US007636650B2

(12) **United States Patent**
Khalil

(10) **Patent No.: US 7,636,650 B2**
(45) **Date of Patent: Dec. 22, 2009**

(54) **METHOD AND APPARATUS FOR AUTOMATING ELECTRICAL ENGINEERING CALCULATIONS**

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(73) Assignee: **Electric Power Calc Holdings, Inc.**, Delray Beach, FL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 855 days.

(21) Appl. No.: **10/280,610**

(22) Filed: **Oct. 25, 2002**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 60/380,317, filed on Oct. 25, 2001.

(51) **Int. Cl.**
G06F 17/50 (2006.01)

(52) **U.S. Cl.** **703/1**

(58) **Field of Classification Search** 700/97, 700/98, 286–298; 716/1, 5, 8, 9, 11; 703/1
See application file for complete search history.

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(74) *Attorney, Agent, or Firm*—Brian K. Johnson, Esq., LLC

(57) **ABSTRACT**

A computer-based method and apparatus are provided for designing a building's electrical power distribution system. An electrical circuit design module accepts electrical requirements for individual circuits and automatically determines values for a set of variables that completely specify the design of the circuits and the physical attributes of the components needed to construct those circuits. The circuit design module determines the set of circuit variables with the aid of electrical standards data, such as the National Electrical Code. Further, multiple circuit design modules may be linked so as to share the data between them thereby providing an hierarchical design process where the design data for higher level electrical circuits is automatically determined from the plurality of individually specified, lower-level circuit data. Finally, the computer-based invention automatically generates an electrical parts inventory for constructing the electrical circuits in the building which may be electronically transmitted to a parts supplier for fulfillment.

36 Claims, 30 Drawing Sheets

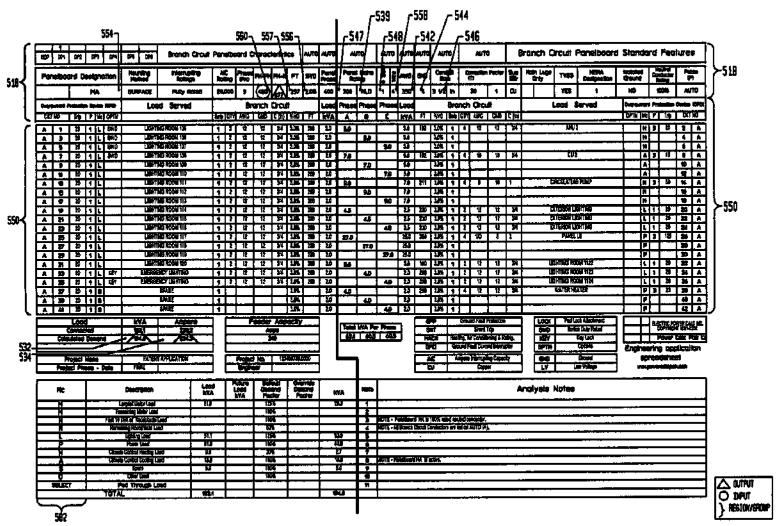

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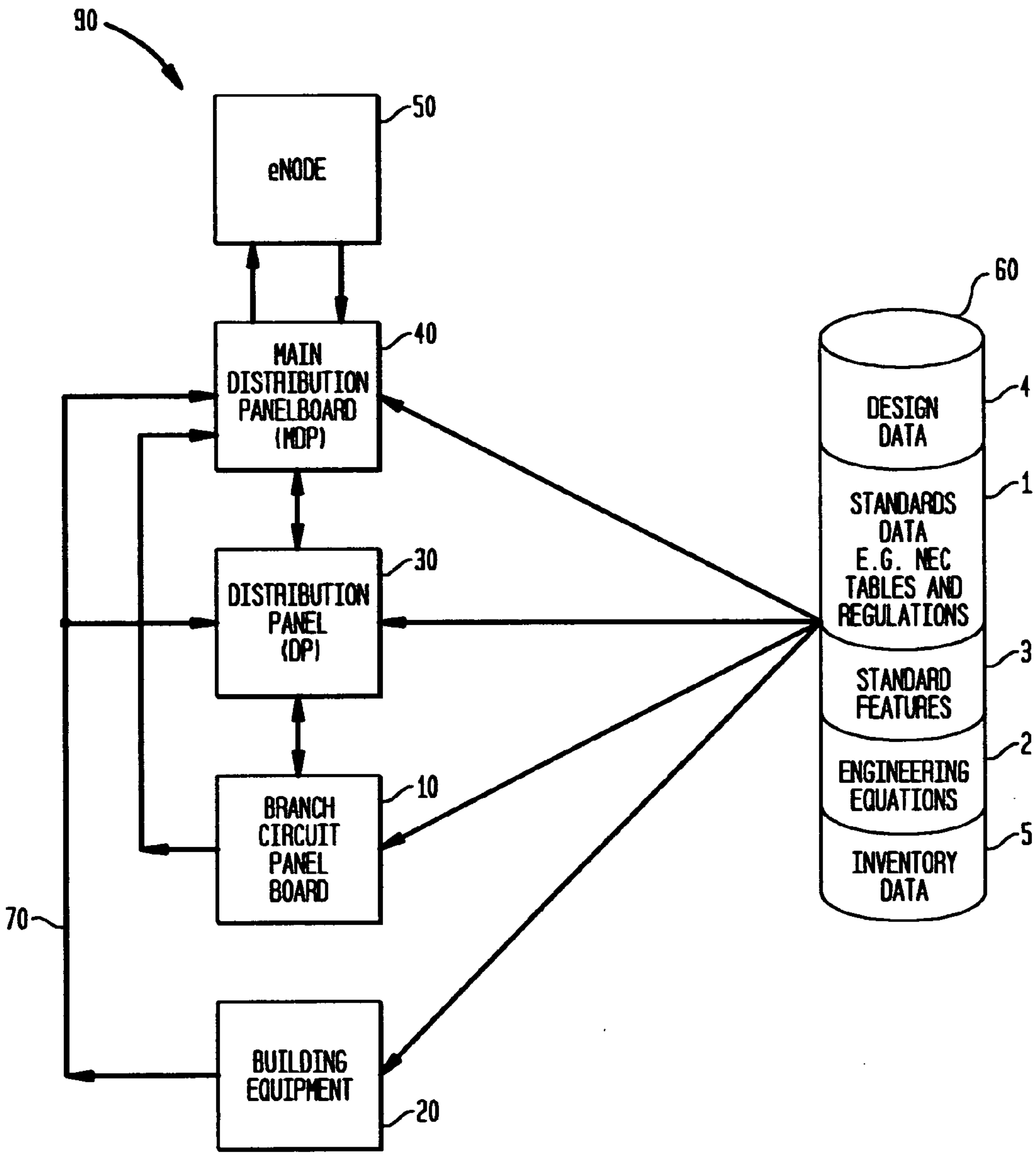
FIG. 1



90
eNODE
50
MAIN
DISTRIBUTION
PANELBOARD
(MDP)
40
DISTRIBUTION
PANEL
(DP)
30
BRANCH
CIRCUIT
PANEL
BOARD
10
70
BUILDING
EQUIPMENT
20
60
DESIGN
DATA
4
STANDARDS
DATA
E.G. NEC
TABLES AND
REGULATIONS
1
STANDARD
FEATURES
3
ENGINEERING
EQUATIONS
2
INVENTORY
DATA
5

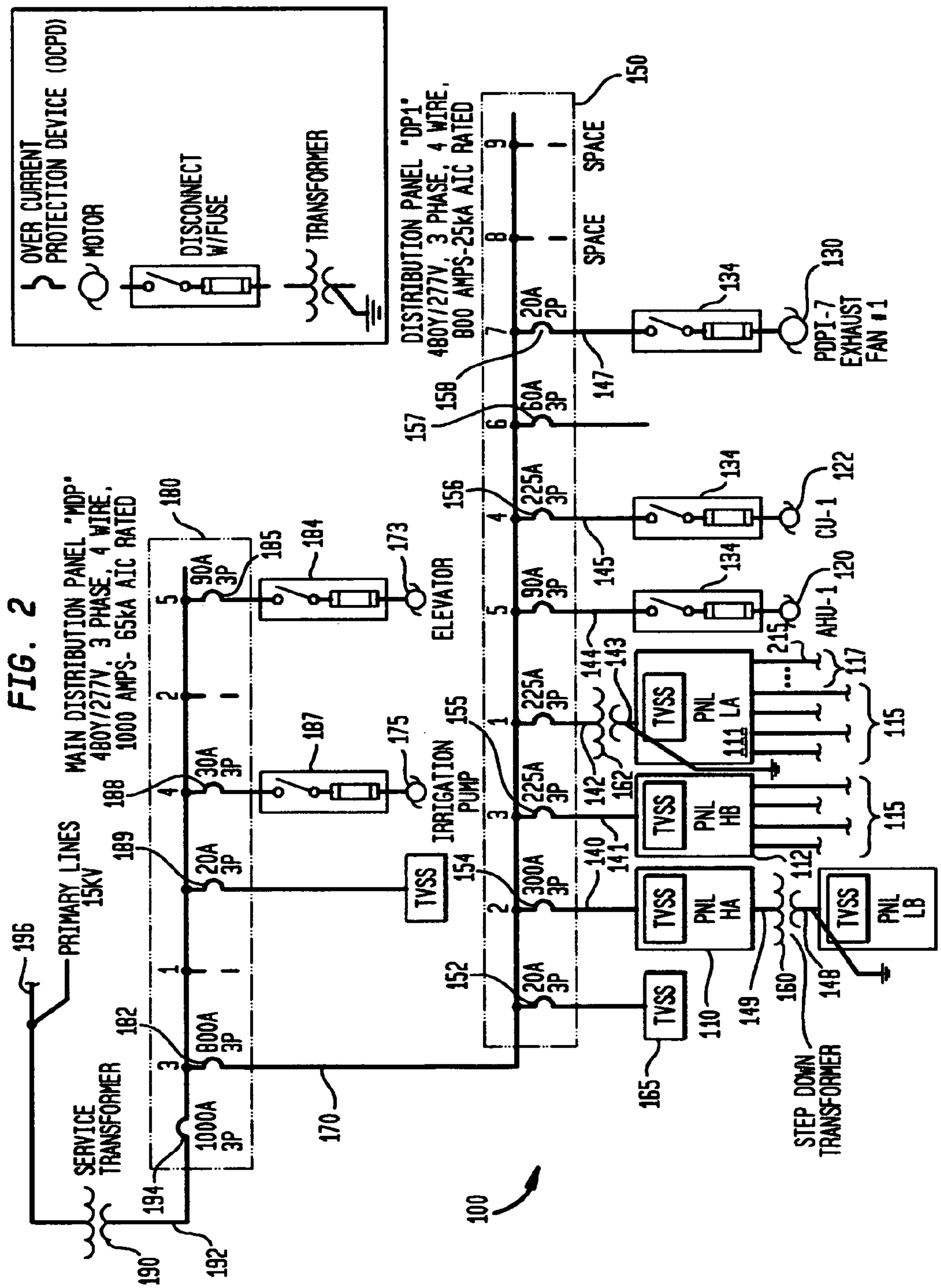

OVER CURRENT PROTECTION DEVICE (OCPD)
MOTOR
DISCONNECT W/FUSE
TRANSFORMER
MAIN DISTRIBUTION PANEL "MDP" 480Y/277V, 3 PHASE, 4 WIRE, 1000 AMPS- 65kA AIC RATED
DISTRIBUTION PANEL "DP1" 480Y/277V, 3 PHASE, 4 WIRE, 800 AMPS-25kA AIC RATED
PRIMARY LINES 15KV
SERVICE TRANSFORMER
1000A 3P
800A 3P
20A 3P
30A 3P
90A 3P
TVSS
IRRIGATION PUMP
ELEVATOR
300A 3P
225A 3P
60A 3P
20A 2P
SPACE
SPACE
PNL HA
PNL HB
PNL LA
PNL LB
AHU-1
CU-1
PDPI-7 EXHAUST FAN #1
STEP DOWN TRANSFORMER
100
110
111
112
115
117
120
122
130
134
140
141
142
143
144
145
147
148
149
150
152
154
155
156
157
158
160
162
165
170
173
175
180
182
184
185
187
188
189
190
192
194
196
215

