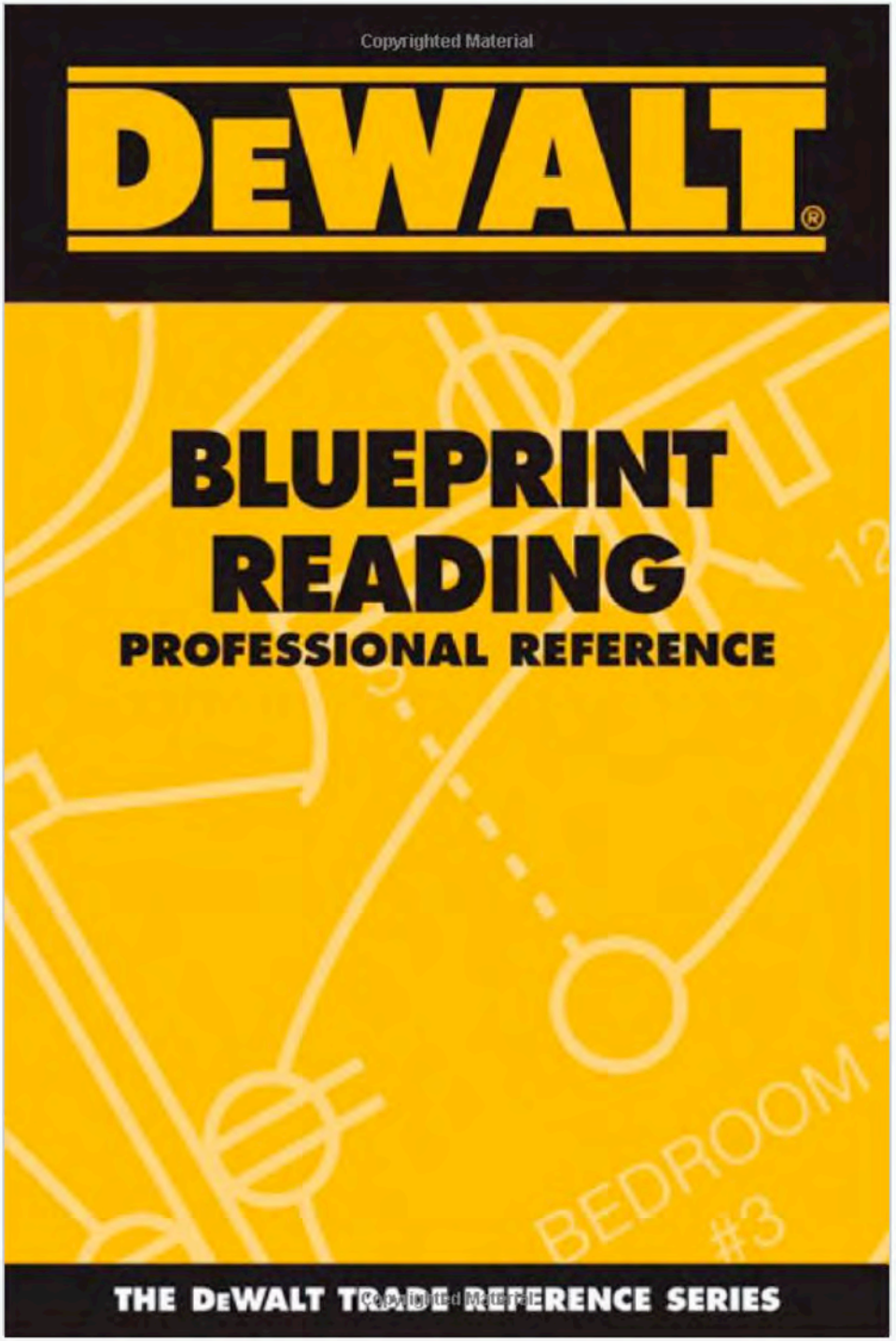
REVIEW THE CODE

DRAW OUTLET PLAN

DRAW LIGHTING PLAN

GET BUILDING PERMIT

PERFORM INSTALLATION



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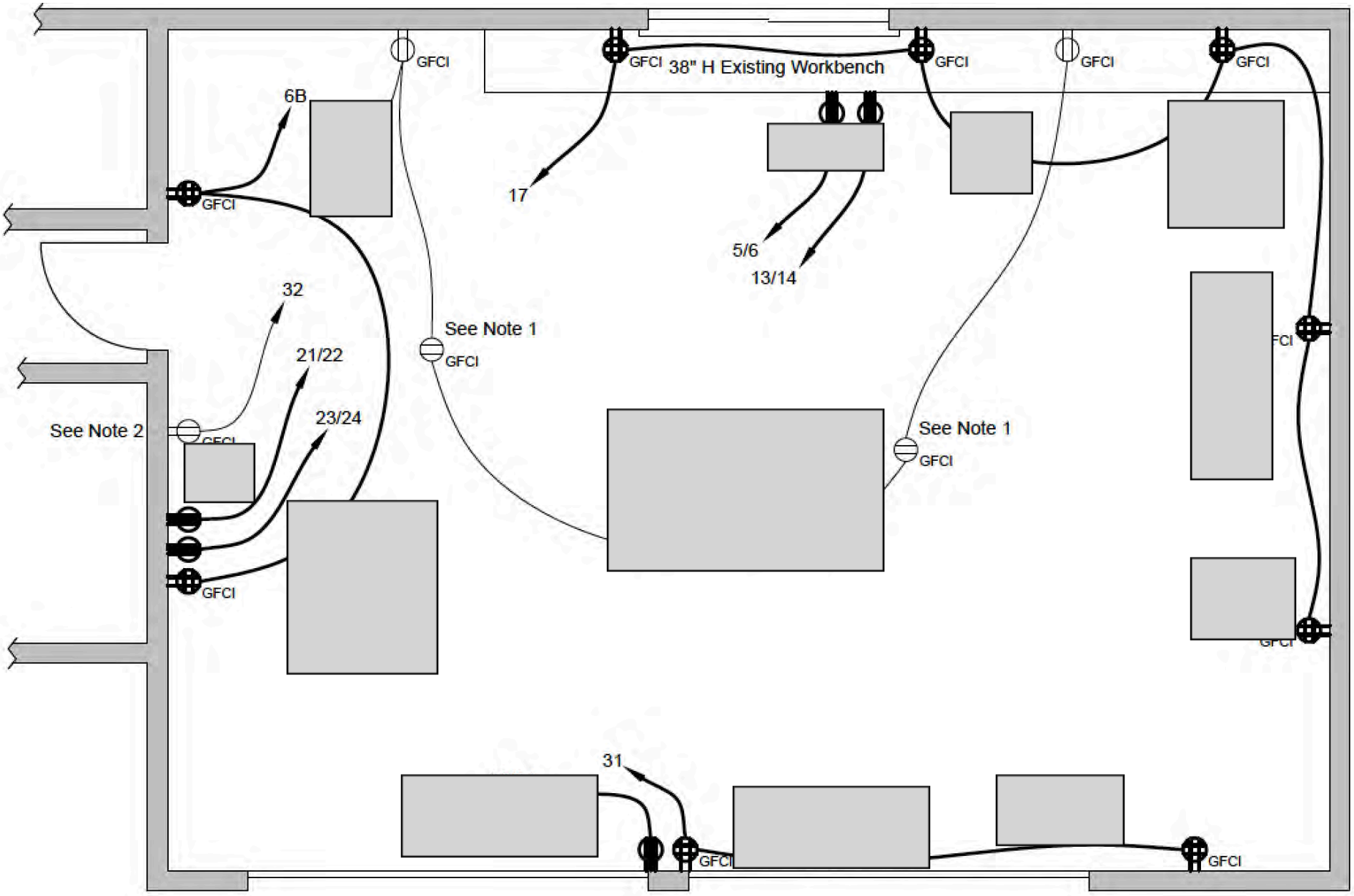
CHAPTER 8 – *Electrical Drawings* 8-1


GFCI
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38" H Existing Workbench
GFCI
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6B
GFCI
17
5/6
13/14
32
See Note 1
GFCI
21/22
23/24
See Note 2
See Note 1
GFCI
GFCI
31
GFCI
GFCI

The Steps

REVIEW THE CODE

DRAW OUTLET PLAN

DRAW LIGHTING PLAN

GET BUILDING PERMIT

PERFORM INSTALLATION

DRAW LIGHTING PLAN

DRAW LIGHTING PLAN

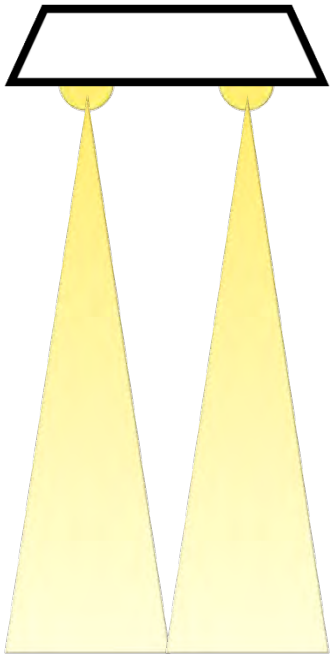
HOW MUCH LIGHT?

DRAW LIGHTING PLAN

HOW MUCH LIGHT?

LUMEN METHOD

LUMEN METHOD



3. Illuminance of Light Bulbs

2. Efficiency of Light Fixture

1. Target Illuminance at Work Surface

LIGHTING DESIGN – FOOTCANDLE RECOMMENDATIONS

Currently Recommended Illuminance Categories & Illuminance Values For Lighting Design—Target Maintined Levels

The tabulation that follows is a consolidated listing of current illuminance recommendations. This listing is intended to guide the lighting designer in selecting an appropriate illuminance for design and evaluation of lighting systems.

Guidance is provided in two forms: (1), in Parts I, II, and III as an Illuminance Category, representing a range of illuminances and (2), in parts IV, V and VI as an Illuminance Value. Illuminance Categories are represented by letter designations A through I. Illuminance Values are given in lux with an approximate equivalence in footcandles and as such are intended as target (nominal) values with deviations expected. These target values also represent maintained values.

This table has been divided into the six parts for ease of use. Part I provides a listing of both Illuminance Categories and Illuminance Values for generic types of interior activities and normally is to be used when Illuminance Categories for a specific Area/Activity cannot be found in Parts II and III. Parts IV, V and VI provide target maintained Illuminance Values for outdoor facilities, sports and recreational areas, and transportation vehicles where special considerations apply.

In all cases, the recommendations in this table are based on the assumption that the lighting will be properly designed to take into account the visual characteristics of the task.

I. Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors

TYPE OF ACTIVITY	CATEGORY	RANGES OF ILLUMINANCES		REFERENCE WORK-PLANE
		LUX	FOOTCANDLES	
Public spaces with dark surroundings	A	20-30-50	2-3-5	General lighting throughout spaces
Simple orientation for short temporary visits	B	50-75-100	5-7,5-10	
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	
Performance of visual	E	500-750-1000	50-75-100	

II. Commercial, Institutional, Residential and Public Assembly Interiors

Area/Activity	Illuminance Category
Air terminals (see Transportation terminals)	
Armories	C[1]
Auditoriums	
Assembly	C[1]
Social activity	B
Banks (also see Reading)	
Lobby	
General	C
Writing area	D
Tellers stations	E[3]
Barber shops and beauty parlors	E
Conference rooms	
Conferring	D
Critical seeing (refer to individual task)	
Depots, terminals and stations (see Transportation terminals)	
Drafting	
Mylar	
High contrast media; india ink, plastic leads, soft graphite leads	E[3]
Low contrast media: hard graphite leads	F[3]
Vellum	
High contrast	E[3]
Low contrast	F[3]
Tracing paper	
High contrast	E[3]
Low contrast	F[3]
Overlays[2]	
Light table	C
Prints	

Area/Activity	Illuminance Category
Food service facilities	
Dining areas	
Cashier	D
Cleaning	C
Dining	B[6]
Food displays (see Merchandising spaces)	
Kitchen	E
Gasoline stations (see Service Stations)	
Graphic design and material	
Color selection	F[11]
Charting and mapping	F
Graphs	E
Keylining	F
Layout and artwork	F
Photographs, moderate detail	E[13]
Health care facilities	
Ambulance (local)	E
Anesthetizing	E
Autopsy and morgue[17,18]	
Autopsy, general	E
Autopsy table	G
Morgue, general	D
Museum	E
Cardiac function lab	E
Central sterile supply	
Inspection, general	E
Inspection	F
At sinks	E
Work areas, general	D
Processed storage	D
Corridors[17]	
Nursing areas — day	C
Nursing areas — night	B
Operating areas, delivery, recovery, and laboratory suites and service	E
Critical care areas[17]	

Area/Activity	Illuminance Category
Examination and treatment rooms[17]	
General	D
Local	E
Eye surgery[17]	F
Fracture room[17]	
General	E
Local	F
Inhalation therapy	D
Laboratories[17]	
Specimen collecting	E
Tissue laboratories	F
Microscopic reading room	D
Gross specimen review	F
Chemistry rooms	E
Bacteriology rooms	
General	E
Reading culture plates	F
Hematology	E
Linens	
Sorting soiled linen	D
Central (clean) linen room	D
Sewing room, general	D
Sewing room, work area	E
Linen closet	B
Lobby	C
Locker rooms	C
Medical illustration studio[17,18]	F
Medical records	E
Nurseries[17]	
General[18]	C
Observation and treatment	E
Nursing stations[17]	
General	D
Desk	E
Corridors day	C
Corridors night	A
Medication station	E

Area/Activity	Illuminance Category
Post-anesthetic recovery room[17]	
General[18]	E
Local	H
Pulmonary function laboratories[17]	E
Radiology suite[17]	
Diagnostic section	
General[18]	A
Waiting area	A
Radiographic/ fluoroscopic room	A
Film sorting	F
Barium kitchen	E
Radiation therapy section	
General[18]	B
Waiting area	B
Isotope kitchen, general	E
Isotope kitchen, benches	E
Computerized radiotomography section	
Scanning room	B
Equipment maintenance room	E
Solarium	
General	C
Local for reading	D
Stairways	C
Surgical suite[17]	
Operating room, general[18]	F
Scrub room[18]	E
Instruments and sterile supply room	D
Clean up room, instruments	E
Anesthesia storage	C
Substerilizing room	C
Surgical induction room[17,18]	E
Surgical holding area[17,18]	E
Toilets	C

Area/Activity	Illuminance Category
Machine shops	
Rough bench or machine work	D
Medium bench or machine work, ordinary automatic machines, rough grinding, medium buffing and polishing	E
Fine bench or machine work, fine automatic machines, medium grinding, fine buffing and polishing	G
Extra-fine bench or machine work, grinding, fine work	H

TYPE OF ACTIVITY	CATEGORY	RANGES OF ILLUMINANCES LUX	RANGES OF ILLUMINANCES FOOTCANDLES	REFERENCE WORK-PLANE
Public spaces with dark surroundings	A	20-30-50	2-3-5	
Simple orientation for short temporary visits	B	50-75-100	5-7,5-10	General lighting throughout spaces
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	Illuminance on task
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	Illuminance on task, obtained by a combination of general and local (supplementary lighting)
Performance of very prolonged and exacting visual tasks	H	5000-7500-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

TYPE OF ACTIVITY	CATEGORY	RANGES OF ILLUMINANCES		REFERENCE WORK-PLANE
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Performance of very prolonged and exacting visual tasks	H	5000-7500-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