FIG. 2

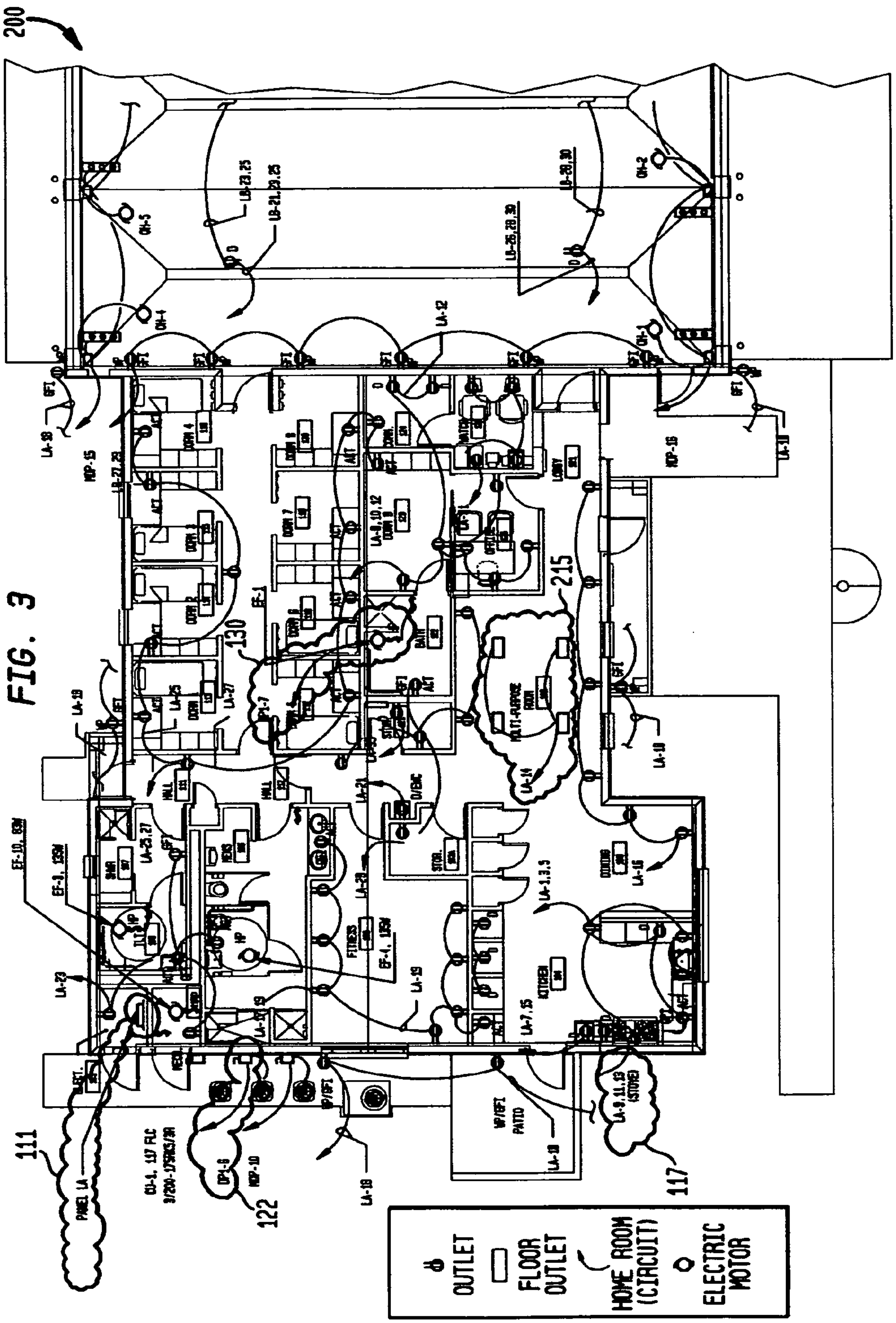

200
130
215
111
122
117
PANEL LA
OUTLET
FLOOR OUTLET
HOME ROOM (CIRCUIT)
ELECTRIC MOTOR

FIG. 3

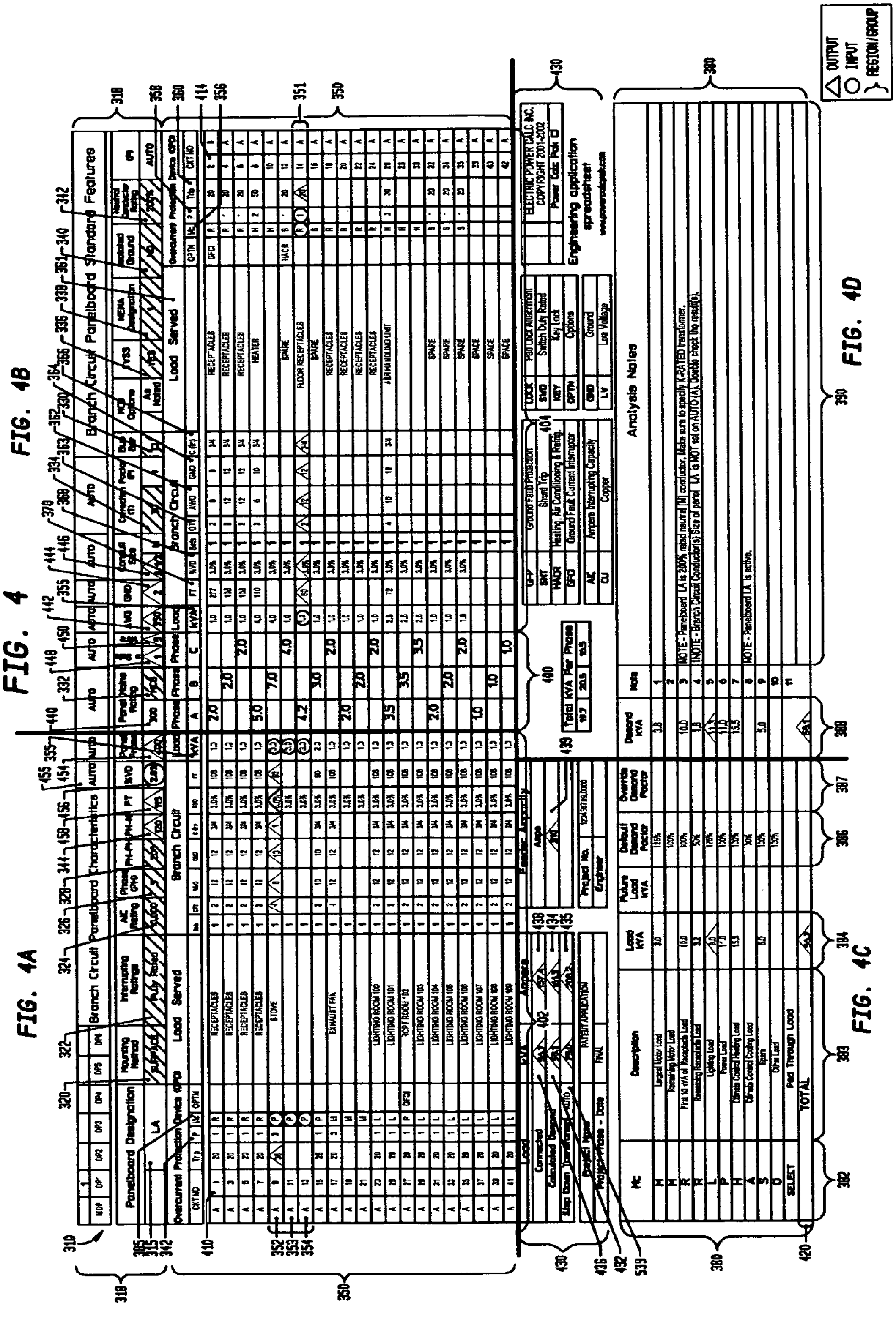


FIG. 4

FIG. 4A FIG. 4B FIG. 4C FIG. 4D

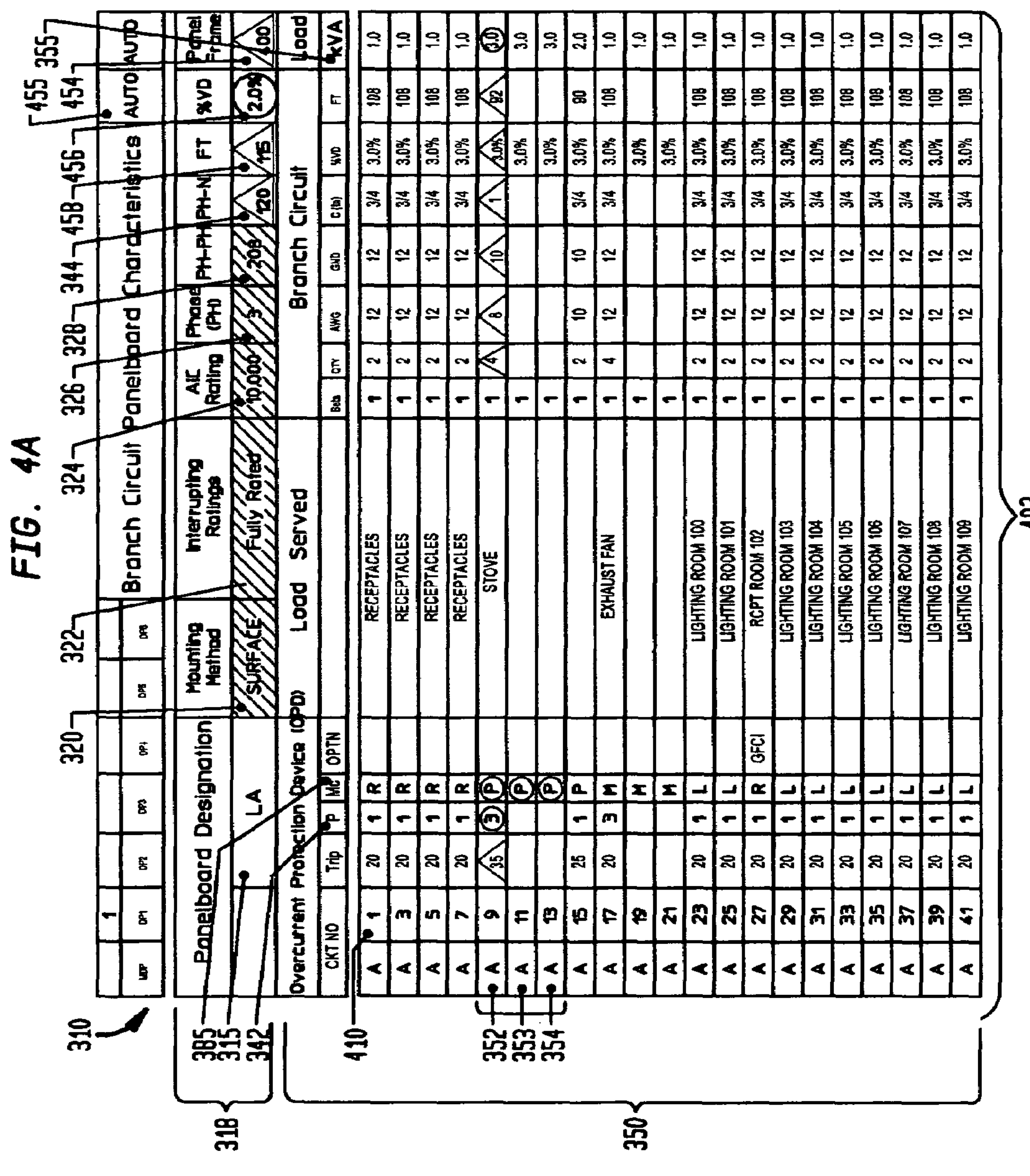


FIG. 4A
310
318
350
402
410
385
315
342
352
353
354
320
322
324
326
328
344
458
456
454
455
355
MDP
DP1
DP2
DP3
DP4
DP5
DP6
1
Panelboard Designation
LA
Mounting Method
SURFACE
Branch Circuit Interrupting Ratings
Fully Rated
Panelboard Characteristics
AIC Rating
10,000
Phase (PH)
3
PH-PH
208
PH-N
120
FT
115
%VD
2.0%
AUTO
Panel Frame
4.00
Overcurrent Protection Device (OPD)
CKT NO
Trip
P
MC
OPTN
Load Served
Branch Circuit
Sets
QTY
AWG
GND
C(in)
%VD
FT
Load
KVA
RECEPTACLES
STOVE
EXHAUST FAN
LIGHTING ROOM 100
LIGHTING ROOM 101
RCPT ROOM 102
GFCI
LIGHTING ROOM 103
LIGHTING ROOM 104
LIGHTING ROOM 105
LIGHTING ROOM 106
LIGHTING ROOM 107
LIGHTING ROOM 108
LIGHTING ROOM 109

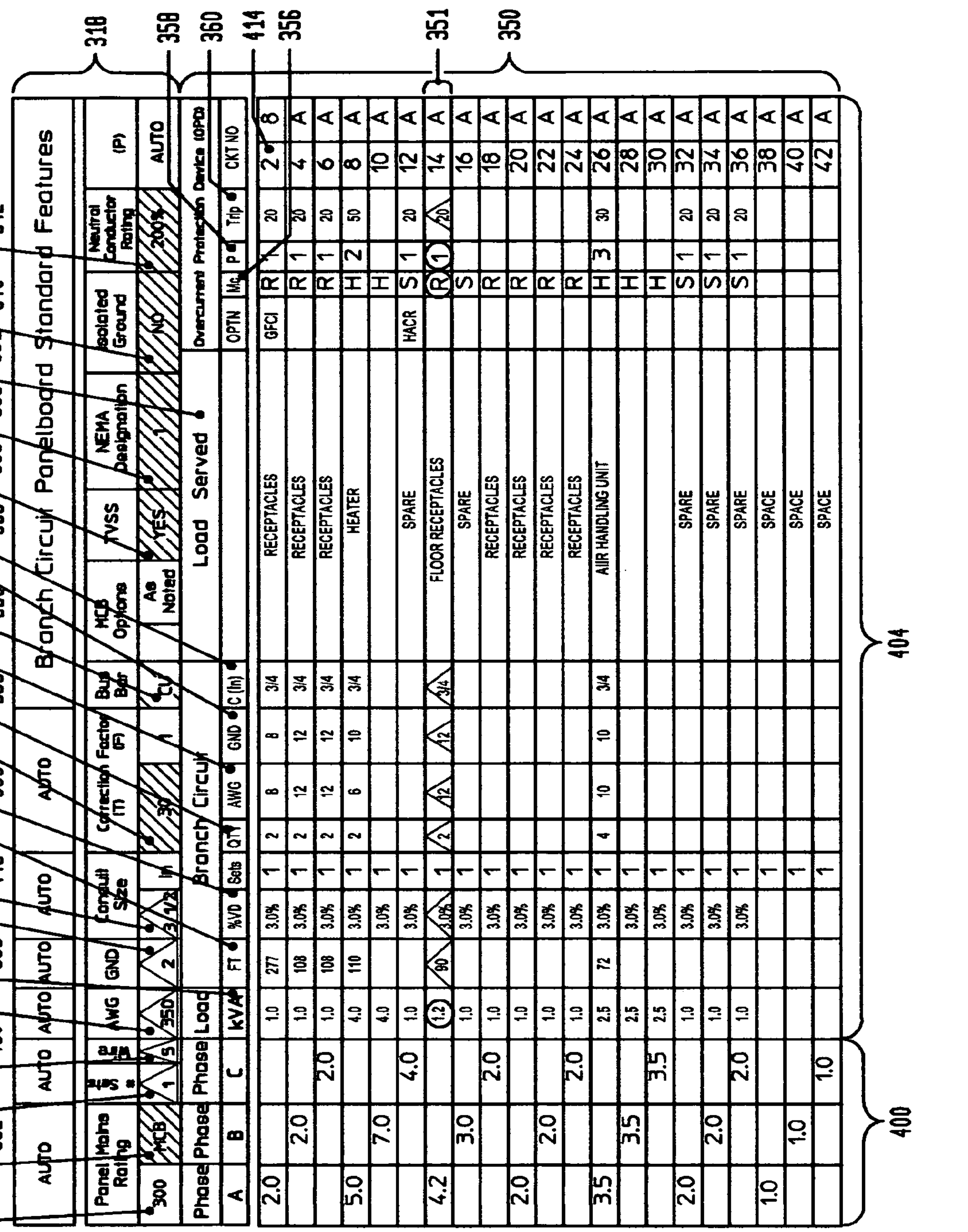

Branch Circuit Panelboard Standard Features
Load Served
Branch Circuit
Overcurrent Protection Device (OPD)
RECEPTACLES
HEATER
SPARE
FLOOR RECEPTACLES
AIR HANDLING UNIT
SPACE

FIG. 4B

FIG. 4C

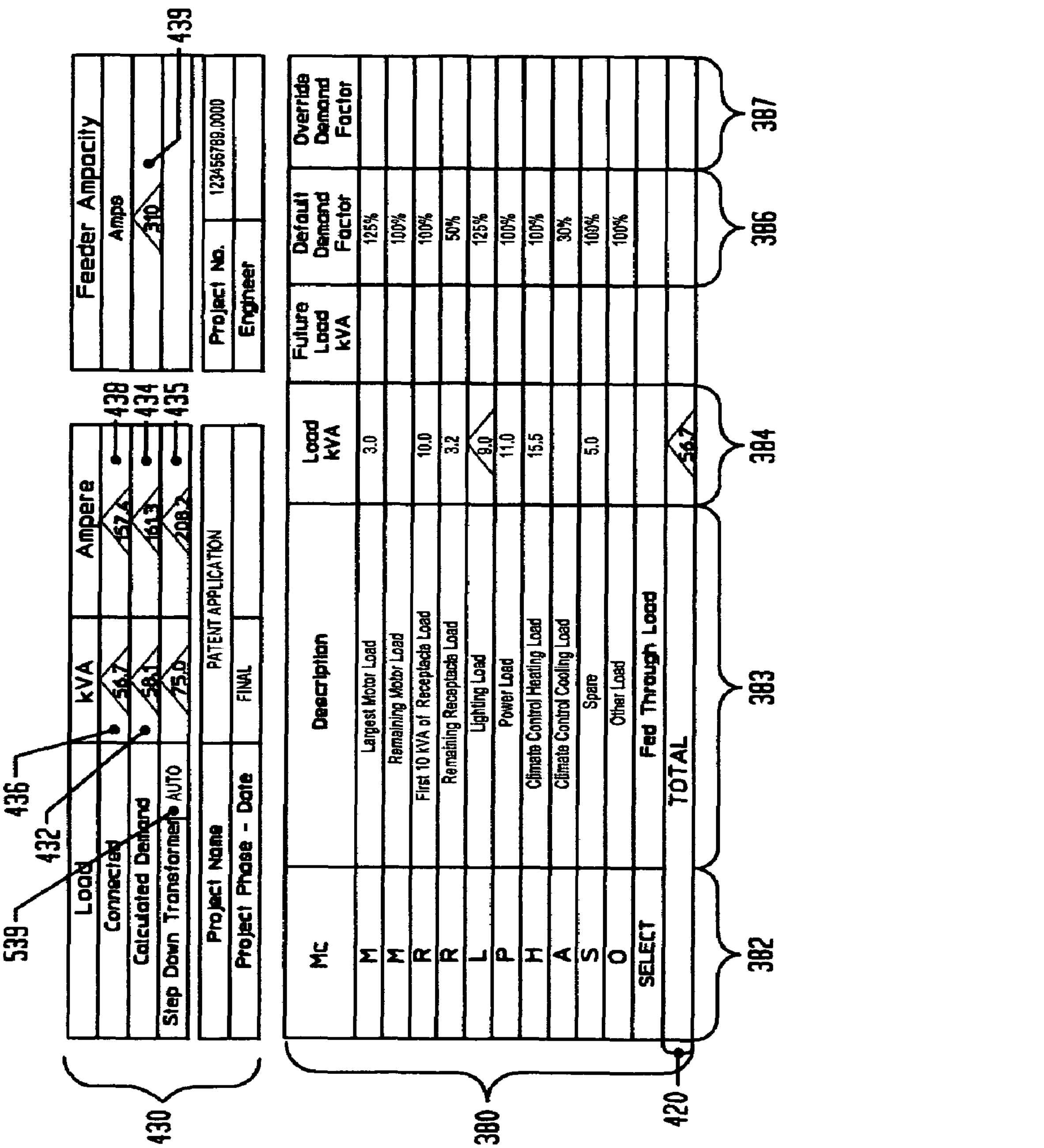

Load
kVA
Ampere
Connected
56.7
157.4
Calculated Demand
58.1
161.3
Step Down Transformer
AUTO
75.0
208.2
Feeder Ampacity
Amps
310
Project Name
PATENT APPLICATION
Project Phase - Date
FINAL
Project No.
123456789.0000
Engineer
Mc
Description
Load kVA
Future Load kVA
Default Demand Factor
Override Demand Factor
M
Largest Motor Load
3.0
125%
M
Remaining Motor Load
100%
R
First 10 kVA of Receptacle Load
10.0
100%
R
Remaining Receptacle Load
3.2
50%
L
Lighting Load
9.0
125%
P
Power Load
11.0
100%
H
Climate Control Heating Load
15.5
100%
A
Climate Control Cooling Load
30%
S
Spare
5.0
100%
O
Other Load
100%
SELECT
Fed Through Load
TOTAL
56.7
430
380
420
382
383
384
386
387
436
432
539
438
434
435
439