FOOTCANDLES = 75

$$\text{FOOTCANDLES} = 75 = \frac{\text{LUMENS}}{\text{SQ. FT.}}$$

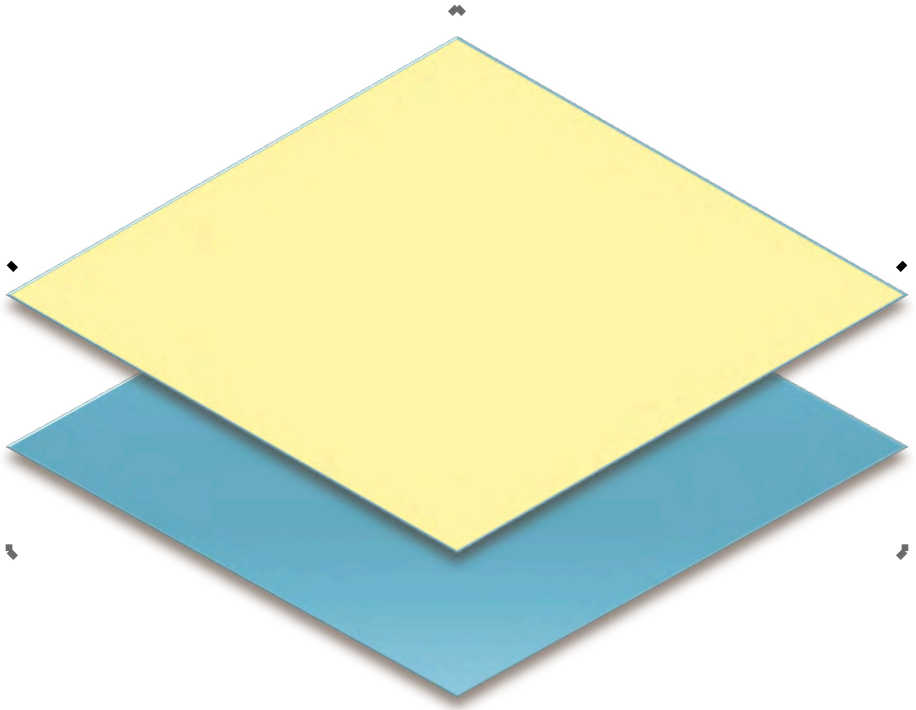
$$\text{FOOTCANDLES} = 75 = \frac{\text{LUMENS}}{\text{SQ. FT.}}$$

$$\text{FOOTCANDLES} = 75 = \frac{\text{LUMENS}}{525}$$

$$\text{LUMENS} = 525 \times 75 = 39{,}375$$

LUMENS = 525 × 75 = 39,375

$$\text{LUMENS} = 39{,}375 \div (0.65 \times 0.9) = 67{,}308$$

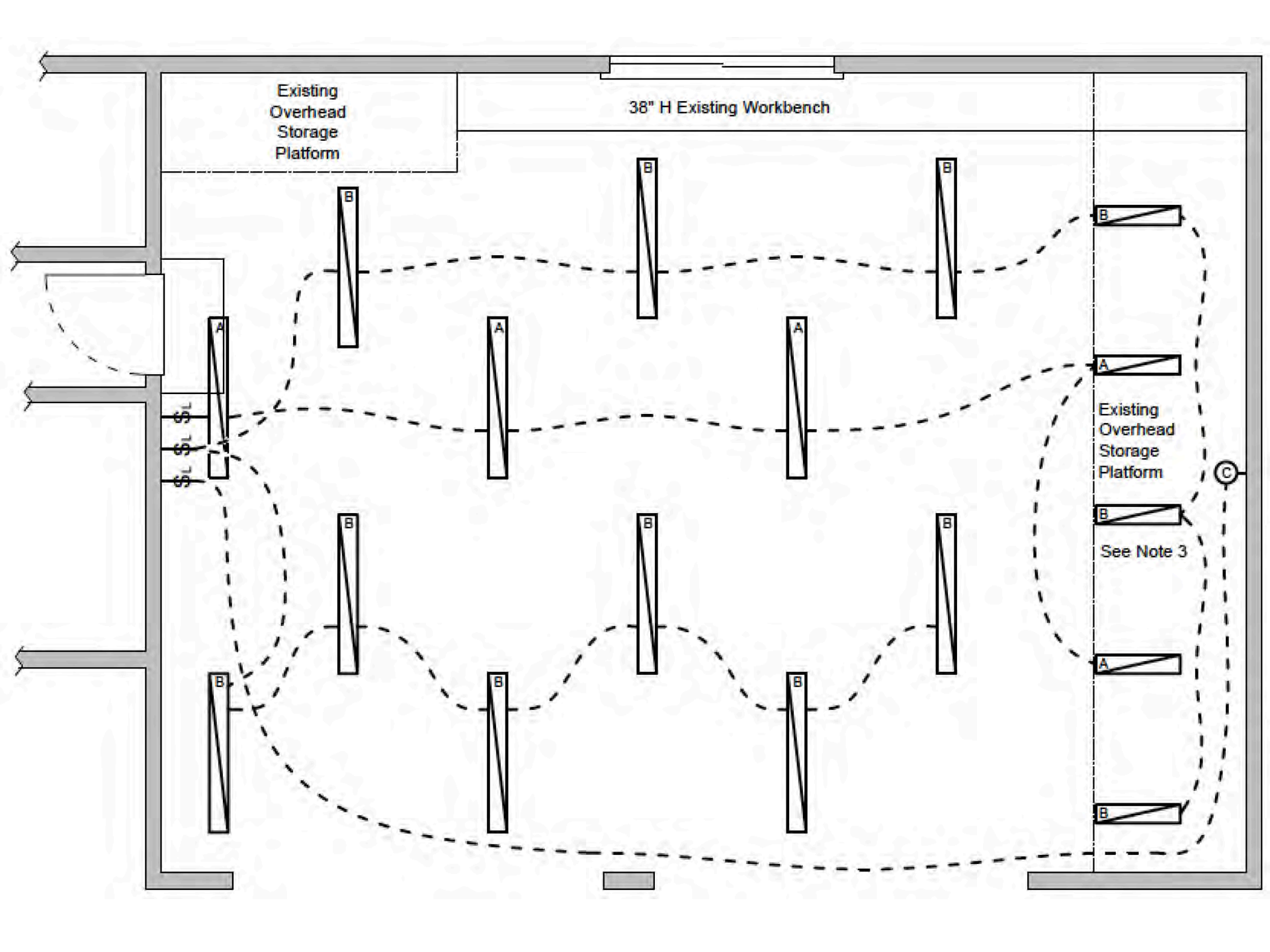


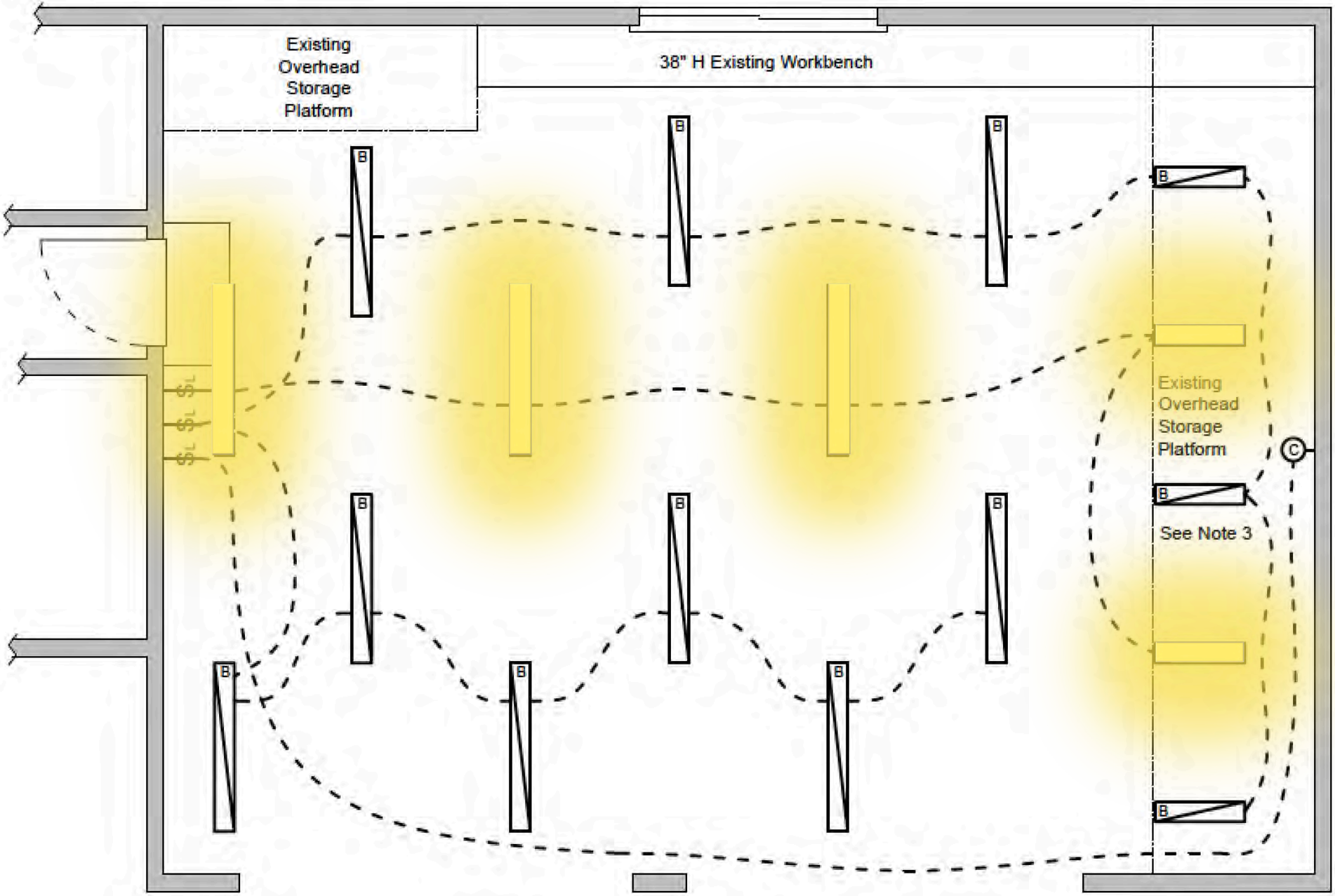
$$\text{LUMENS} = 525 \times 75 = 39{,}375$$

LUMENS = 39,375 ÷ (0.65 × 0.9) = 67,308

2,875 LUMENS PER BULB
2 BULBS
12 FIXTURES

69,000 LUMENS TOTAL


Existing
Overhead
Storage
Platform
38" H Existing Workbench
A
B
C
69"L
69"L
69"L
Existing
Overhead
Storage
Platform
See Note 3


Existing
Overhead
Storage
Platform
38" H Existing Workbench
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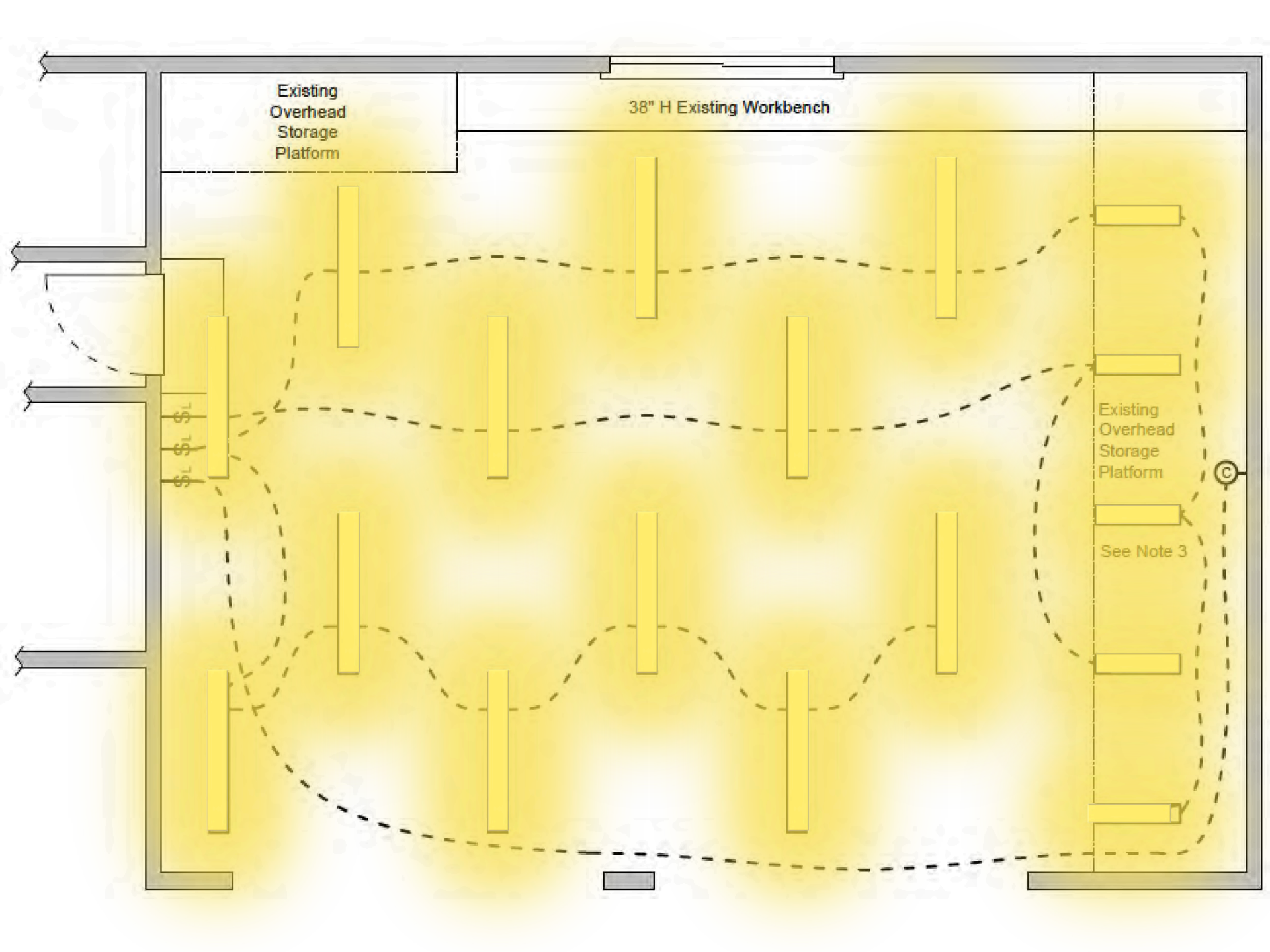
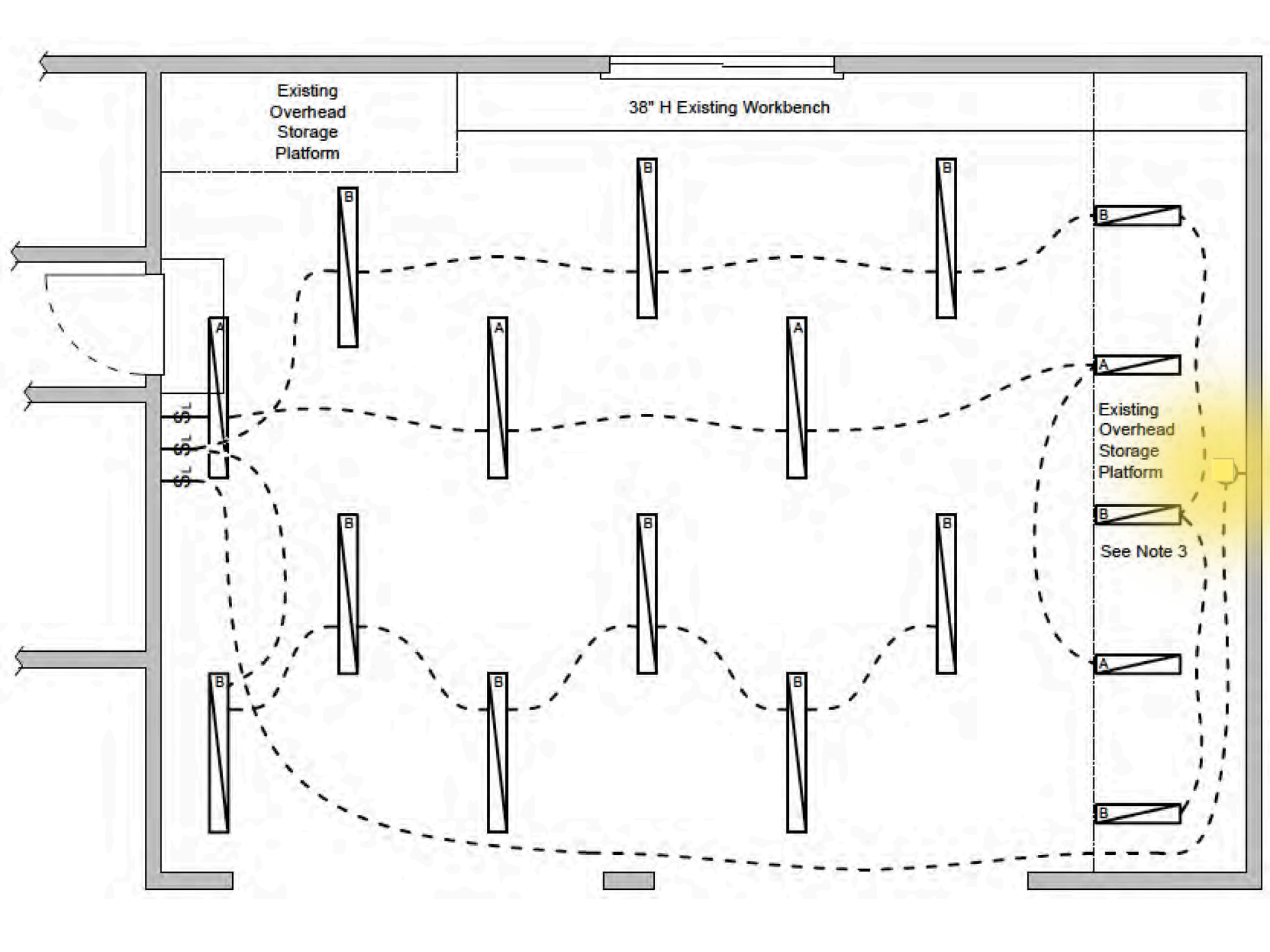
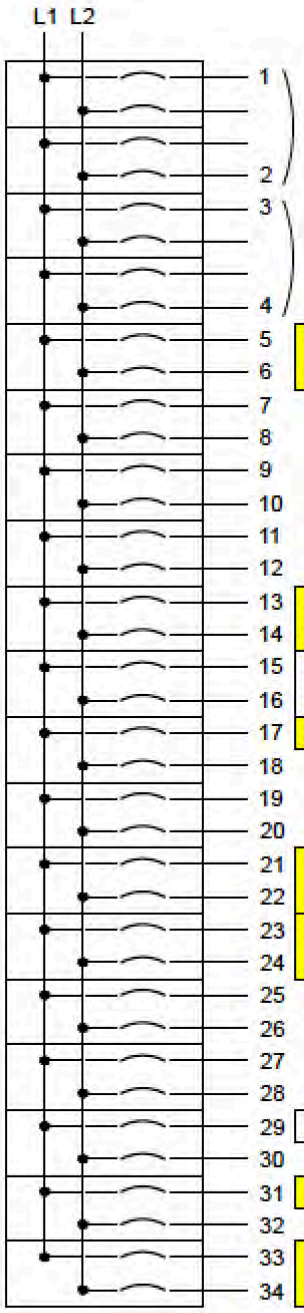
Overhead
Storage
Platform
C
See Note 3

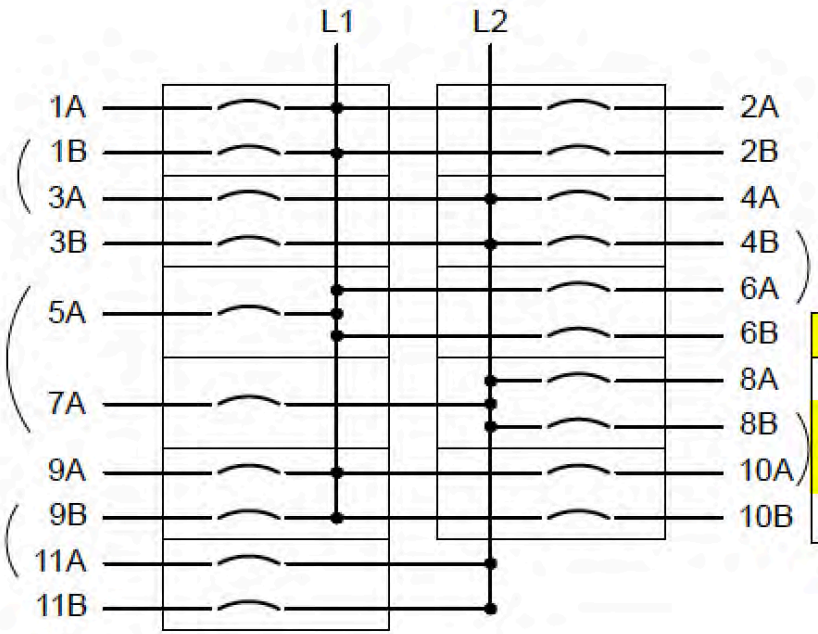

Existing
Overhead
Storage
Platform
38" H Existing Workbench
6'-0"
6'-0"
6'-0"
Existing
Overhead
Storage
Platform
See Note 3
C


Existing
Overhead
Storage
Platform
38" H Existing Workbench
B
A
69"L
Existing
Overhead
Storage
Platform
See Note 3



1 2	40A 40A	Spare Spare	Surface-mount 6-50R along back wall's workbench
3 4			
5 6			
7 8			
9 10			
11 12			
13 14	50A 50A	Spare Spare	Surface-mount 6-50R along back wall's workbench
15 16	30A 30A	Spare Spare	Remains unused
17	20A	Spare	Five quadraplex GFCI 5-20R along back and right wall
18			
19			
20			
21 22	20A 20A	Spare Spare	First L6-20R along left wall. (Upgrade existing 15/20A tandem breaker to 20/20A and Tie as Double Pole.)
23 24	20A 20A	Spare Spare	Second L6-20R along left wall. (Tie existing 20/20A tandem breaker as Double Pole.)
25			
26			
27			
28			
29	15A	Spare	Remains unused
30			
31	20A	Spare	Two quadraplex GFCI 5-20R along front wall
32			
33 34	20A 20A	Spare Spare	L6-20R along front wall. (Tie existing 20/20A tandem breaker as Double Pole.)

Sylvania model MLB20(20-40)C



20A	Spare	Two quadraplex GFCI 5-20R along left wall.
15A	Used	Original 8B moved here to allow 8B/10A be two-pole.
20A	Spare	New garage lighting, multiwire phase L2
20A	Spare	New garage lighting, multiwire phase L1
15A	Used	