FIG. 4D

Total kVA Per Phase		
19.7	20.5	16.5

GFP	Ground Fault Protection
SNT	Shunt Trip
HACR	Heating, Air Conditioning & Refrig.
GFCI	Ground Fault Current Interrupter

AIC	Ampere Interrupting Capacity
CU	Copper

LOCK	Pad Lock Attachment
SWD	Switch Duty Rated
KEY	Key Lock
OPTN	Options

GND	Ground
LV	Low Voltage

		ELECTRIC POWER CALC INC. COPYRIGHT 2001-2002
		Power Calc Pak □

Engineering application spreadsheet

www.powercalcpak.com

430

Demand kVA	Note	Analysis Notes
3.8	1	
	2	
10.0	3	NOTE - Panelboard LA is 200% rated neutral (N) conductor. Make sure to specify K-RATED transformer.
1.6	4	1NOTE - Branch Circuit Conductor(s) Size of panel LA is NOT set on AUTO (A). Double check the result(s).
11.3	5	
11.0	6	
15.5	7	
	8	NOTE - Panelboard LA is active.
5.0	9	
	10	
	11	
58.1		

380

388

390

FIG. 5

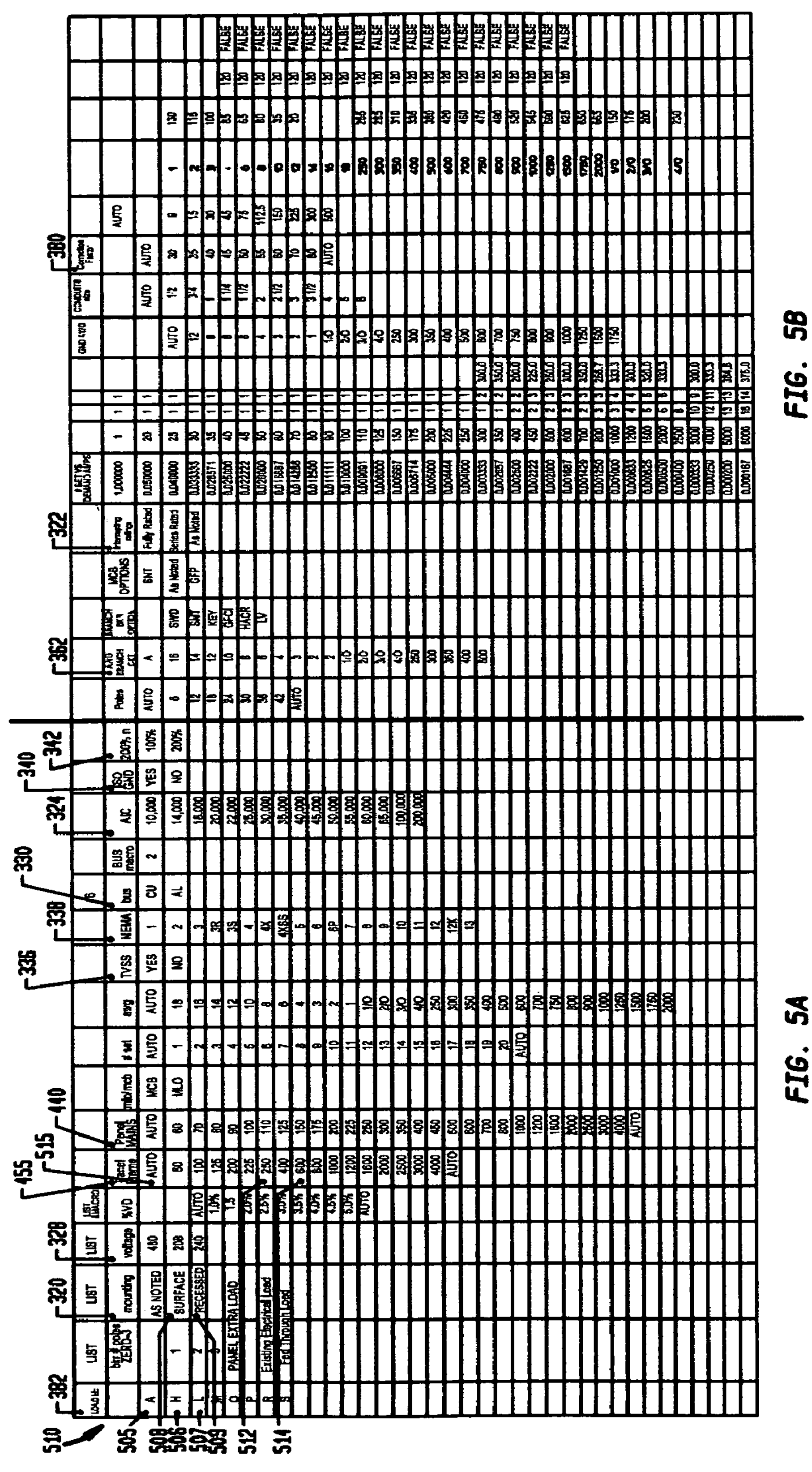


FIG. 5A

FIG. 5B

FIG. 5A

510 382 320 328 455 515 440 336 338 330 324 340 342

505 508 506 507 509 512 514

LOAD No	LIST	LIST	LIST	LIST &MACRO								6				
	blkr # poles ZERO-3	mounting	voltage	%VD	Panel Frame	Panel MAINS	mlo/mcb	# set	awg	TVSS	NEMA	bus	BUS macro	AIC	ISO GND	200% n
A		AS NOTED	480		AUTO	AUTO	MCB	AUTO	AUTO	YES	1	CU	2	10,000	YES	100%
H	1	SURFACE	208		60	60	MLO	1	18	NO	2	AL		14,000	NO	200%
L	2	RECESSED	240	AUTO	100	70		2	16		3			18,000		
M	3			1.0%	125	80		3	14		3R			20,000		
O	PANEL EXTRA LOAD			1.5	200	90		4	12		3S			22,000		
P				2.0%	225	100		5	10		4			25,000		
R	Existing Electrical Load			2.5%	250	110		6	8		4X			30,000		
S	Fed Through Load			3.0%	400	125		7	6		4XSS			35,000		
				3.5%	600	150		8	4		5			40,000		
				4.0%	800	175		9	3		6			45,000		
				4.5%	1000	200		10	2		6P			50,000		
				5.0%	1200	225		11	1		7			55,000		
				AUTO	1600	250		12	1/0		8			60,000		
					2000	300		13	2/0		9			65,000		
					2500	350		14	3/0		10			100,000		
					3000	400		15	4/0		11			200,000		
					4000	450		16	250		12					
					AUTO	500		17	300		12K					
						600		18	350		13					
						700		19	400							
						800		20	500							
						1000		AUTO	600							
						1200			700							
						1600			750							
						2000			800							
						2500			900							
						3000			1000							
						4000			1250							
						AUTO			1500							
									1750							
									2000							

FIG. 5B

362 322 380

					# SET VS DEMAND AMPS					GND AWG	CONDUITS size	Correction Factor					
Poles	AWG BRANCH CKT	BRANCH BKR OPTION	MCB OPTIONS	Interrupting ratings	1.000000	1	1	1					AUTO				
AUTO	A		SNT	Fully Rated	0.050000	20	1	1			AUTO	AUTO					
6	16	SWD	As Noted	Series Rated	0.040000	25	1	1		AUTO	1/2	30	9	1	130		
12	14	SNT	GFP	As Noted	0.033333	30	1	1		12	3/4	35	15	2	115		
18	12	KEY			0.028571	35	1	1		8	1	40	30	3	100		
24	10	GFCI			0.025000	40	1			8	1 1/4	45	45	4	85	120	FALSE
30	8	HACR			0.022222	45	1	1		6	1 1/2	50	75	6	65	120	FALSE
36	6	LV			0.020000	50	1	1		4	2	55	112.5	8	80	120	FALSE
42	4				0.016667	60	1	1		3	2 1/2	60	150	10	35	120	FALSE
AUTO	3				0.014286	70	1	1		2	3	70	225	12	20	120	FALSE
	2				0.012500	80	1	1		1	3 1/2	80	300	14		120	FALSE
	2				0.011111	90	1	1		1/0	4	AUTO	500	16		120	FALSE
	1/0				0.010000	100	1	1		2/0	5			18		120	FALSE
	2/0				0.009091	110	1	1		3/0	6			250	255	120	FALSE
	3/0				0.008000	125	1	1		4/0				300	285	120	FALSE
	4/0				0.006667	150	1	1		250				350	310	120	FALSE
	250				0.005714	175	1	1		300				400	335	120	FALSE
	300				0.005000	200	1	1		350				500	380	120	FALSE
	350				0.004444	225	1	1		400				600	420	120	FALSE
	400				0.004000	250	1	1		500				700	460	120	FALSE
	500				0.003333	300	1	2	300.0	600				750	475	120	FALSE
					0.002857	350	1	2	350.0	700				800	490	120	FALSE
					0.002500	400	2	2	200.0	750				900	520	120	FALSE
					0.002222	450	2	3	225.0	800				1000	545	120	FALSE
					0.002000	500	2	3	250.0	900				1250	590	120	FALSE
					0.001667	600	2	3	300.0	1000				1500	625	120	FALSE
					0.001429	700	2	3	350.0	1250				1750	650		
					0.001250	800	3	3	266.7	1500				2000	665		
					0.001000	1000	3	4	333.3	1750				1/0	150		
					0.000833	1200	4	4	300.0					2/0	175		
					0.000625	1600	5	5	320.0					3/0	200		
					0.000500	2000	6	6	333.3								
					0.000400	2500	8							4/0	230		
					0.000333	3000	10	9	300.0								
					0.000250	4000	12	11	333.3								
					0.000200	5000	13	13	384.6								
					0.000167	6000	16	14	375.0								