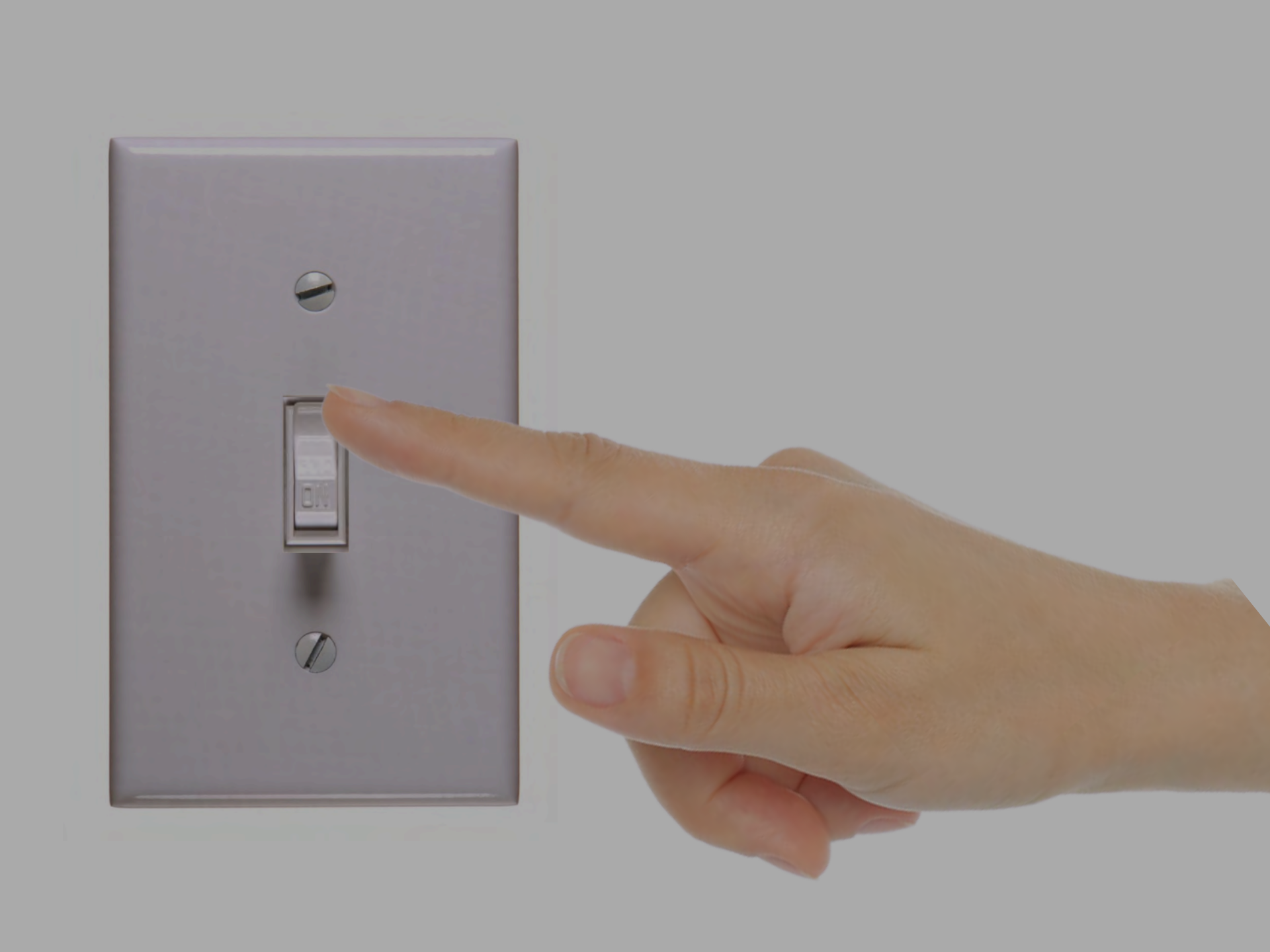
Square D model HOMC12UC


Image attribution: Google Maps

New Rule

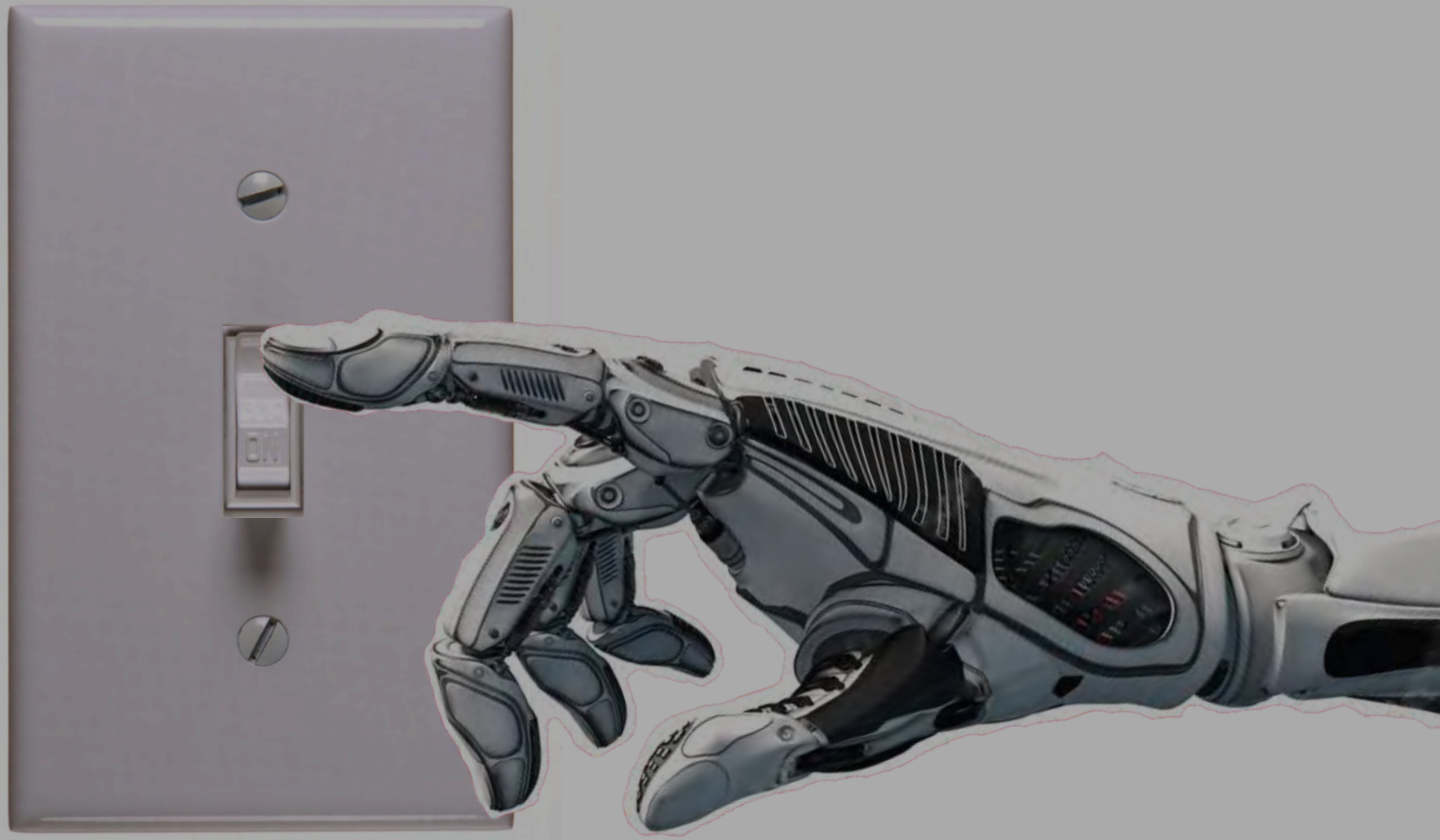
Garages now need vacancy sensors

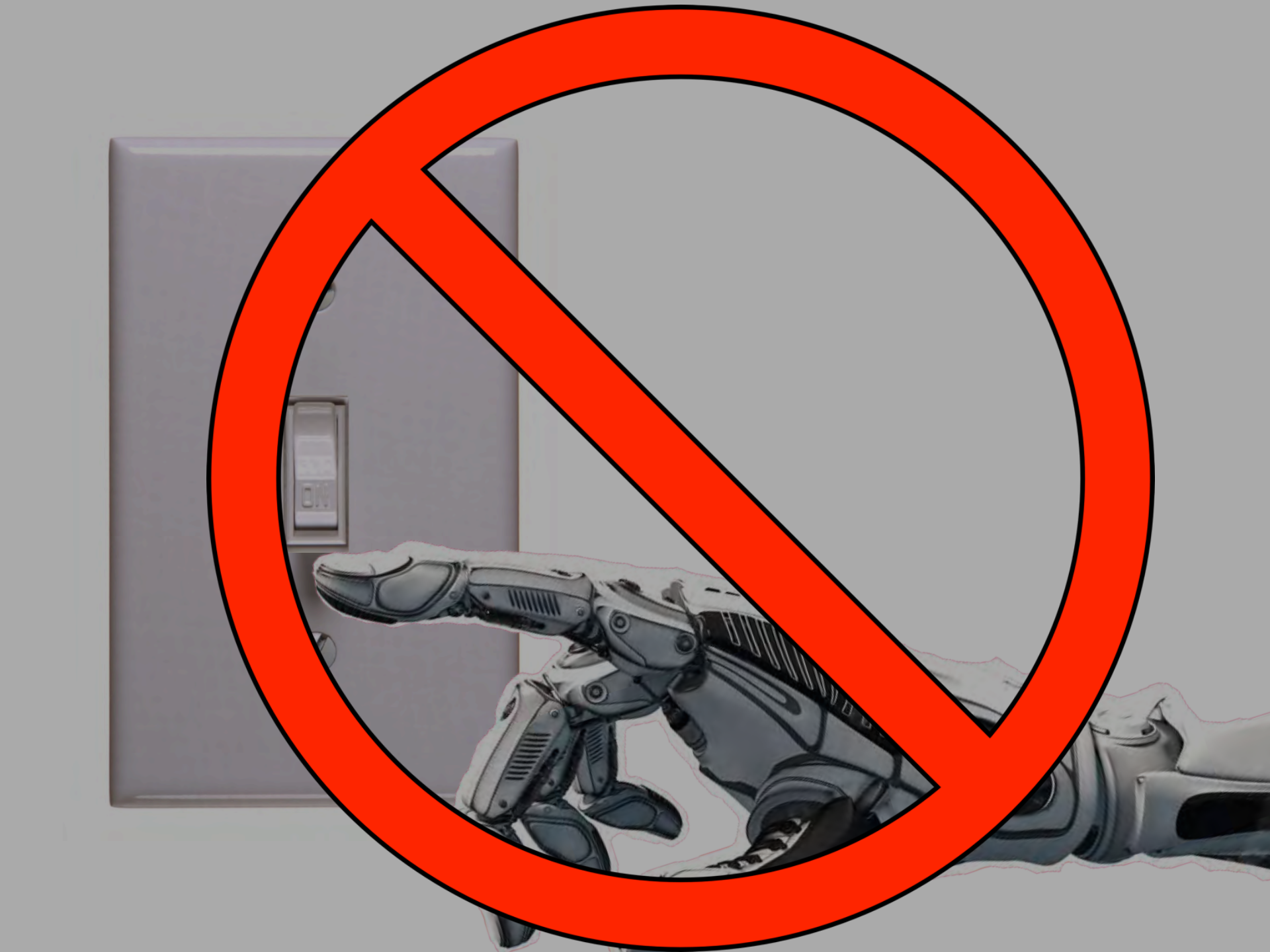

ON


ON


ON

20 Minutes


ON


ON

Occupancy Sensor

- Manual On
- Manual Off
- Automatic On
- Automatic Off

Vacancy Sensor

Manual On

Manual Off

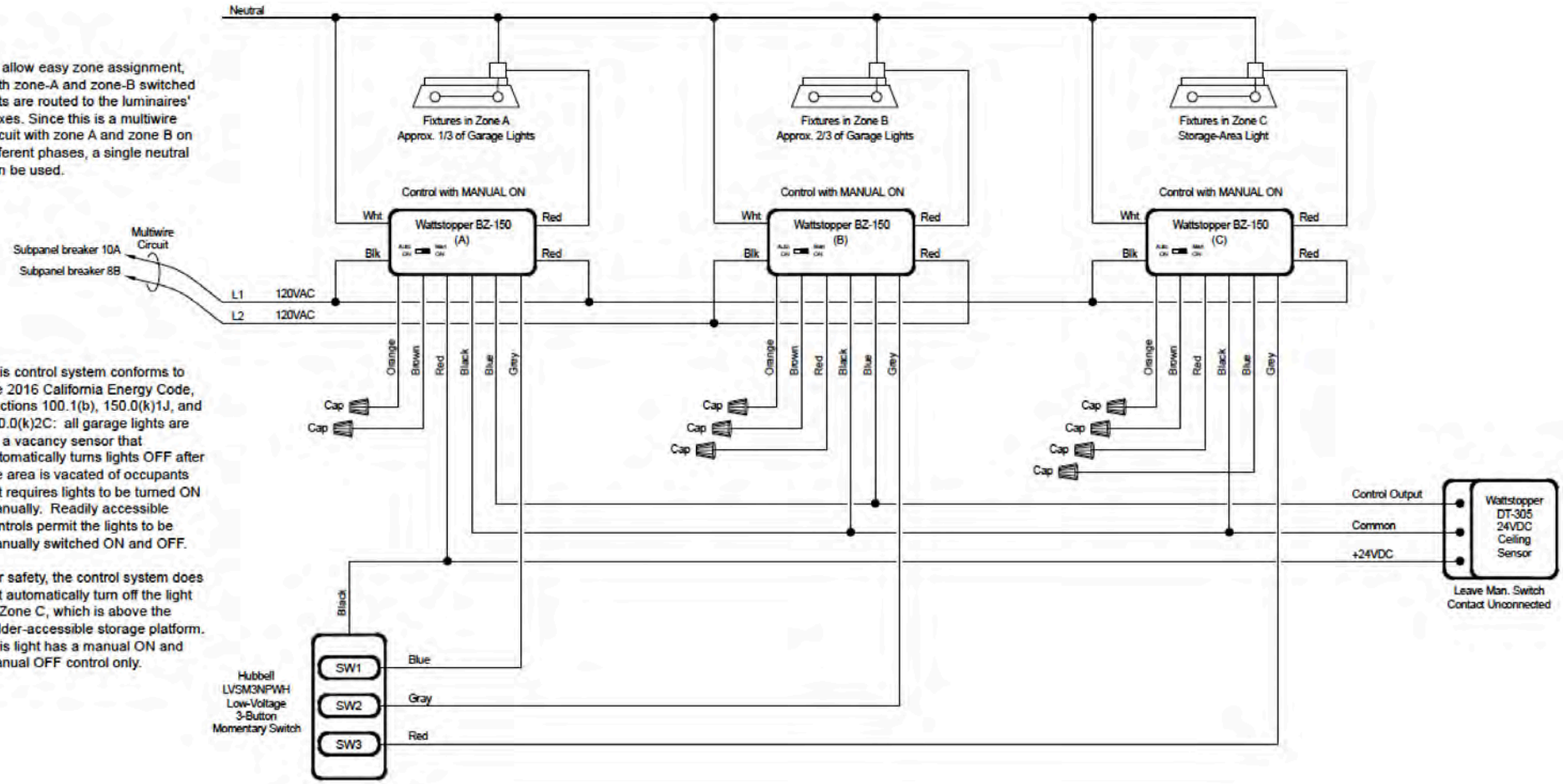
Automatic On

Automatic Off

To allow easy zone assignment, both zone-A and zone-B switched hots are routed to the luminaires' boxes. Since this is a multiwire circuit with zone A and zone B on different phases, a single neutral can be used.

This control system conforms to the 2016 California Energy Code, Sections 100.1(b), 150.0(k)1J, and 150.0(k)2C: all garage lights are on a vacancy sensor that automatically turns lights OFF after the area is vacated of occupants but requires lights to be turned ON manually. Readily accessible controls permit the lights to be manually switched ON and OFF.

For safety, the control system does not automatically turn off the light of Zone C, which is above the ladder-accessible storage platform. This light has a manual ON and manual OFF control only.



The Steps

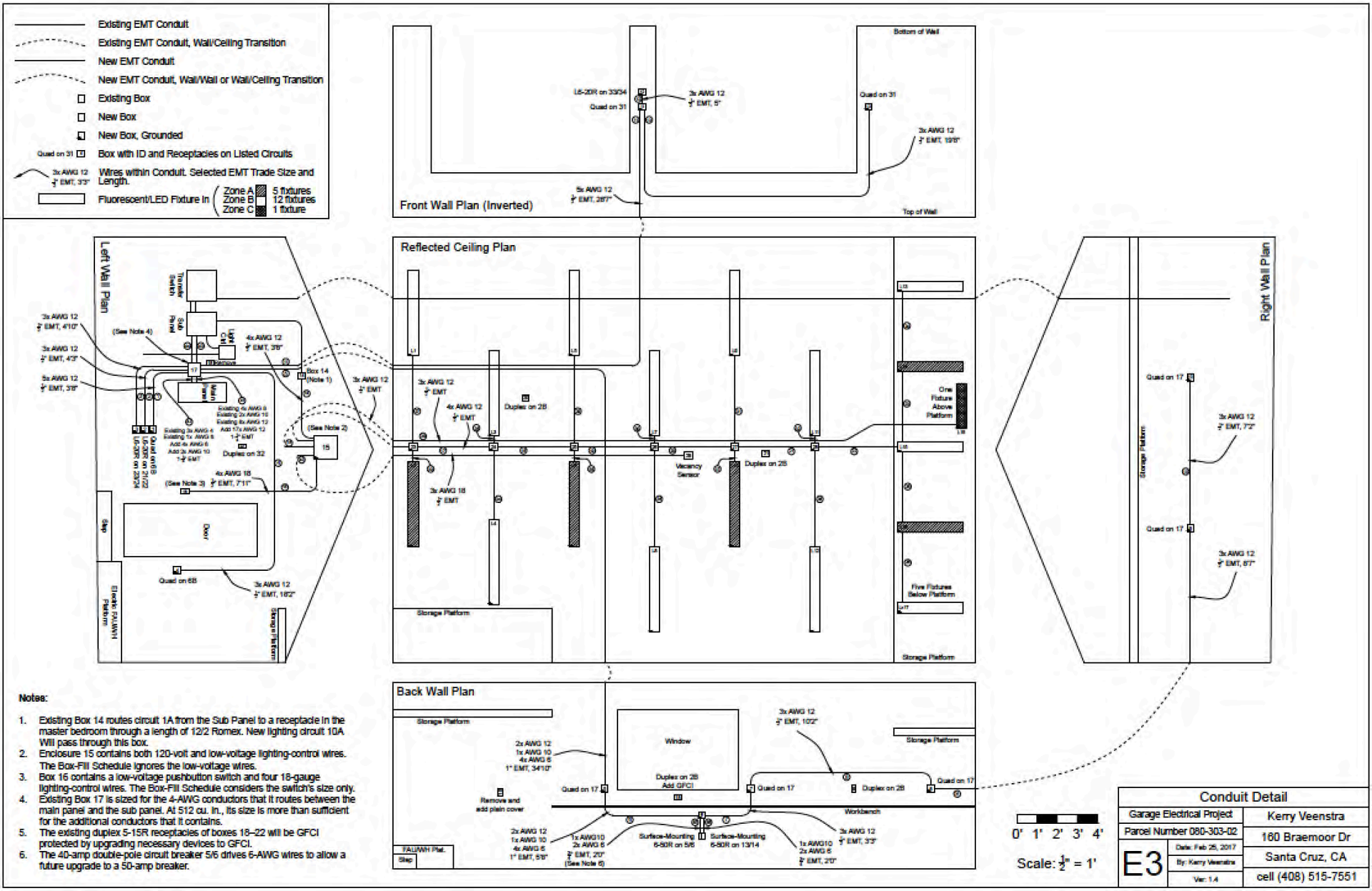
REVIEW THE CODE

DRAW OUTLET PLAN

DRAW LIGHTING PLAN

GET BUILDING PERMIT

PERFORM INSTALLATION



Notes:

1. Existing Box 14 routes circuit 1A from the Sub Panel to a receptacle in the master bedroom through a length of 12/2 Romex. New lighting circuit 10A will pass through this box.
2. Enclosure 15 contains both 120-volt and low-voltage lighting-control wires. The Box-Fill Schedule ignores the low-voltage wires.
3. Box 16 contains a low-voltage pushbutton switch and four 18-gauge lighting-control wires. The Box-Fill Schedule considers the switch's size only.
4. Existing Box 17 is sized for the 4-AWG conductors that it routes between the main panel and the sub panel. At 512 cu. in., its size is more than sufficient for the additional conductors that it contains.
5. The existing duplex 5-15R receptacles of boxes 18–22 will be GFCI protected by upgrading necessary devices to GFCI.
6. The 40-amp double-pole circuit breaker 5/6 drives 6-AWG wires to allow a future upgrade to a 50-amp breaker.

Conduit Detail

Garage Electrical Project	Kerry Veenstra
Parcel Number 080-303-02	160 Braemoor Dr
E3	Santa Cruz, CA
Date: Feb 25, 2017	cell (408) 515-7551
By: Kerry Veenstra	
Ver: 1.4	

Choose Box Sizes

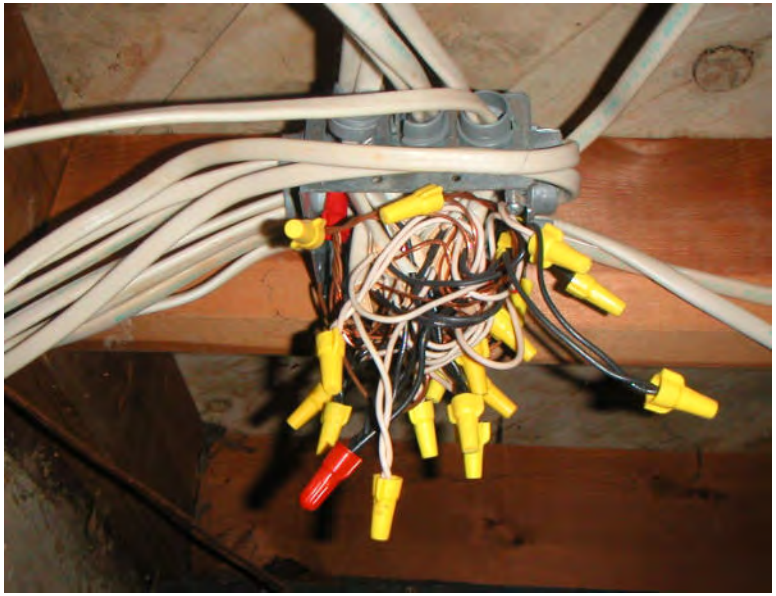
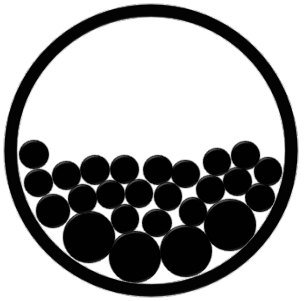


Image attribution: Lozier Home Inspections, LLC

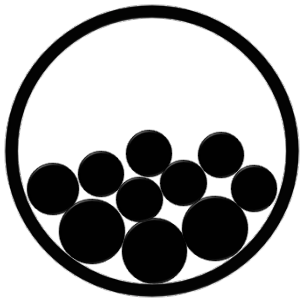
Box IDs	Devices	Current-Carrying Exiting/Through Conductors			Largest Grounding Conductor		Number of Devices	Required Volume (cu. in.)	Smallest Box		Notes
		#12 2.25	#10 2.5	#6 5	#12 2.25	#10 2.5	#12 4.5		Trade Size	Volume (cu. in.)	
1	GFCI 5-20R, Duplex 5-20R	4			1		2	20.25	4 sq x 1-1/4	18.0	1
2	L6-20R	2			1		1	11.25	4 sq x 1-1/4	18.0	1
3	L6-20R	2			1		1	11.25	4 sq x 1-1/4	18.0	1
4	2x Duplex 5-20R	2			1		2	15.75	4 sq x 1-1/4	18.0	1
5	GFCI 5-20R, Duplex 5-20R	4		4		1	2	40.50	4-11/16 x 2-1/8	42.0	1
6	—	2		4		1		27.00	4 sq x 2-1/8	30.3	1
7–9	2x Duplex 5-20R	4			1		2	20.25	4 sq x 1-1/2	21.0	1
10	2x Duplex 5-20R	2			1		2	15.75	4 sq x 1-1/4	18.0	1
11	GFCI 5-20R, Duplex 5-20R	6			1		2	24.75	4 sq x 2-1/8	30.3	1
12	L6-20R	2			1		1	11.25	4 sq x 1-1/4	18.0	1
13	2x Duplex 5-20R	2			1		2	15.75	4 sq x 1-1/4	18.0	1
14	—	5			1			13.50	4 sq x 1-1/4	18.0	2
15	3x Wattstopper BZ-150	8			1		3	33.75	TBD	TBD	3
16	Hubbell LVSM3NPWH								4 x 2-1/8 x 1-1/2	10.3	4
17	—								8 x 8 x 8	512	5
18	GFCI 5-15R										6
19	Duplex 5-15R										6
20	GFCI 5-15R										6
21	Duplex 5-15R										6
22	GFCI 5-15R										6
23–28	—	10			1			24.75	4 sq x 2-1/8	30.3	
L1–12	48" fluorescent fixture	2			1						
L13	24" fluorescent fixture	3			1						7
L14	24" fluorescent fixture	6			1						7
L15	24" fluorescent fixture	9			1						7
L16	24" fluorescent fixture	6			1						7
L17	24" fluorsecent fixture	3			1						7
L18	24" fluorescent fixture	2			1						

Choose Conduit Sizes

12 GA
10 GA
6 GA

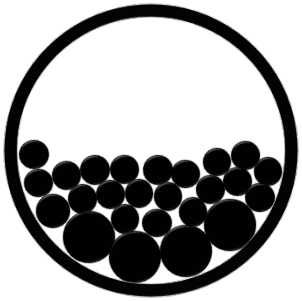


8 GA
6 GA
4 GA



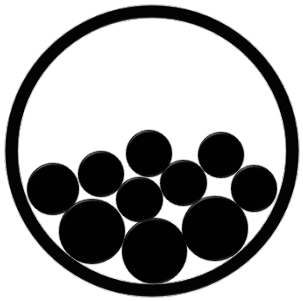
Conduit Fill

Gauge	Area	Quantity	Total
6	0.0507	4	0.203
10	0.0211	1	0.021
12	0.0133	20	0.266
			0.490



1.496
× 0.400
0.598

Gauge	Area	Quantity	Total
4	0.0824	3	0.247
6	0.0507	1	0.051
8	0.0366	6	0.220
			0.518