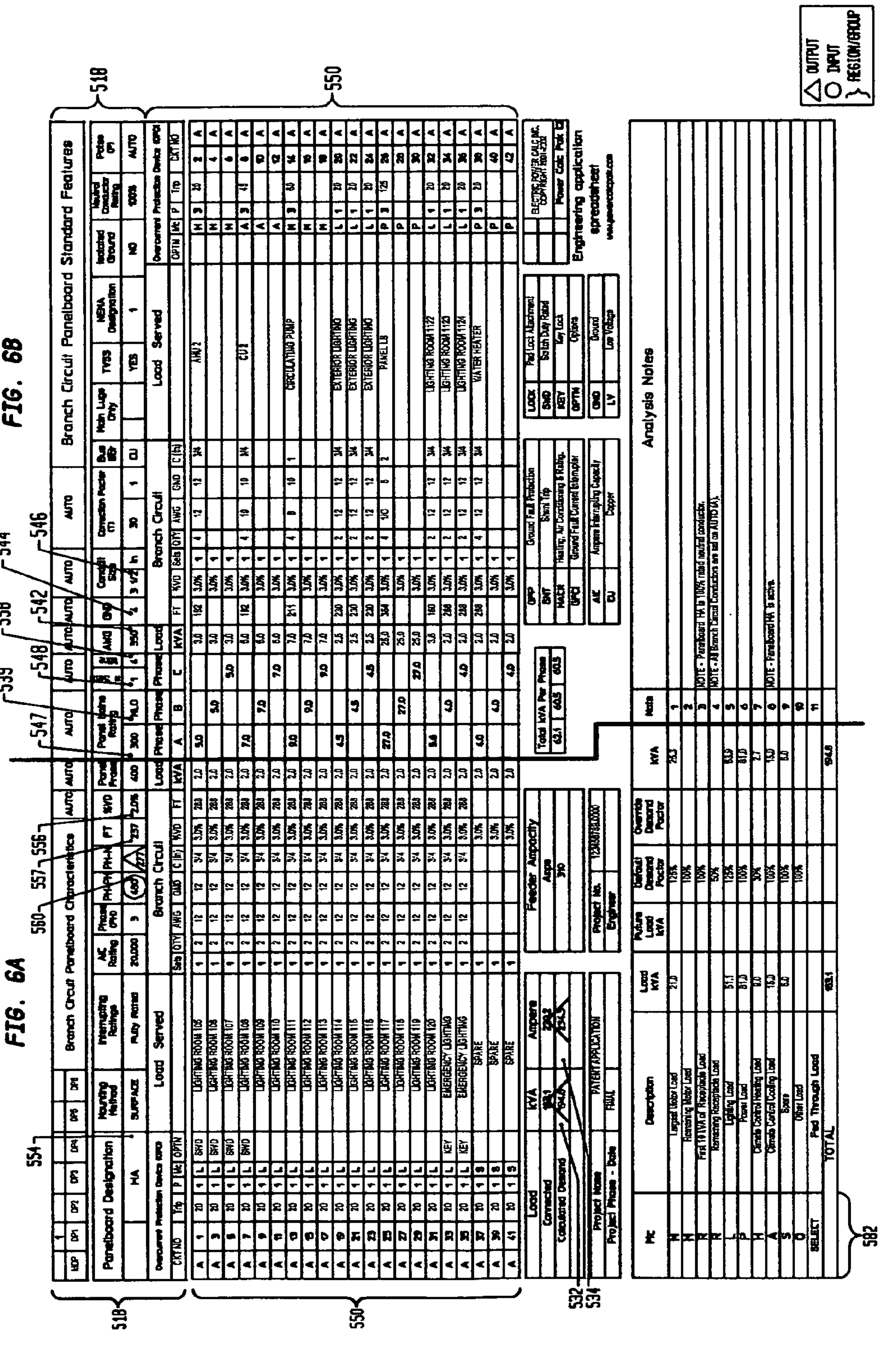


FIG. 6
FIG. 6A
FIG. 6B
Branch Circuit Panelboard Characteristics
Branch Circuit Panelboard Standard Features
Load Served
Branch Circuit
Analysis Notes
Feeder Ampacity
Engineering application spreadsheet
OUTPUT
INPUT
REGION/GROUP
518
550
554
560
557
556
547
539
548
558
542
544
546
532
534
582

FIG. 6A

554 560 557 556

518

MDP	DP1	DP2	DP3	DP4	DP5	DP6	Branch Circuit Panelboard Characteristics	AUTO	AUTO
	1								

Panelboard Designation		Mounting Method	Interrupting Ratings	AIC Rating	Phase (PH)	PH-PH	PH-N	FT	%VD	Panel Frame
	HA	SURFACE	Fully Rated	20,000	3	480	277	237	2.0%	400

550

Overcurrent Protection Device (OPD)						Load Served	Branch Circuit							Load
CKT NO		Trip	P	Mc	OPTN		Sets	QTY	AWG	GND	C (In)	%VD	FT	kVA
A	1	20	1	L	SWD	LIGHTING ROOM 105	1	2	12	12	3/4	3.0%	288	2.0
A	3	20	1	L	SWD	LIGHTING ROOM 106	1	2	12	12	3/4	3.0%	288	2.0
A	5	20	1	L	SWD	LIGHTING ROOM 107	1	2	12	12	3/4	3.0%	288	2.0
A	7	20	1	L	SWD	LIGHTING ROOM 108	1	2	12	12	3/4	3.0%	288	2.0
A	9	20	1	L		LIGHTING ROOM 109	1	2	12	12	3/4	3.0%	288	2.0
A	11	20	1	L		LIGHTING ROOM 110	1	2	12	12	3/4	3.0%	288	2.0
A	13	20	1	L		LIGHTING ROOM 111	1	2	12	12	3/4	3.0%	288	2.0
A	15	20	1	L		LIGHTING ROOM 112	1	2	12	12	3/4	3.0%	288	2.0
A	17	20	1	L		LIGHTING ROOM 113	1	2	12	12	3/4	3.0%	288	2.0
A	19	20	1	L		LIGHTING ROOM 114	1	2	12	12	3/4	3.0%	288	2.0
A	21	20	1	L		LIGHTING ROOM 115	1	2	12	12	3/4	3.0%	288	2.0
A	23	20	1	L		LIGHTING ROOM 116	1	2	12	12	3/4	3.0%	288	2.0
A	25	20	1	L		LIGHTING ROOM 117	1	2	12	12	3/4	3.0%	288	2.0
A	27	20	1	L		LIGHTING ROOM 118	1	2	12	12	3/4	3.0%	288	2.0
A	29	20	1	L		LIGHTING ROOM 119	1	2	12	12	3/4	3.0%	288	2.0
A	31	20	1	L		LIGHTING ROOM 120	1	2	12	12	3/4	3.0%	288	2.0
A	33	20	1	L	KEY	EMERGENCY LIGHTING	1	2	12	12	3/4	3.0%	288	2.0
A	35	20	1	L	KEY	EMERGENCY LIGHTING	1	2	12	12	3/4	3.0%	288	2.0
A	37	20	1	S		SPARE	1					3.0%		2.0
A	39	20	1	S		SPARE	1					3.0%		2.0
A	41	20	1	S		SPARE	1					3.0%		2.0

Load	kVA	Ampere
Connected	183.1	220.2
Calculated Demand	194.8	234.3

Feeder Ampacity
Amps
310

532
534

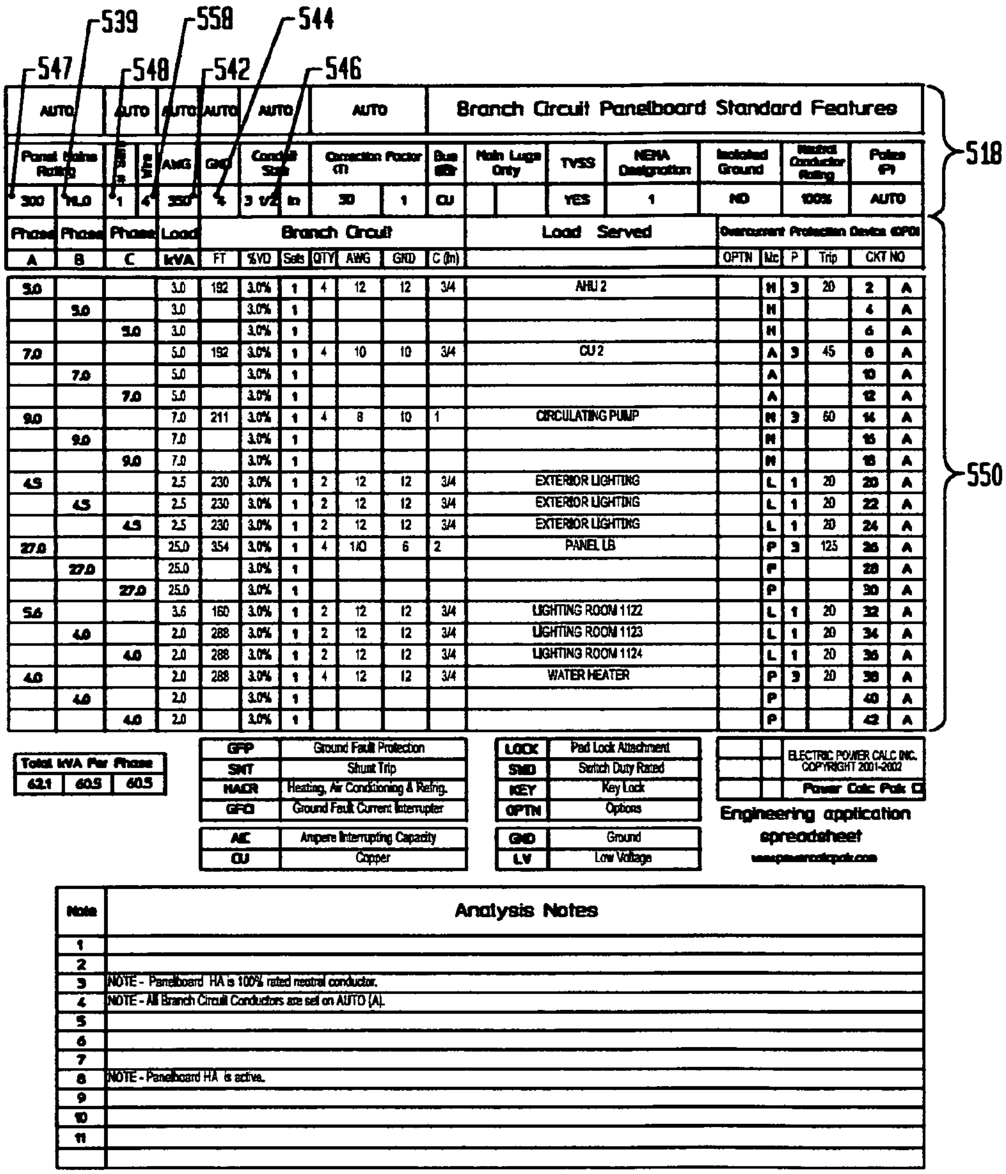
Project Name	PATENT APPLICATION	
Project Phase - Date	FINAL	

Project No.	123456789.0000
Engineer	

Mc	Description	Load kVA	Future Load kVA	Default Demand Factor	Override Demand Factor	kVA
M	Largest Motor Load	21.0		125%		26.3
M	Remaining Motor Load			100%		
R	First 10 kVA of Receptacle Load			100%		
R	Remaining Receptacle Load			50%		
L	Lighting Load	51.1		125%		63.9
P	Power Load	81.0		100%		81.0
H	Climate Control Heating Load	9.0		30%		2.7
A	Climate Control Cooling Load	15.0		100%		15.0
S	Spare	6.0		100%		6.0
O	Other Load			100%		
SELECT	Fed Through Load					
TOTAL		183.1				194.8

582

FIG. 6B



AUTO		AUTO		AUTO	AUTO	AUTO		AUTO		Branch Circuit Panelboard Standard Features							
Panel Mains Rating		Sets	Wire	AWG	GND	Conduit Size		Correction Factor (T)		Bus (Br)	Main Lugs Only		TVSS	NEMA Designation	Isolated Ground	Neutral Conductor Rating	Poles (P)
300	11.0	1	4	350	4	3 1/2	In	30	1	CU			YES	1	NO	100%	AUTO

Phase	Phase	Phase	Load	Branch Circuit							Load Served	Overcurrent Protection Device (OPD)					
A	B	C	kVA	FT	%VD	Sets	QTY	AWG	GND	C (In)		OPTN	Mc	P	Trip	CKT NO	
5.0			3.0	192	3.0%	1	4	12	12	3/4	AHU 2		H	3	20	2	A
	5.0		3.0		3.0%	1							H			4	A
		5.0	3.0		3.0%	1							H			6	A
7.0			5.0	192	3.0%	1	4	10	10	3/4	CU 2		A	3	45	8	A
	7.0		5.0		3.0%	1							A			10	A
		7.0	5.0		3.0%	1							A			12	A
9.0			7.0	211	3.0%	1	4	8	10	1	CIRCULATING PUMP		H	3	60	14	A
	9.0		7.0		3.0%	1							H			16	A
		9.0	7.0		3.0%	1							H			18	A
4.5			2.5	230	3.0%	1	2	12	12	3/4	EXTERIOR LIGHTING		L	1	20	20	A
	4.5		2.5	230	3.0%	1	2	12	12	3/4	EXTERIOR LIGHTING		L	1	20	22	A
		4.5	2.5	230	3.0%	1	2	12	12	3/4	EXTERIOR LIGHTING		L	1	20	24	A
27.0			25.0	354	3.0%	1	4	1/0	6	2	PANEL LB		P	3	125	26	A
	27.0		25.0		3.0%	1							P			28	A
		27.0	25.0		3.0%	1							P			30	A
5.6			3.6	160	3.0%	1	2	12	12	3/4	LIGHTING ROOM 1122		L	1	20	32	A
	4.0		2.0	288	3.0%	1	2	12	12	3/4	LIGHTING ROOM 1123		L	1	20	34	A
		4.0	2.0	288	3.0%	1	2	12	12	3/4	LIGHTING ROOM 1124		L	1	20	36	A
4.0			2.0	288	3.0%	1	4	12	12	3/4	WATER HEATER		P	3	20	38	A
	4.0		2.0		3.0%	1							P			40	A
		4.0	2.0		3.0%	1							P			42	A

Total kVA Per Phase		
62.1	60.5	60.5

GFP	Ground Fault Protection
SNT	Shunt Trip
HACR	Heating, Air Conditioning & Refrig.
GFCI	Ground Fault Current Interrupter
AIC	Ampere Interrupting Capacity
CU	Copper

LOCK	Pad Lock Attachment
SWD	Switch Duty Rated
KEY	Key Lock
OPTN	Options
GND	Ground
LV	Low Voltage

		ELECTRIC POWER CALC INC. COPYRIGHT 2001-2002
		Power Calc Pak C

Engineering application spreadsheet

www.powercalcpak.com

Note	Analysis Notes
1	
2	
3	NOTE - Panelboard HA is 100% rated neutral conductor.
4	NOTE - All Branch Circuit Conductors are set on AUTO (A).
5	
6	
7	
8	NOTE - Panelboard HA is active.
9	
10	
11	

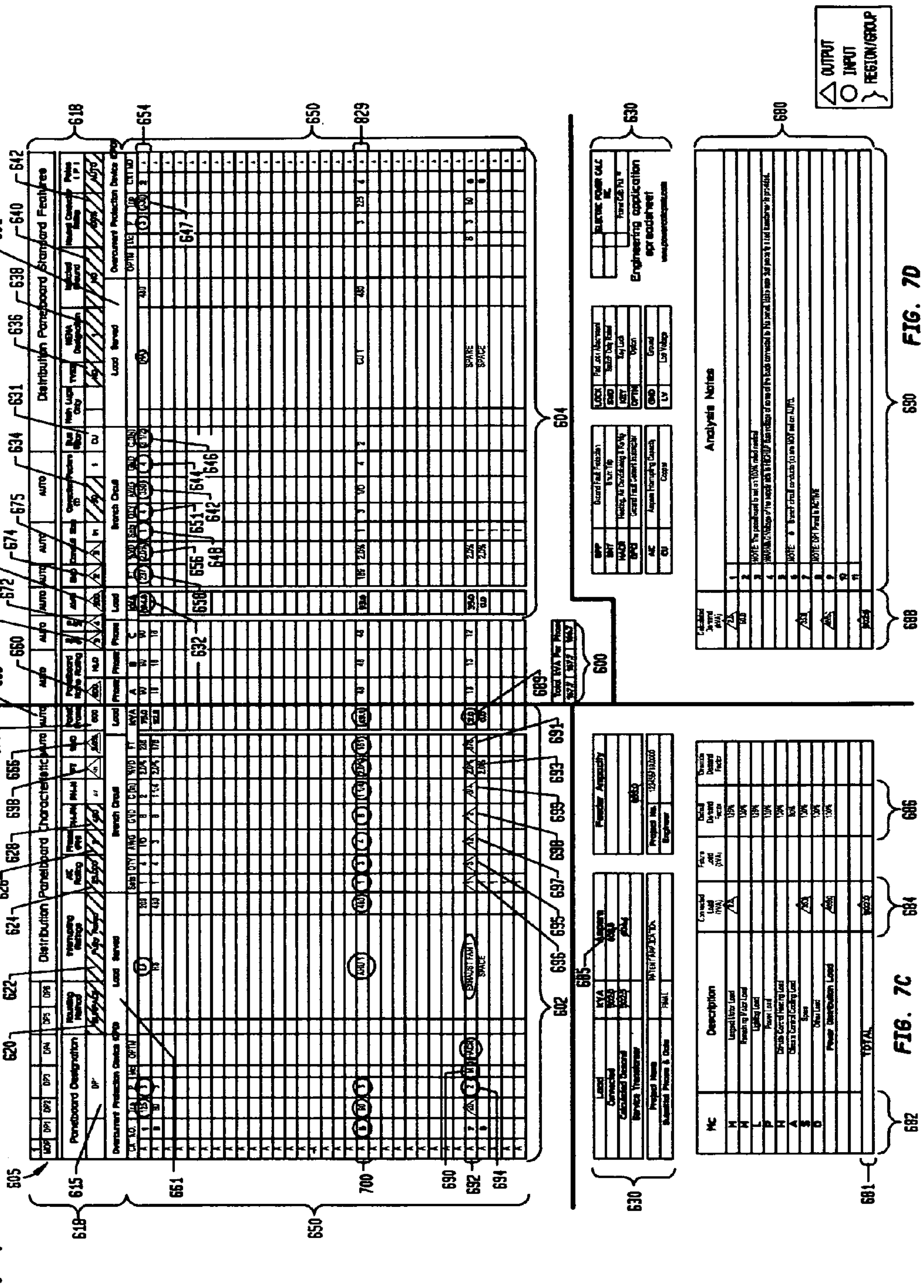


FIG. 7A
FIG. 7B
FIG. 7C
FIG. 7D
Panelboard Designation
Distribution Panelboard Characteristic
Distribution Panelboard Standard Features
Load Served
Branch Circuit
Feeder Ampacity
Analysis Notes
Description
TOTAL
Engineering application spreadsheet
OUTPUT
INPUT
REGION/GROUP