1.496
× 0.400
0.598

ID	Between Boxes		Length Feet	Length Inch	Dec. Feet	New Wires 4x #18 0.05	#12 W 0.0133	#12 BK 0.0133	#12 R 0.0133	#12 GN 0.0133	#10 GN 0.211	#6 BK 0.0507	#6 R 0.0507	Existing Wires #12 0.0133	#10 0.0211	#8 0.0366	#6 0.0507	#4 0.0824	Total Area	Selected Conduit	40% Area
1	17	1	3	8	3.67		2	2		1									0.0665	1/2	0.122
2	17	2	4	3	4.25			1	1	1									0.0399	1/2	0.122
3	17	3	4	10	4.83			1	1	1									0.0399	1/2	0.122
4	17	4	18	2	18.2		1	1		1									0.0399	1/2	0.122
5	17	5	34	10	34.8		1	1			1	2	2						0.2505	1	0.346
6	5	6	5	8	5.67		1	1			1	2	2						0.2505	1	0.346
7	6	7	3	3	3.25		1	1		1									0.0399	1/2	0.122
8	7	8	10	2	10.17		1	1		1									0.0399	1/2	0.122
9	8	9	8	7	8.58		1	1		1									0.0399	1/2	0.122
10	9	10	7	2	7.17		1	1		1									0.0399	1/2	0.122
11	17	11	28	7	28.58		1	2	1	1									0.0665	1/2	0.122
12	11	12	0	5	0.42			1	1	1									0.0399	1/2	0.122
13	11	13	19	8	19.67		1	1		1									0.0399	1/2	0.122
14	14	15	3	8	3.67		1	1	1	1									0.0532	1/2	0.122
15	15	16	7	11	7.92	1													0.05	1/2	0.122
16	15	23	1	5	1.42		1	1	1	1									0.0532	1/2	0.122
17	23	24	3	7	3.58		1	1	1	1									0.0532	1/2	0.122
18	24	25	3	7	3.58		1	1	1	1									0.0532	1/2	0.122
19	25	26	3	7	3.58		1	1	1	1									0.0532	1/2	0.122
20	26	27	3	7	3.58		1	1	1	1									0.0532	1/2	0.122
21	27	28	3	7	3.58		1	1	1	1									0.0532	1/2	0.122
22	28	light	5	0	5		1	1	1	1									0.0532	1/2	0.122
23	light	light	3	6	3.5		1	1	1	1									0.0532	1/2	0.122
24	light	light	3	6	3.5		1	1	1	1									0.0532	1/2	0.122
25	light	light	3	6	3.5		1	1	1	1									0.0532	1/2	0.122
26	light	light	3	6	3.5		1	1	1	1									0.0532	1/2	0.122
27	23	light	4	5	4.42		1	1		1									0.0399	1/2	0.122
28	24	light	0	5	0.42		1	1		1									0.0399	1/2	0.122
29	25	light	4	5	4.42		1	1		1									0.0399	1/2	0.122
30	26	light	0	5	0.42		1	1		1									0.0399	1/2	0.122
31	27	light	4	5	4.42		1	1		1									0.0399	1/2	0.122
32	28	light	0	5	0.42		1	1		1									0.0399	1/2	0.122
33	23	light	0	6	0.5		1	1		1									0.0399	1/2	0.122
34	24	light	3	5	3.42		1	1		1									0.0399	1/2	0.122
35	25	light	0	6	0.5		1	1		1									0.0399	1/2	0.122
36	26	light	4	10	4.83		1	1		1									0.0399	1/2	0.122
37	27	light	0	6	0.5		1	1		1									0.0399	1/2	0.122
38	28	light	4	10	4.83		1	1		1									0.0399	1/2	0.122
39	15	light	28	9	28.75		1	1		1									0.0399	1/2	0.122
40	15	sens	15	4	15.33	1 **													0.05	1/2	0.122
41	Panel	17	0	4	0.33		3	6	3	5				8	2	4			0.5211	1 1/4	0.598
42	Panel	17	0	4	0.33						1	2	2				1	3	0.5218	1 1/4	0.598
43	Panel	Sub	1	4	1.33																
44	Panel	Sub	1	4	1.33																
45	6	6-50R	2	0	2						1	1	1								
46	6	6-50R	2	0	2						1	1	1								

A brief

ASIDE

regarding

WIRE COLORS

Colleague's Wire Colors

Hot

Neutral

Ground

Colleague's Motivation

+V

–V

Ground

Actual Meaning

Hot

Hot

Ground

Used White Electrical Tape

Hot

~~Hot~~ Neutral

Ground

New Rule

Inspector may require dimmers on LED fixtures

Replace

LED Fixtures

with

Fluorescent Fixtures

&

LED Bulbs

The Steps

Review the code

Draw outlet plan

Draw lighting plan

Get building permit

Perform installation

PERFORM INSTALLATION

PERFORM INSTALLATION

BOXES

CONDUITS

WIRES

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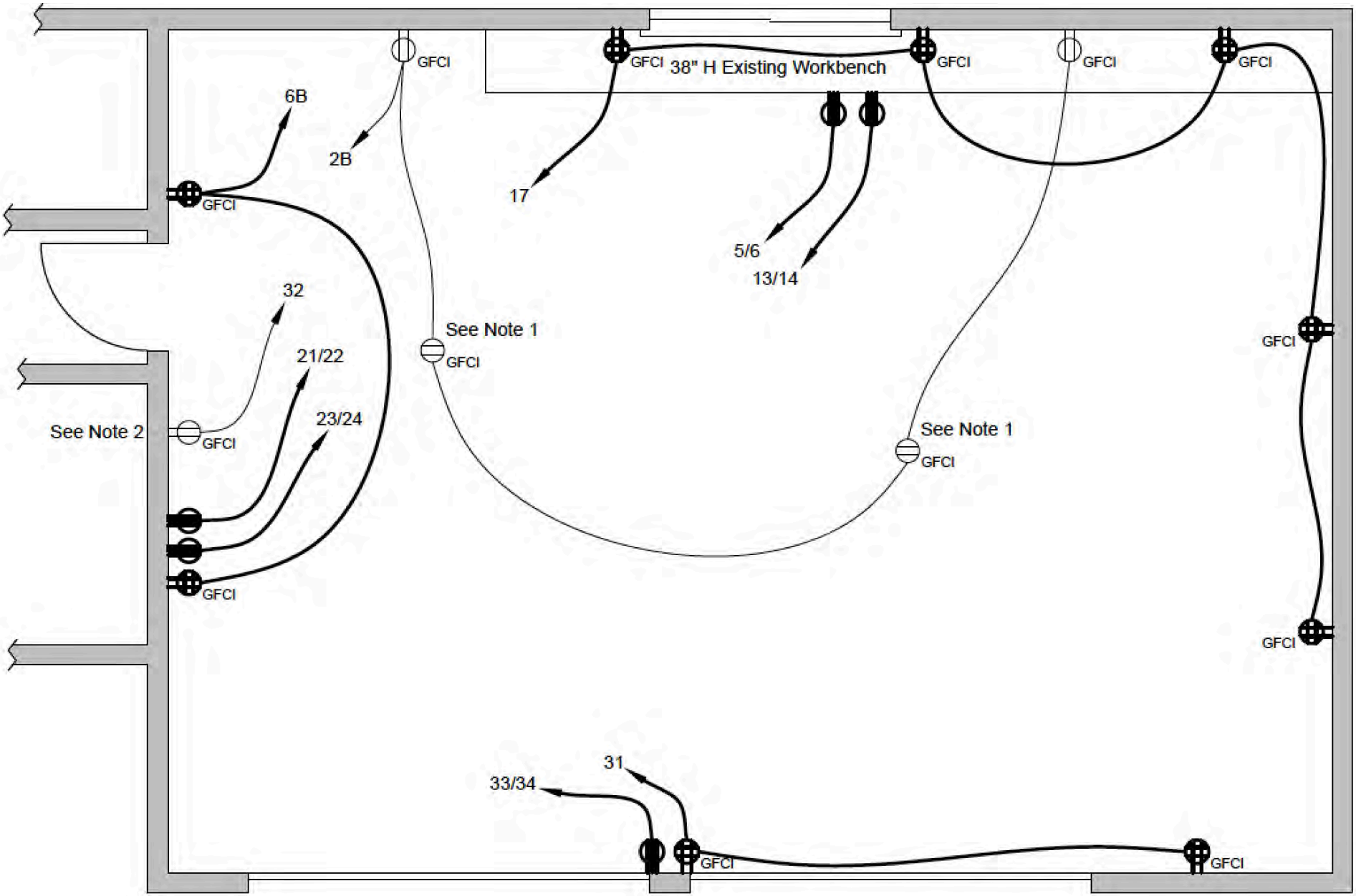

GFCI
GFCI
38" H Existing Workbench
GFCI
GFCI
GFCI
6B
2B
GFCI
17
5/6
13/14
32
See Note 1
GFCI
GFCI
21/22
See Note 2
23/24
GFCI
See Note 1
GFCI
GFCI
31
33/34
GFCI
GFCI

Romex

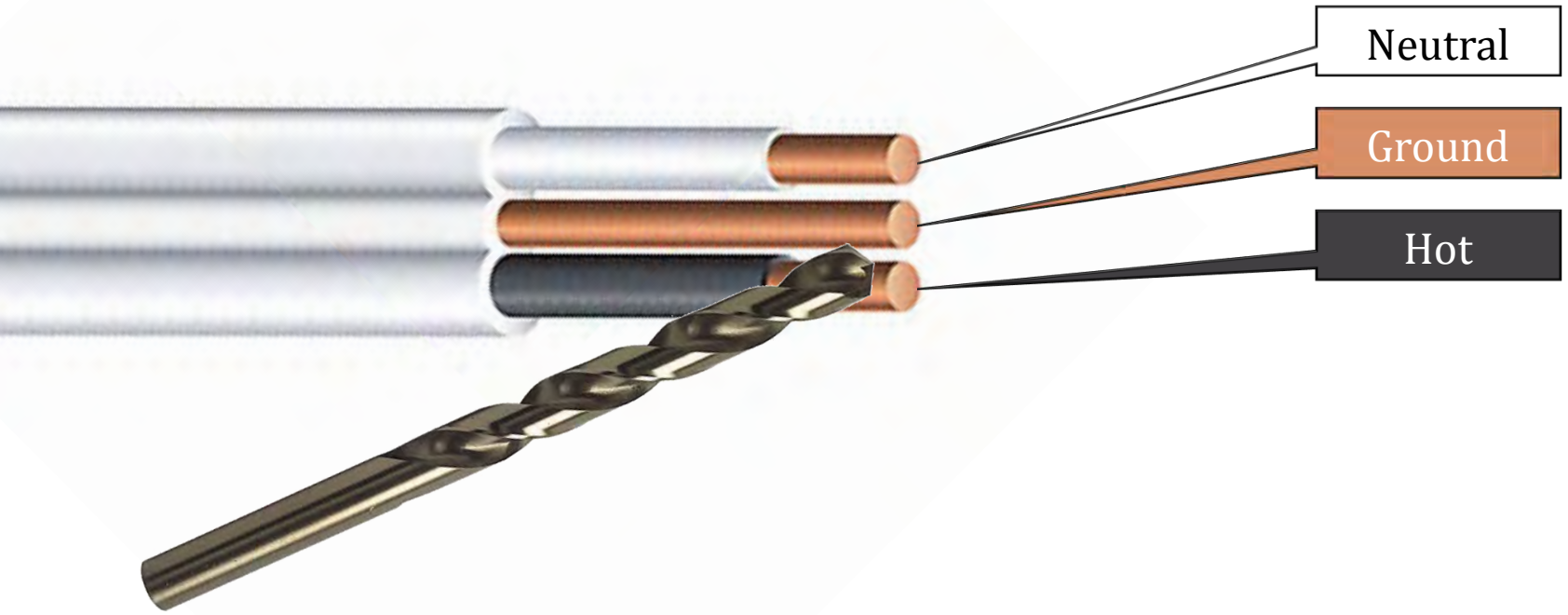
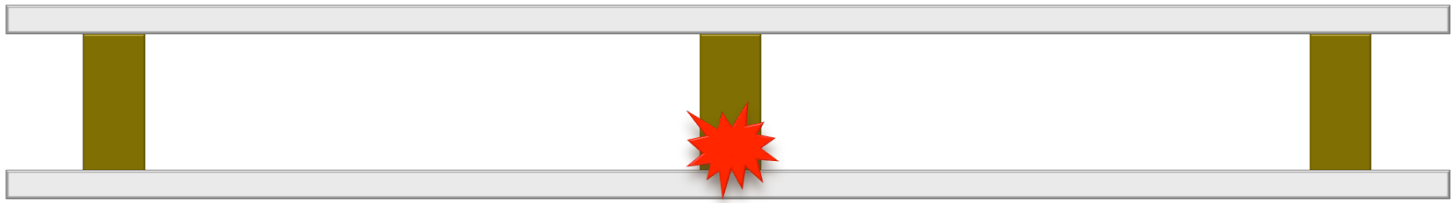


Image attribution: ffx.co.uk

No Protection Plate

Image attribution: rona.ca

How to Repair?



Bypass Damaged Cable

This Romex is Round

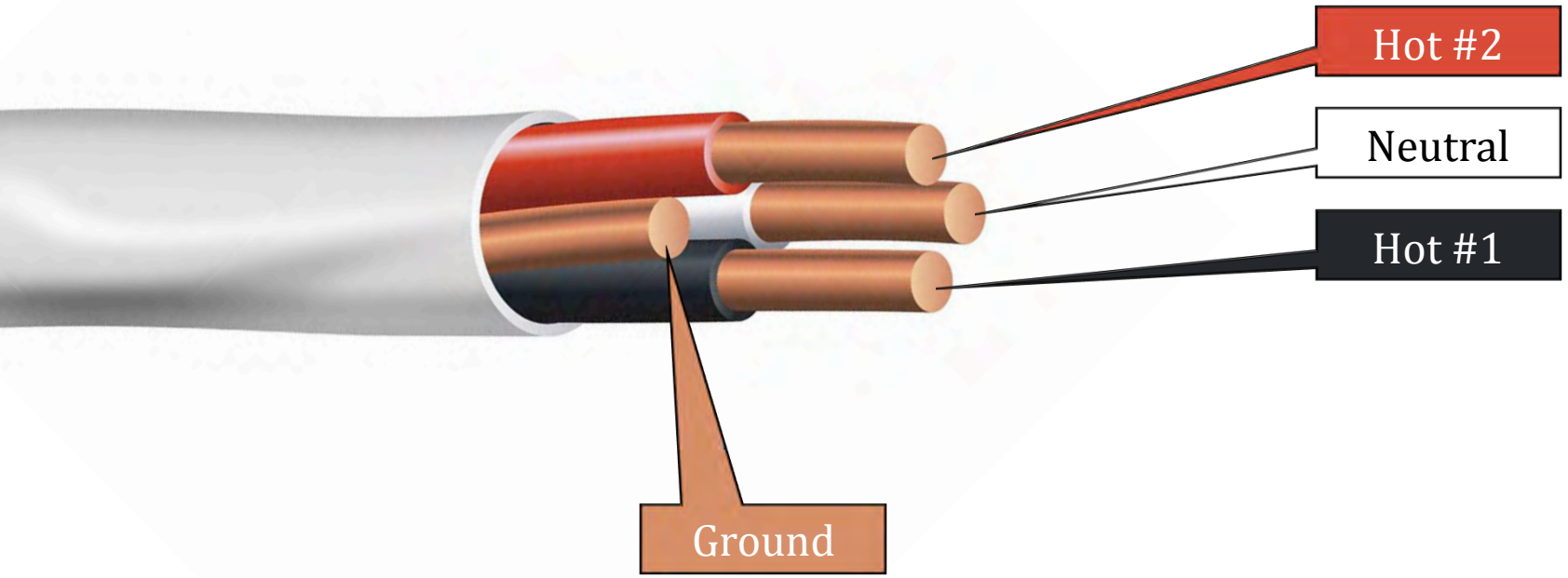


Image attribution: ffx.co.uk

Non-contact Voltage Detector

Image attribution: Greenlee

Violation of Code

.