FIG. 7

FIG. 7A

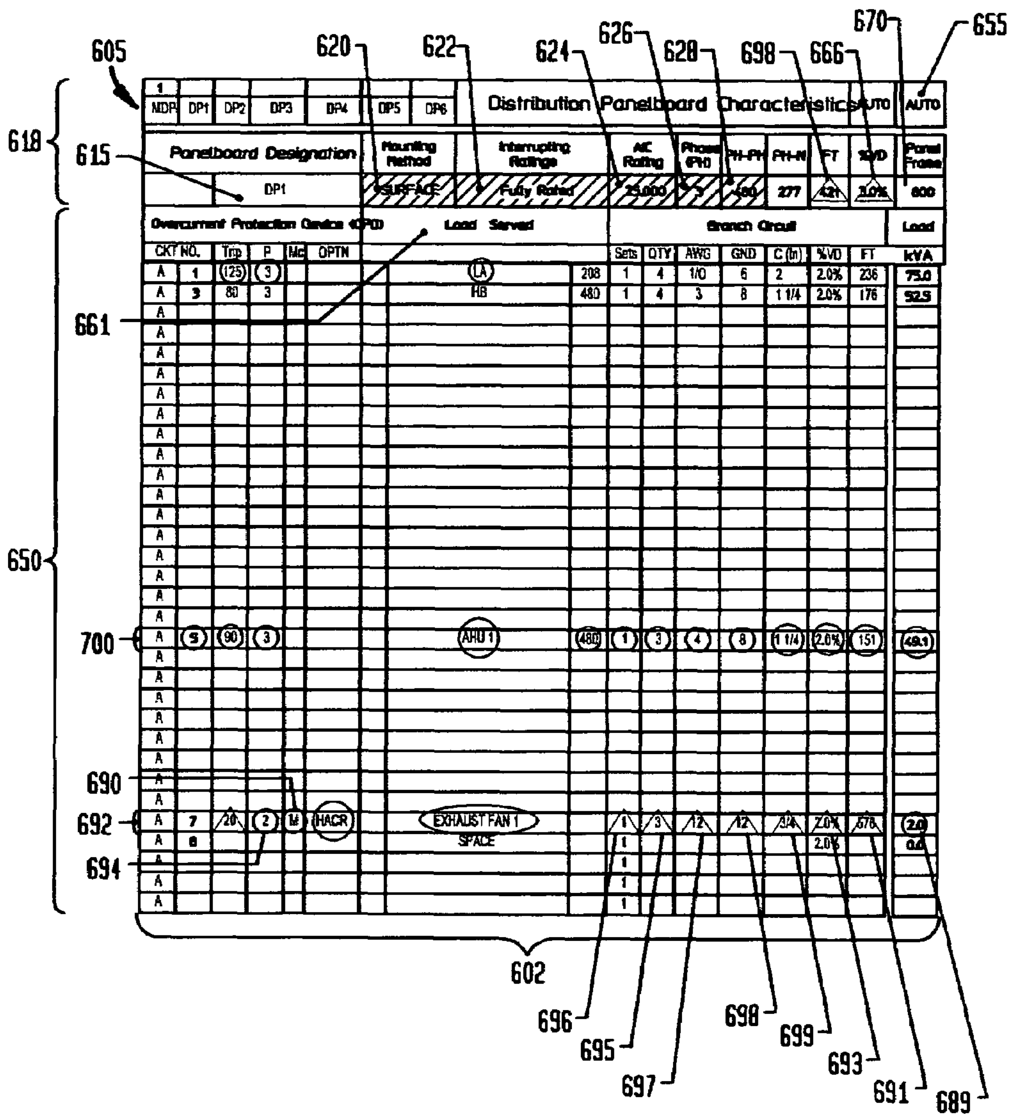

605
620
622
624
626
628
698
666
670
655
618
615
650
661
700
690
692
694
602
696
695
697
698
699
693
691
689
NDP
DP1
DP2
DP3
DP4
DP5
DP6
Distribution Panelboard Characteristics
AUTO
Panelboard Designation
Mounting Method
Interrupting Ratings
AIC Rating
Phase (PH)
PH-PH
PH-N
FT
%VD
Panel Frame
SURFACE
Fully Rated
25,000
3
480
277
421
3.0%
800
Overcurrent Protection Device (OPD)
Load Served
Branch Circuit
Load
CKT NO.
Trip
P
Mc
OPTN
Sets
QTY
AWG
GND
C (in)
%VD
FT
kVA
LA
HB
AHU 1
HACR
EXHAUST FAN 1
SPACE

FIG. 7B

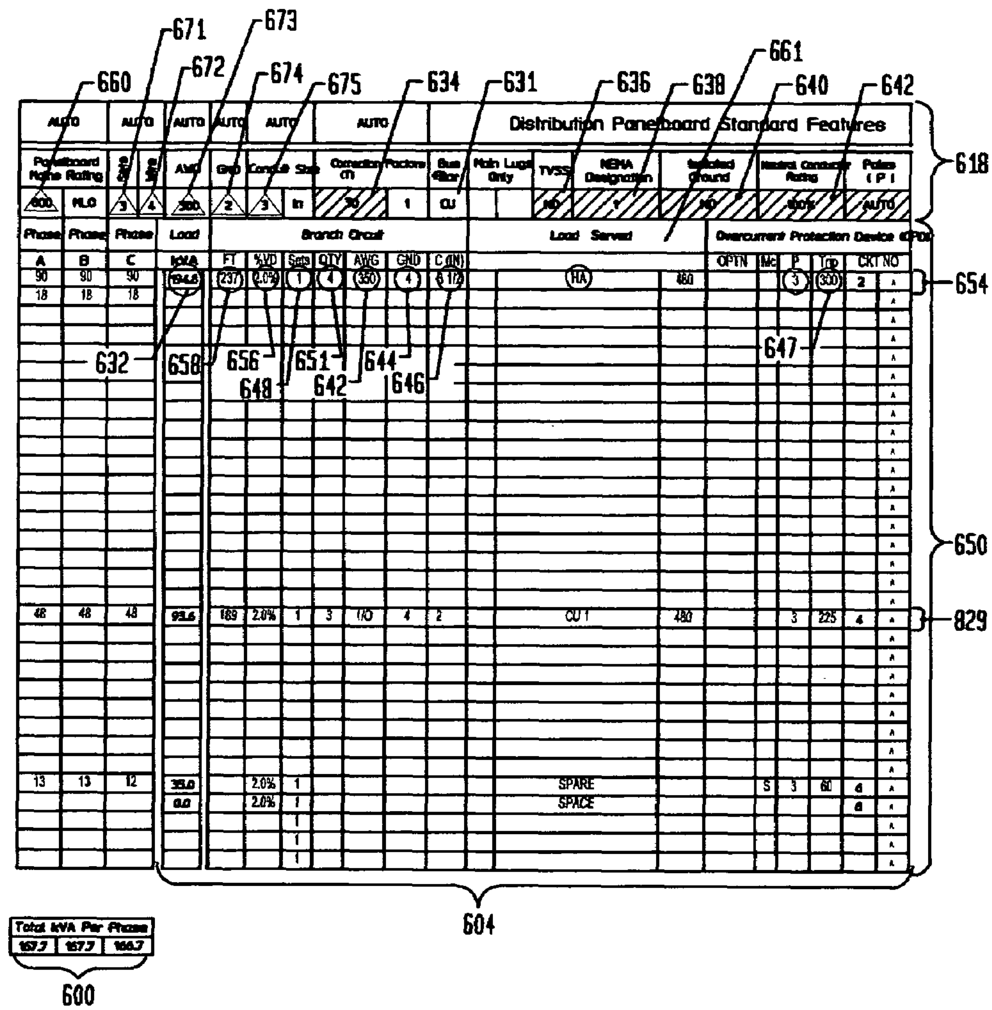

Distribution Panelboard Standard Features
AUTO
Panelboard Frame Rating
AWG
Correction Factors
Main Lugs Only
TVSS
NEMA Designation
Isolated Ground
Neutral Conductor Rating
Poles
Phase
Load
Branch Circuit
Load Served
Overcurrent Protection Device
A
B
C
kVA
FT
%VD
Sets
QTY
AWG
GND
C (IN)
OPTN
P
Trip
CKT NO
SPARE
SPACE
Total kVA Per Phase
660
671
672
673
674
675
634
631
636
638
661
640
642
618
654
632
658
656
648
651
642
644
646
647
650
829
604
600

FIG. 7C

Load	kVA	Ampere
Connected	502.0	609.8
Calculated Demand	502.5	604.4
Service Transformer		
Project Name	PATENT APPLICATION	
Submittal Phase & Date	FINAL	

Feeder Ampacity	
655.0	
Project No.	123456789.0000
Engineer	

Mc	Description	Connected Load (kVA)	Future Load (kVA)	Default Demand Factor	Override Demand Factor
M	Largest Motor Load	2.0		125%	
M	Remaining Motor Load			100%	
L	Lighting Load			125%	
P	Power Load			100%	
H	Climate Control Heating Load			100%	
A	Climate Control Cooling Load			30%	
S	Spare	35.0		100%	
O	Other Load			100%	
	Power Distribution Load	465.0		100%	
TOTAL		502.0			

685
630
681
682
684
686

FIG. 7D

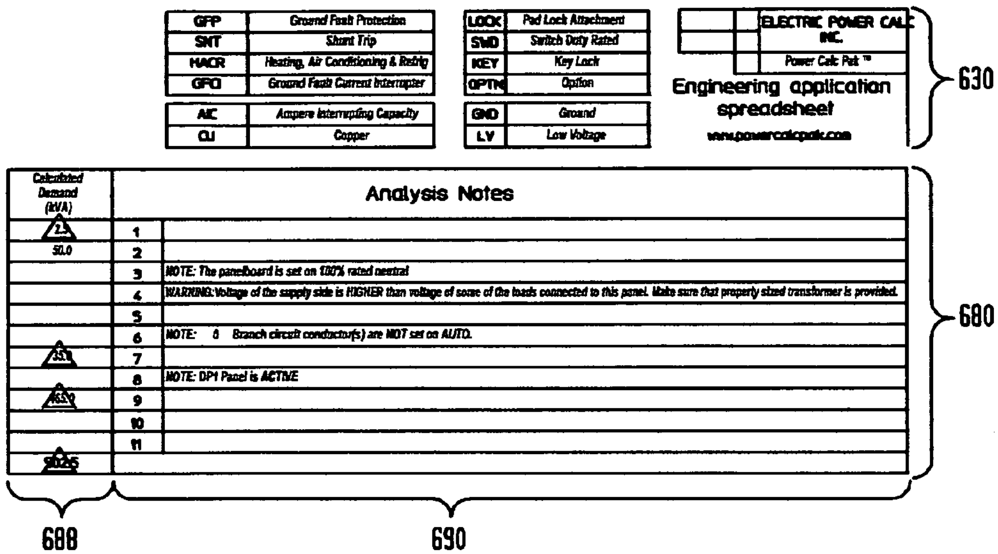

GFP
Ground Fault Protection
SNT
Shunt Trip
HACR
Heating, Air Conditioning & Refrig
GFCI
Ground Fault Current Interrupter
AIC
Ampere Interrupting Capacity
CU
Copper
LOCK
Pad Lock Attachment
SWD
Switch Duty Rated
KEY
Key Lock
OPTN
Option
GND
Ground
LV
Low Voltage
ELECTRIC POWER CALC INC.
Power Calc Pak ™
Engineering application spreadsheet
www.powercalcpak.com
630
Calculated Demand (kVA)
Analysis Notes
50.0
1
2
3
NOTE: The panelboard is set on 100% rated neutral
4
WARNING: Voltage of the supply side is HIGHER than voltage of some of the loads connected to this panel. Make sure that properly sized transformer is provided.
5
6
NOTE: 0 Branch circuit conductor(s) are NOT set on AUTO.
7
8
NOTE: DP1 Panel is ACTIVE
9
10
11
680
688
690