THE HOT CONDUCTORS OF A MULTIWIRE CIRCUIT MUST BE SWITCHED BY A SINGLE LEVER (IN THE SAME BREAKER PANEL)

PERFORM INSTALLATION

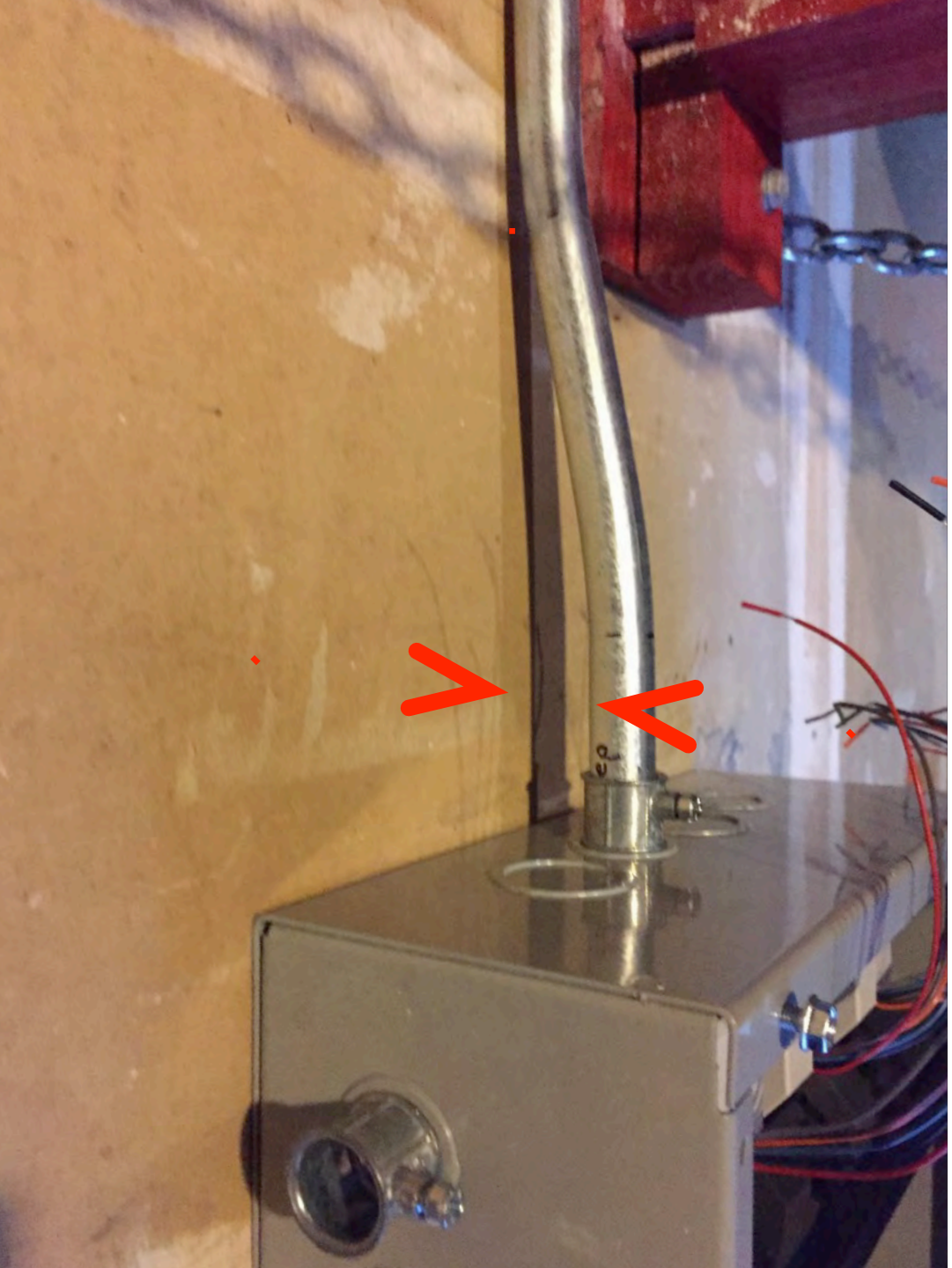
BOXES

CONDUITS

WIRES

Bending EMT Conduit

Offset Bend
Stub-Up Bend
Back-to-Back Bend



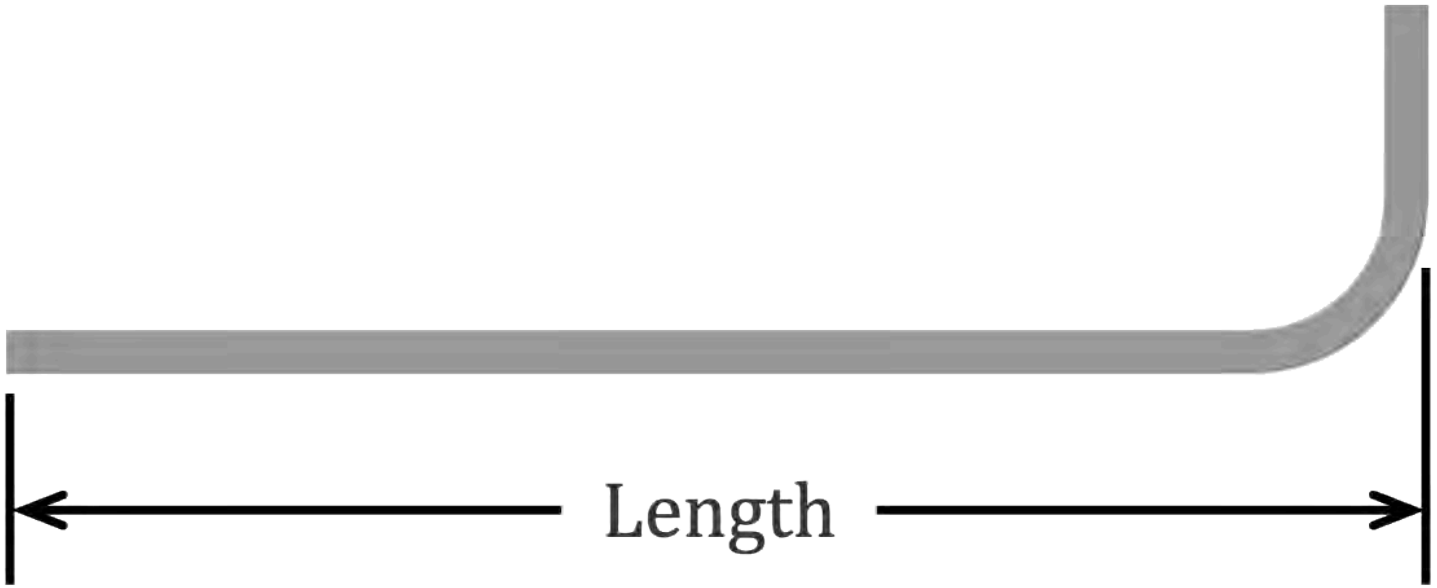
Offset Bend

Stub-Up Bend

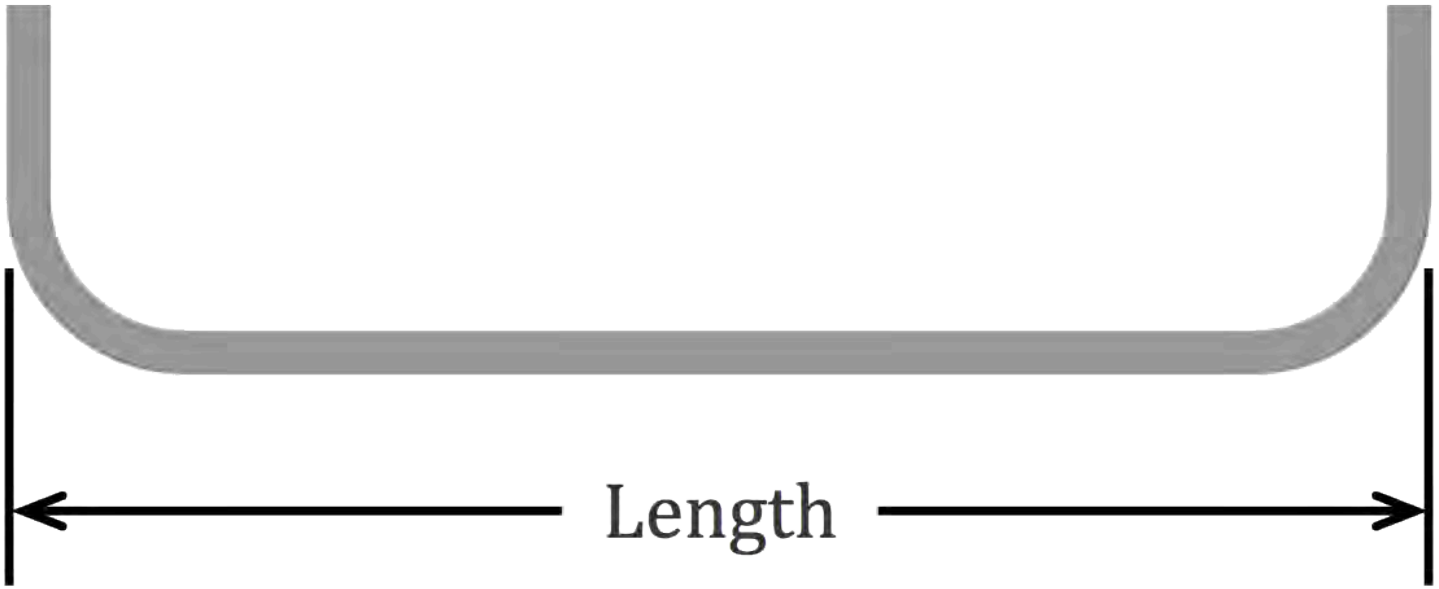
Stub-Up Bend

Stub-Up Bend

Back-to-Back Bend



Back-to-Back Bend



Abrasive Cutoff Machine

Image attribution: Ridge Tool Company

SAWZALL

Image attribution: Milwaukee Tool

Tubing/Conduit Cutter

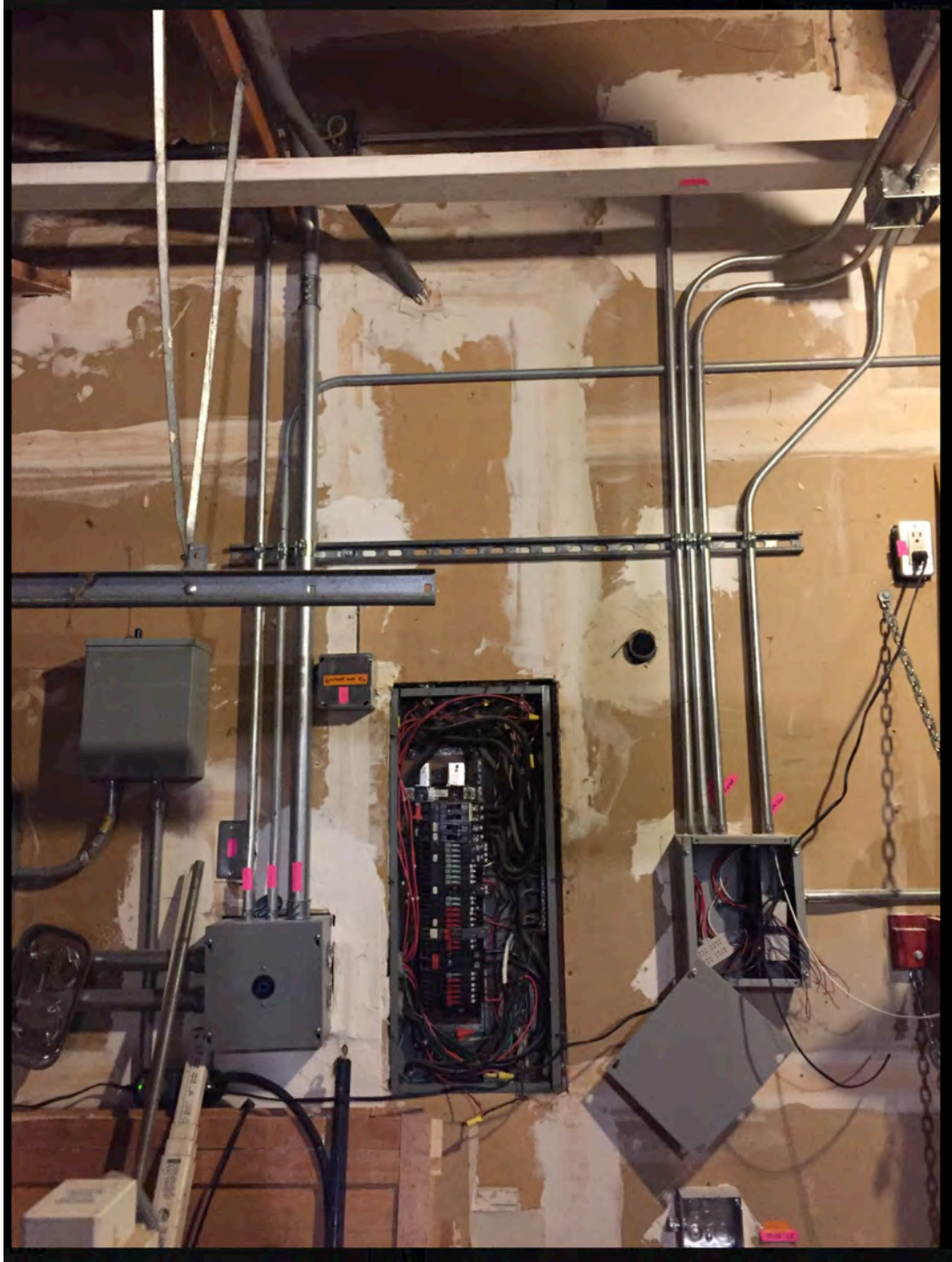
Image attribution: Ridge Tool Company

Conduit Reemer

Image attribution: DeWALT

Progress!

Progress!



Social Media

Matthew Kaufman You're removing that Zinsco panel, right?

Like · Reply · June 14 at 10:25am

Matthew Kaufman They're dangerous (as in fire hazard), so I'd swap that way before doing other work.

What are the Problems *with* Zinsco Breaker Panels?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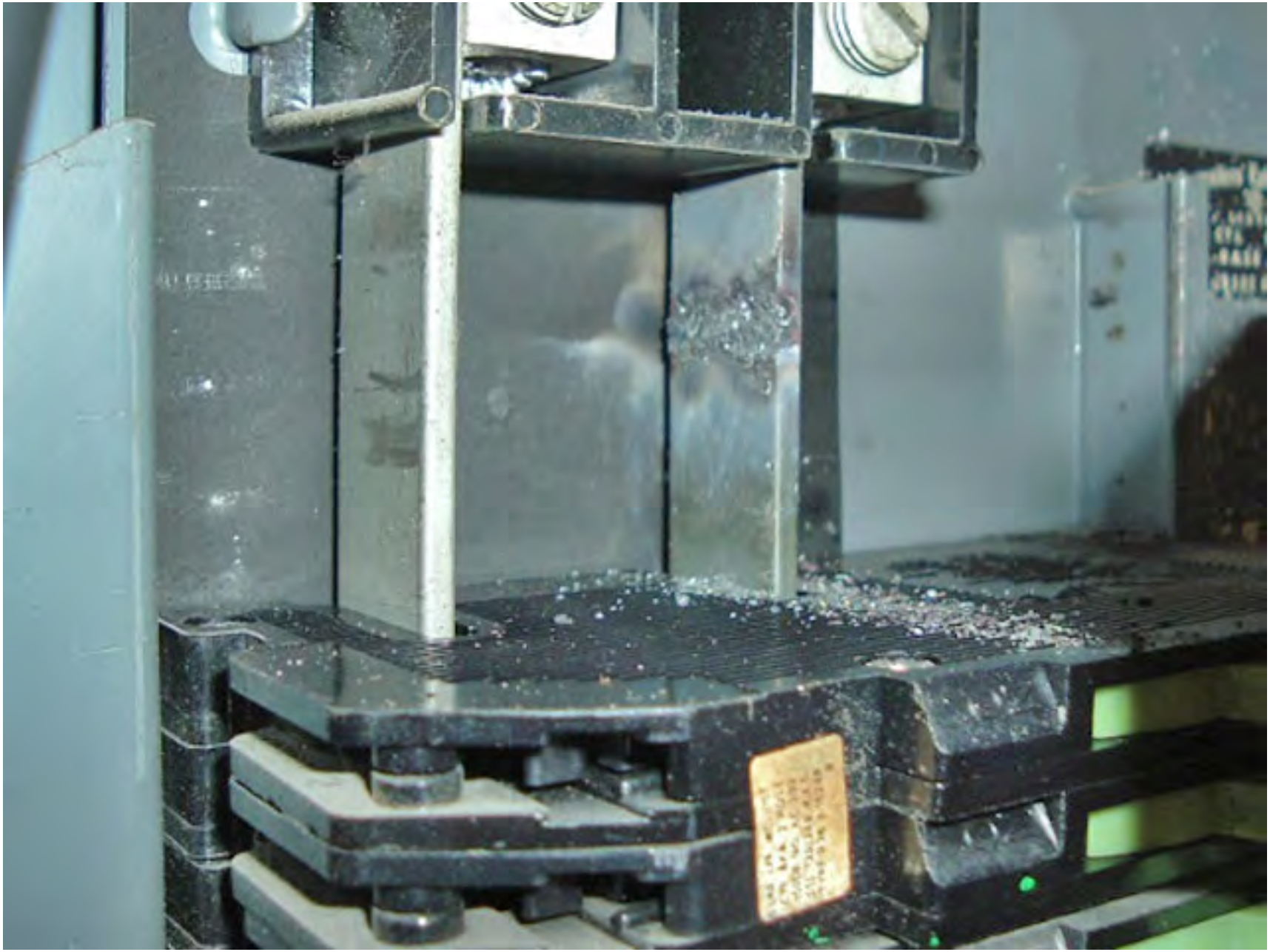

Image attribution: http://ismypanelsafe.com/images/zinsco_panel_01.jpg


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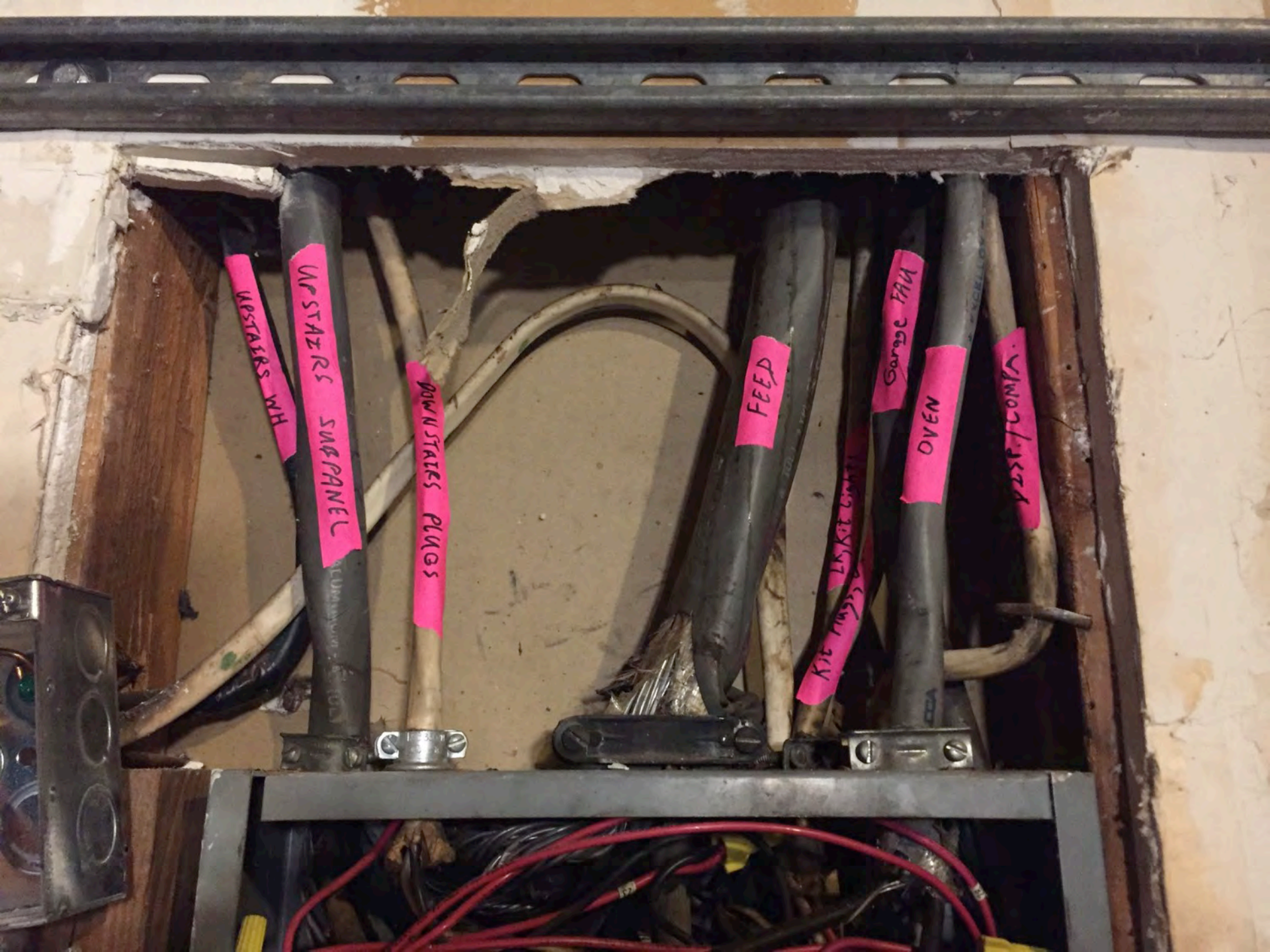
(C) 2008 Daniel Friedman www.inspect-ny.com

New Plan

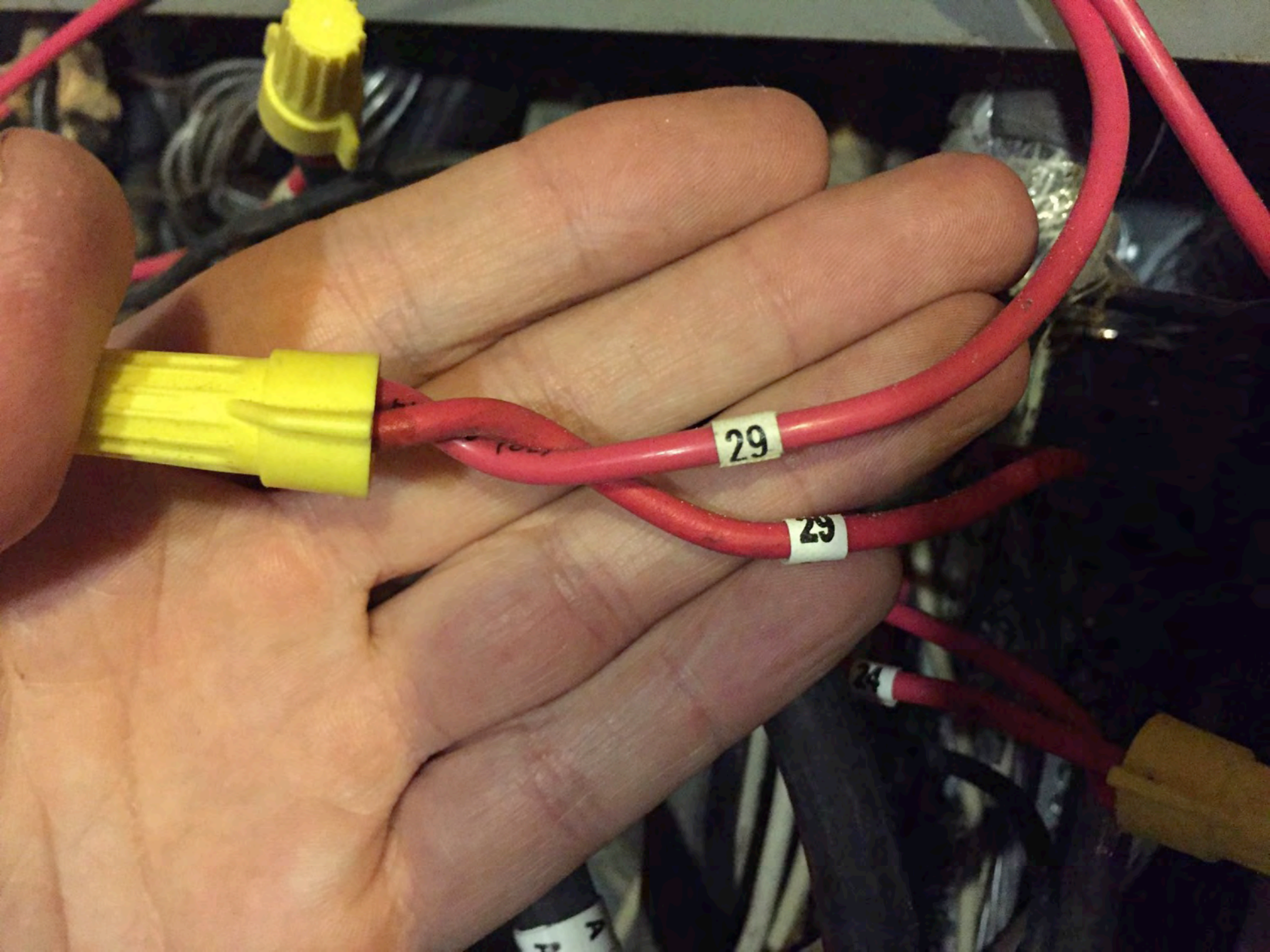
stop work on everything

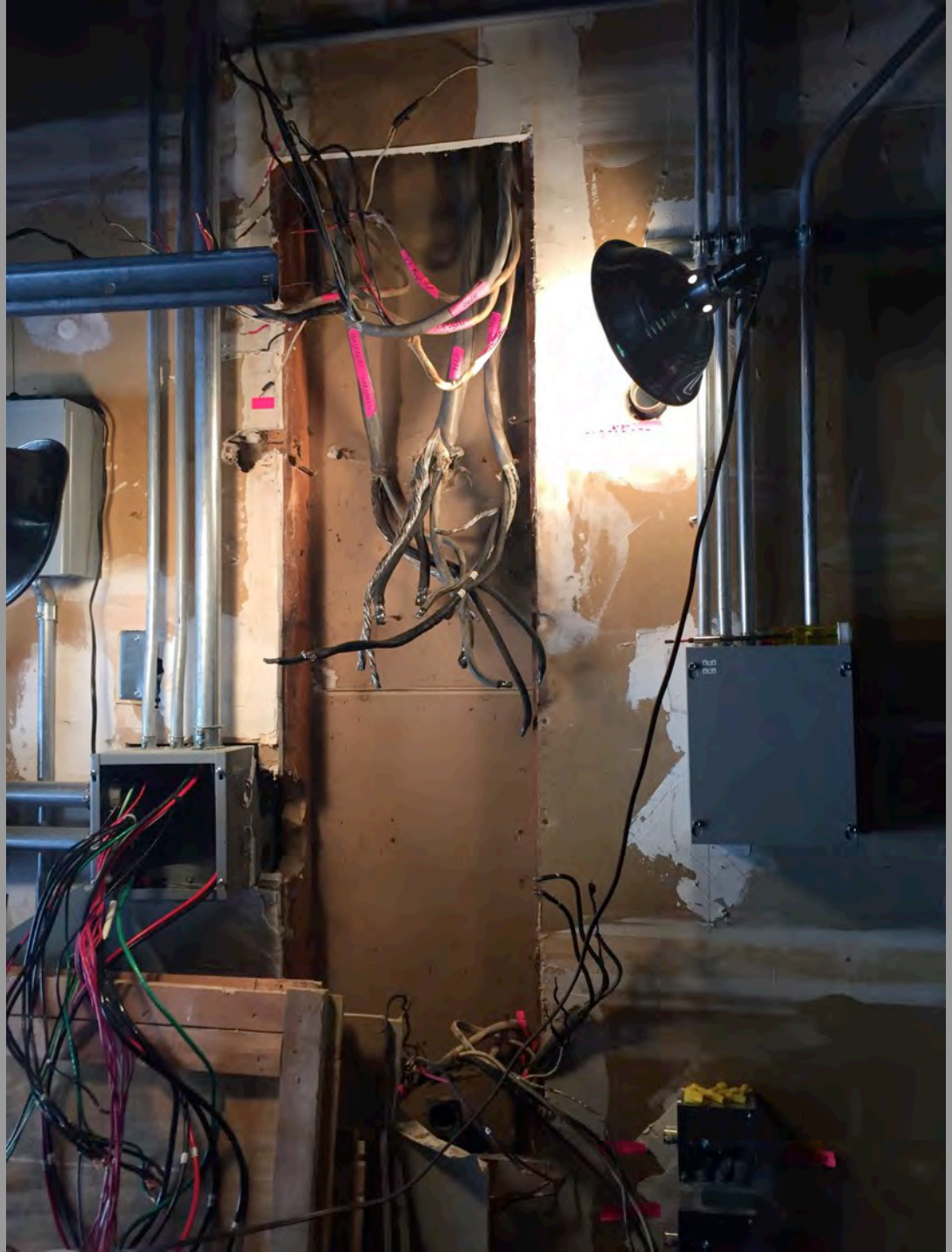
review code again

replace panel


UPSTAIRS WH
UPSTAIRS SUBPANEL
DOWNSTAIRS PLUGS
FEED
Garage FAN
OVEN


RANGE


29
29



14 AWG
12 AWG
10 AWG
8 AWG
6 AWG
4 AWG
3 AWG
2 AWG
1 AWG

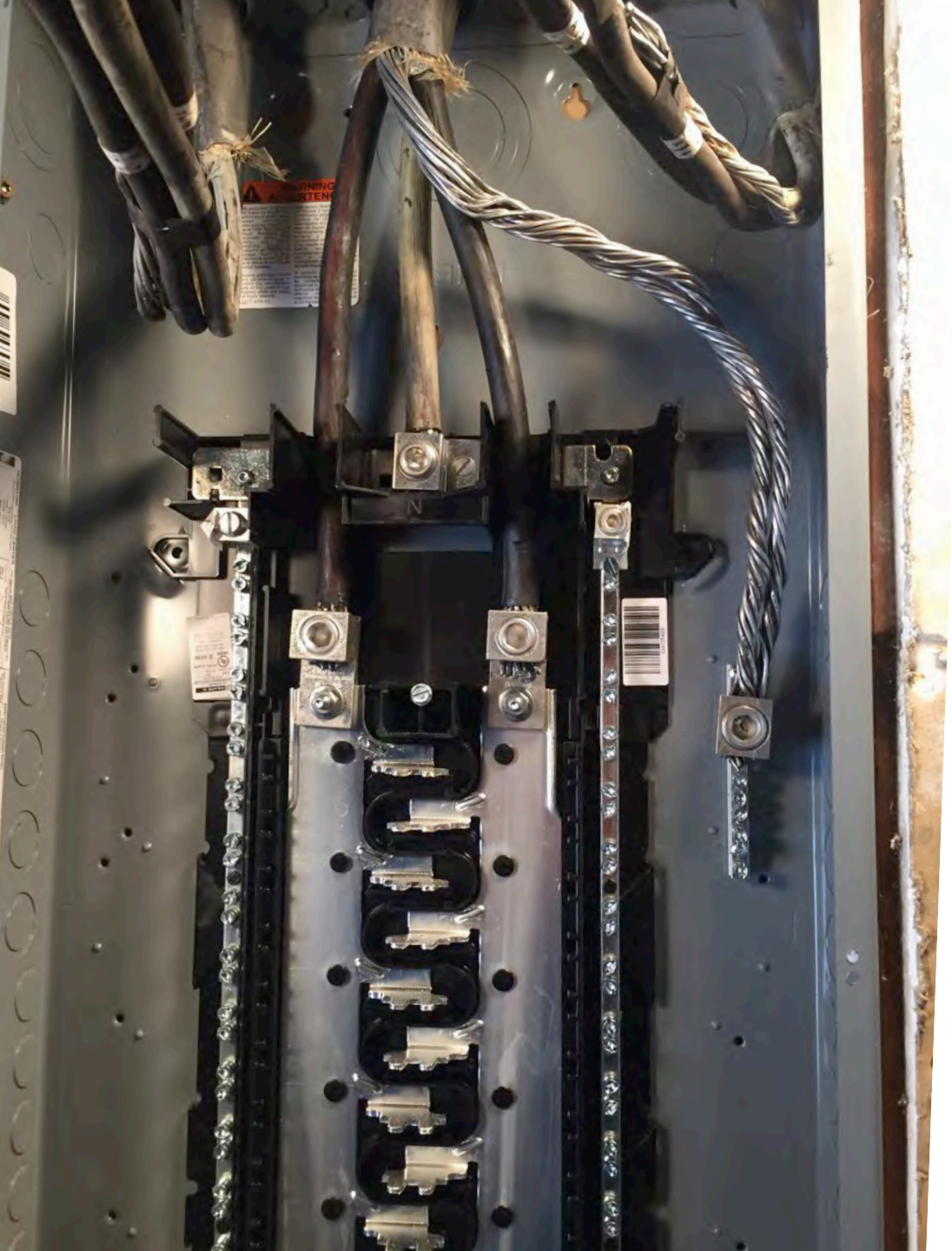
4 AWG
3 AWG
2 AWG
1 AWG
1/0 AWG
2/0 AWG
3/0 AWG
4/0 AWG

1/0

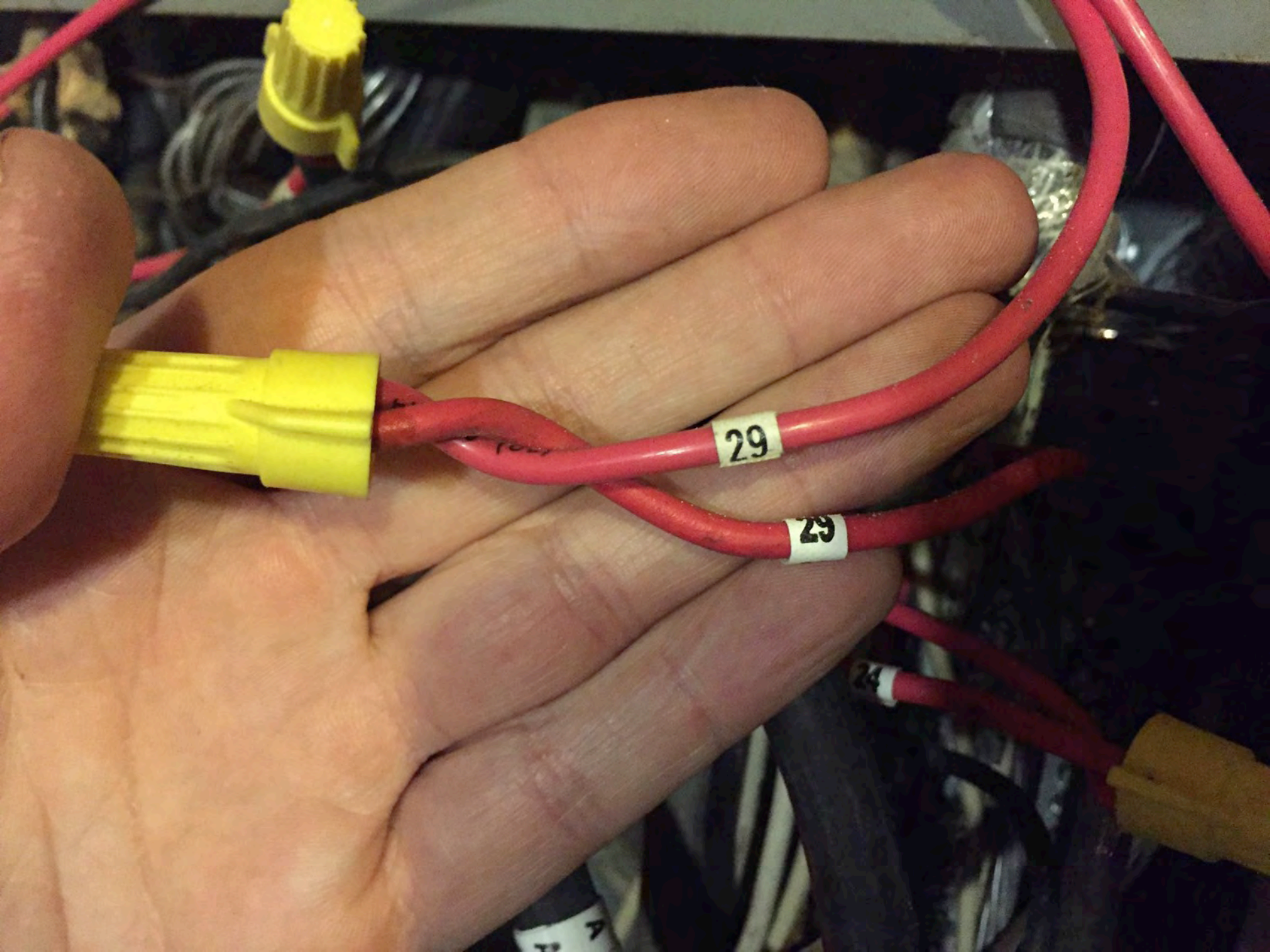
and

4/0

ALUMINUM



Torque!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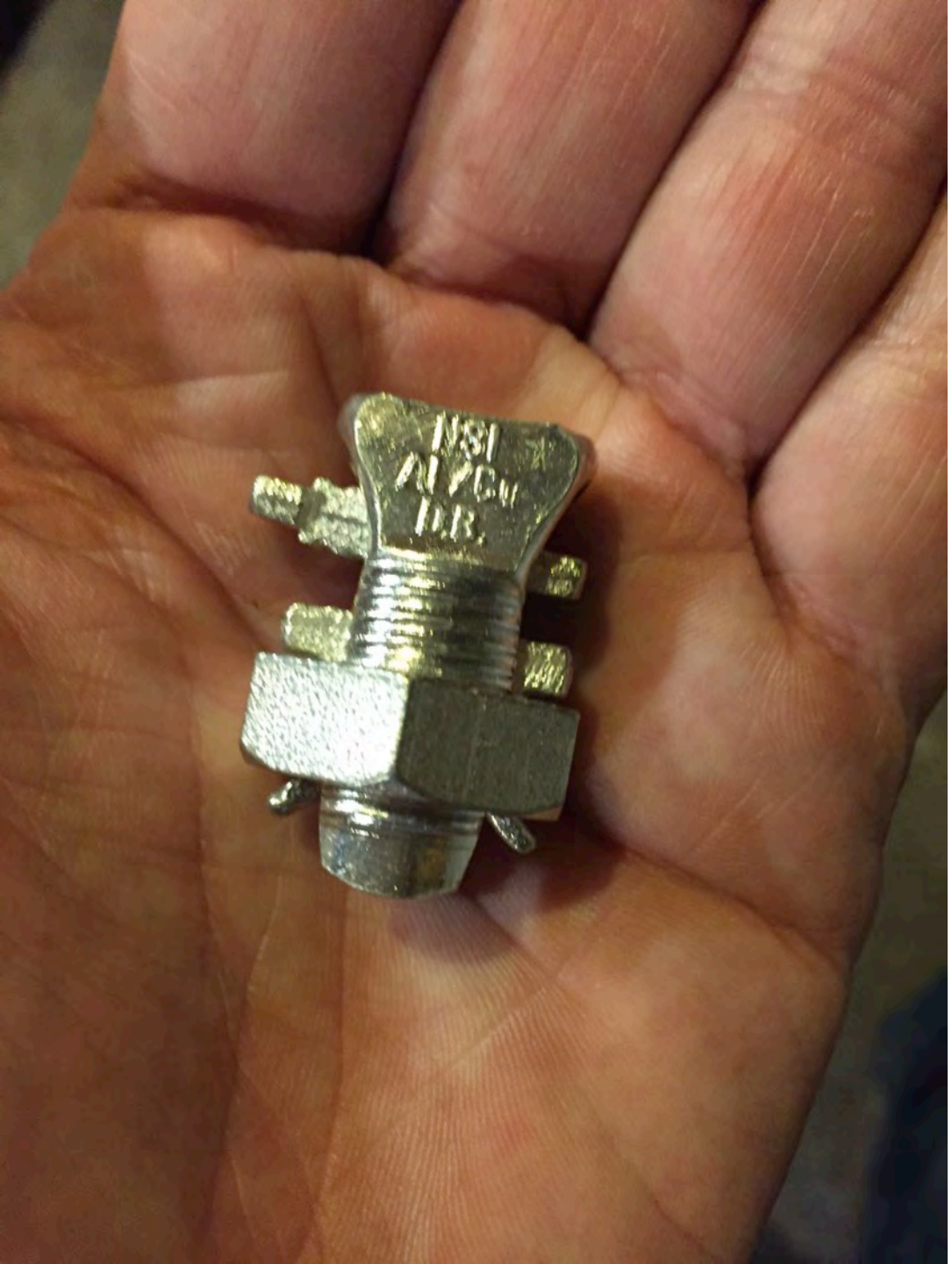
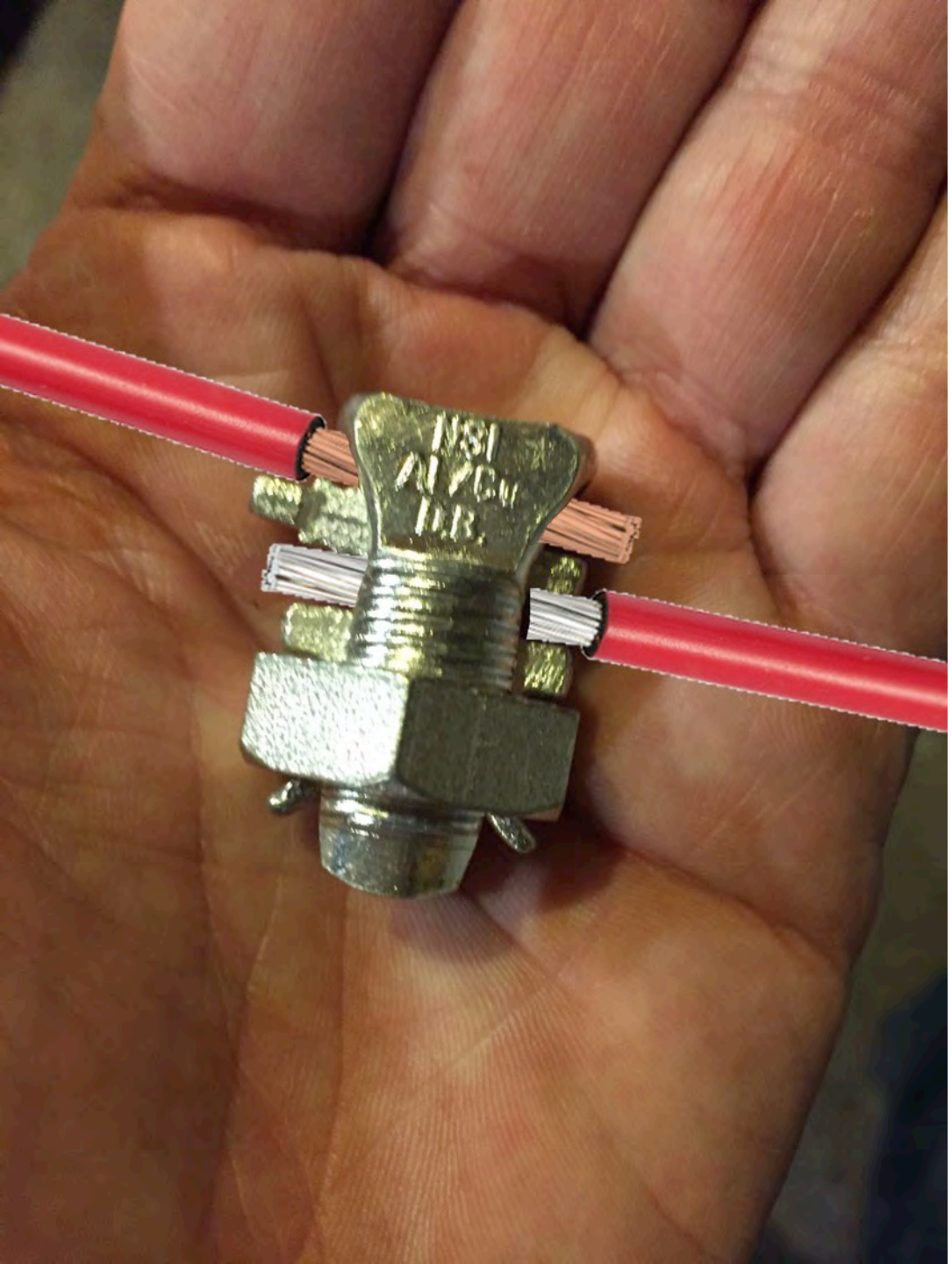


Split Bolt



Split Bolt

Noalox anti-oxidant

Boxes

Boxes

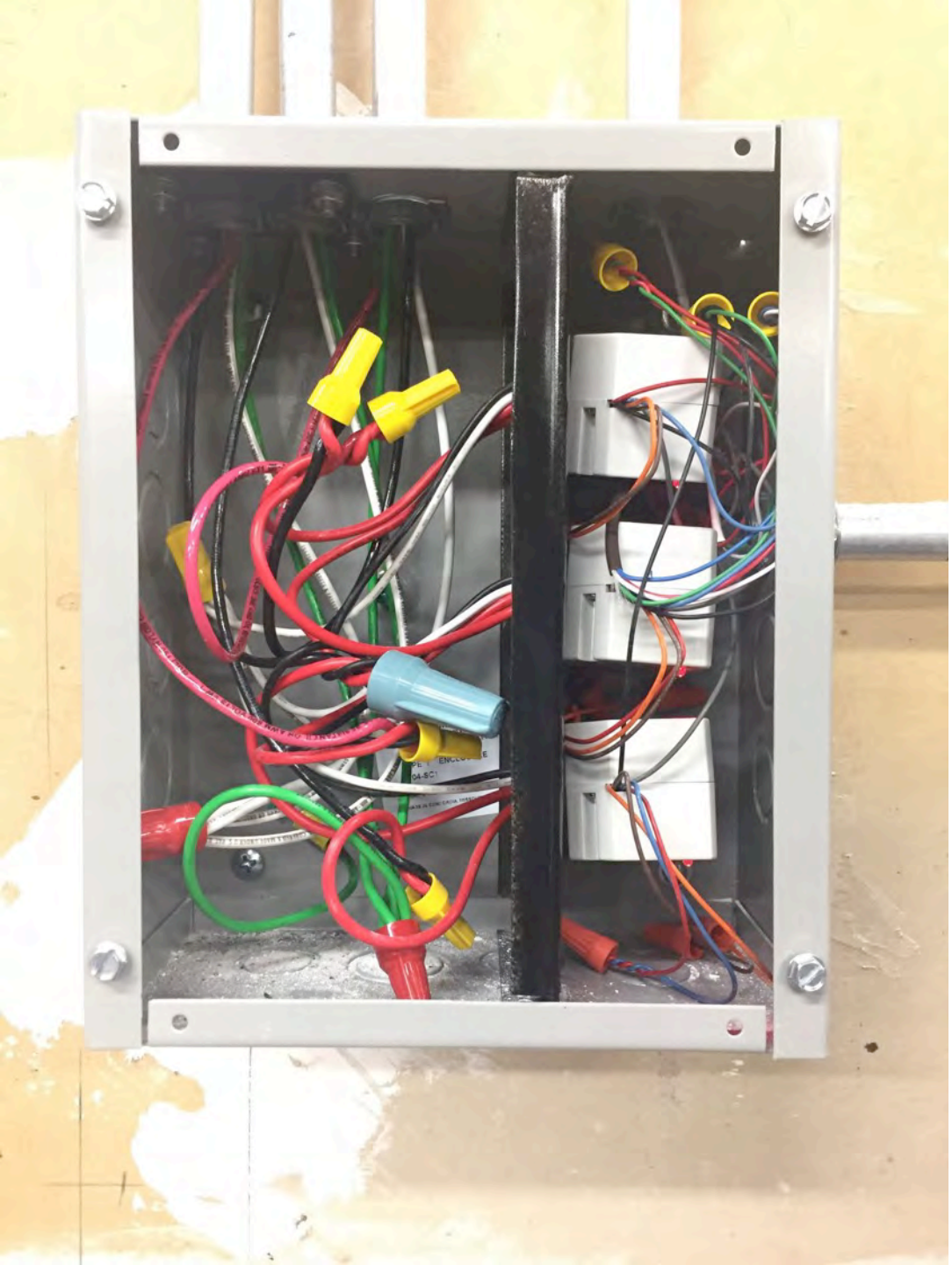
Boxes


SWITCHING AC/DC
POWER ADAPTER
CAUTION :
RISK OF ELECTRIC SHOCK
DRY LOCATION USE ONLY
SHOCK HAZARD SOR-
SERVICEABLE PARTS INSIDE
MADE IN CHINA
FSP

Boxes

Boxes

Boxes



LIGHTING CONTROL

LIGHT SWITCH

Top Ten Favorites

#10 – Sharpie Fine Point *and* Neon Artist Tape

Image attribution: Sanford LP, Amazon

#9 – Scaffold

#8 – Greenlee GT-12A
Non-contact Voltage Detector

Image attribution: Greenlee

#7 – Fluke T+ Electrical Tester

Image attribution: Fluke Corporation

#6 – Sperry HGT6520 Outlet Tester

Image attribution: Sperry Instruments

#5 – Klein Tools 89091 Power Conduit Reemer

Image attribution: DeWALT

#4 – Scotch Super 33+ Electrical Tape

Image attribution: 3M Company

#3 – Ideal 45-615 Reflex Super T-Stripper

Image attribution: Ideal Electrical

#2 – Knipex 87 01 250 Cobra Water Pump Pliers

Image attribution: Knipex Tools

Before Revealing #1

Here are Some Honorable Mentions

Honorable Mention
Utica TS-30
Torque Screwdriver

Image attribution: Apex Tool Group, LLC

Honorable Mention
Knipex 74 01 250
Diagonal Cutters

Image attribution: Knipex Tools

Honorable Mention
Xeno #2 / Phillips #3
Driver BIts

Image attribution: Wiha

Honorable Mentions Milwaukee Cordless Drill & Impact Driver

Image attribution: Milwaukee Tool

#1 – Klein Tools 56203 ½" Conduit Bender

Image attribution: Klein Tools

Adventures
in
Residential
Electrical Wiring
or
Why You Should
Hire an Electrician