FIG. 8

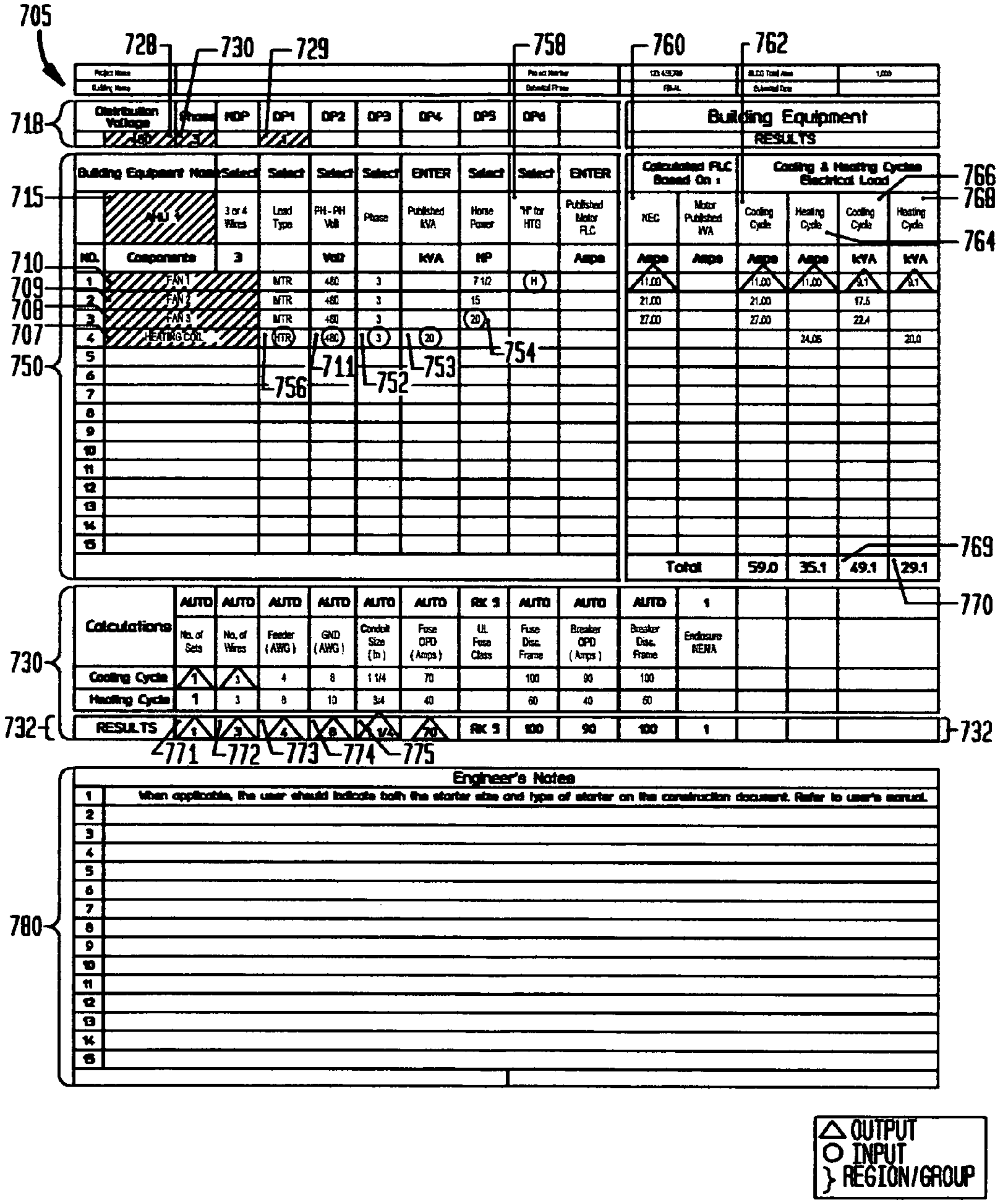

705
728
730
729
758
760
762
718
Distribution Voltage
Phase
MDP
DP1
DP2
DP3
DP4
DP5
DP6
Building Equipment
RESULTS
715
Building Equipment Name
Select
ENTER
3 or 4 Wires
Load Type
PH-PH Volt
Phase
Published kVA
Horse Power
"H" for HTG
Published Motor FLC
Calculated FLC Based On :
NEC
Motor Published kVA
Cooling & Heating Cycles Electrical Load
Cooling Cycle
Heating Cycle
766
768
764
NO.
Components
Volt
kVA
HP
Amps
kVA
710
709
708
707
750
FAN 1
FAN 2
FAN 3
HEATING COIL
MTR
HTR
480
756
711
752
753
754
Total
59.0
35.1
49.1
29.1
769
770
Calculations
AUTO
RK 5
No. of Sets
No. of Wires
Feeder (AWG)
GND (AWG)
Conduit Size (In)
Fuse OPD (Amps)
UL Fuse Class
Fuse Disc. Frame
Breaker OPD (Amps)
Breaker Disc. Frame
Enclosure NEMA
730
Cooling Cycle
Heating Cycle
732
RESULTS
771
772
773
774
775
Engineer's Notes
When applicable, the user should indicate both the starter size and type of starter on the construction document. Refer to user's manual.
780
OUTPUT
INPUT
REGION/GROUP

FIG. 9

Project Name		Project Number	123,456,789	BLDG Total Area	1,000
Building Name		Submittal Phase	FINAL	Submittal Date	

Distribution Voltage	Phase	HOP	OP1	OP2	OP3	OP4	OP5	OP6	
480	3		1						

Building Equipment RESULTS

815

Building Equipment Name		Select	Select	Select	Select	ENTER	Select	Select	ENTER	Calculated FLC Based On :		Cooling & Heating Cycles Electrical Load			
	CU 1	3 or 4 Wires	Load Type	PH - PH Volt	Phase	Published kVA	Horse Power	"H" for HTG	Published Motor FLC	NEC	Motor Published kVA	Cooling Cycle	Heating Cycle	Cooling Cycle	Heating Cycle
NO.	Components	3		Volt		kVA	HP		Amps	Amps	Amps	Amps	Amps	kVA	kVA
1	COMPRESSOR 1		MTR	480	3		25			34.00		34.00		28.3	
2	COMPRESSOR 2		MTR	480	3		60			77.00		77.00		64.0	
3	CONDENSER FAN 1		MTR	208	1		1/3			4.00		4.00		0.8	
4	CONDENSER FAN 2		MTR	208	1		1/6			2.40		2.40		0.5	
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
										Total		117.4		93.6	

Calculations	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	RK 5	AUTO	AUTO	AUTO	3R			
	No. of Sets	No. of Wires	Feeder (AWG)	GND (AWG)	Conduit Size (In)	Fuse OPD (Amps)	UL Fuse Class	Fuse Disc. Frame	Breaker OPD (Amps)	Breaker Disc. Frame	Enclosure NEMA			
Cooling Cycle	1	3	1/0	4	2	175		200	225	400				
RESULTS	1	3	1/0	4	2	175	RK 5	200	225	400	3R			

832

Engineer's Notes	
1	When applicable, the user should indicate both the starter size and type of starter on the construction document. Refer to user's manual.
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

△ OUTPUT
○ INPUT
} REGION/GROUP

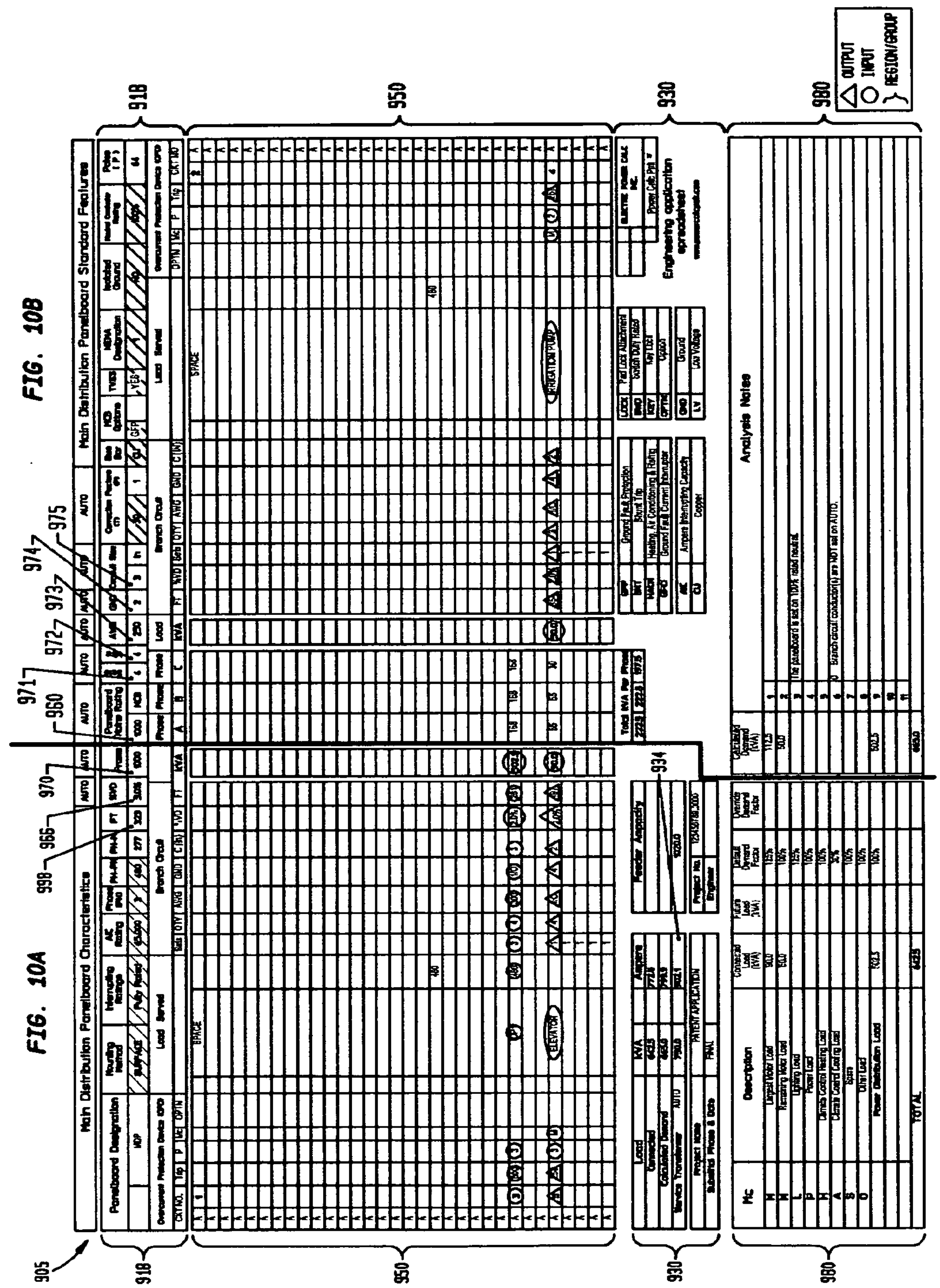


FIG. 10A
FIG. 10B
Main Distribution Panelboard Characteristics
Main Distribution Panelboard Standard Features
Analysis Notes
Engineering application spreadsheet
OUTPUT
INPUT
REGION/GROUP
905
918
950
930
980
960
971
972
973
974
975
970
965
998
934

FIG. 10

FIG. 10A

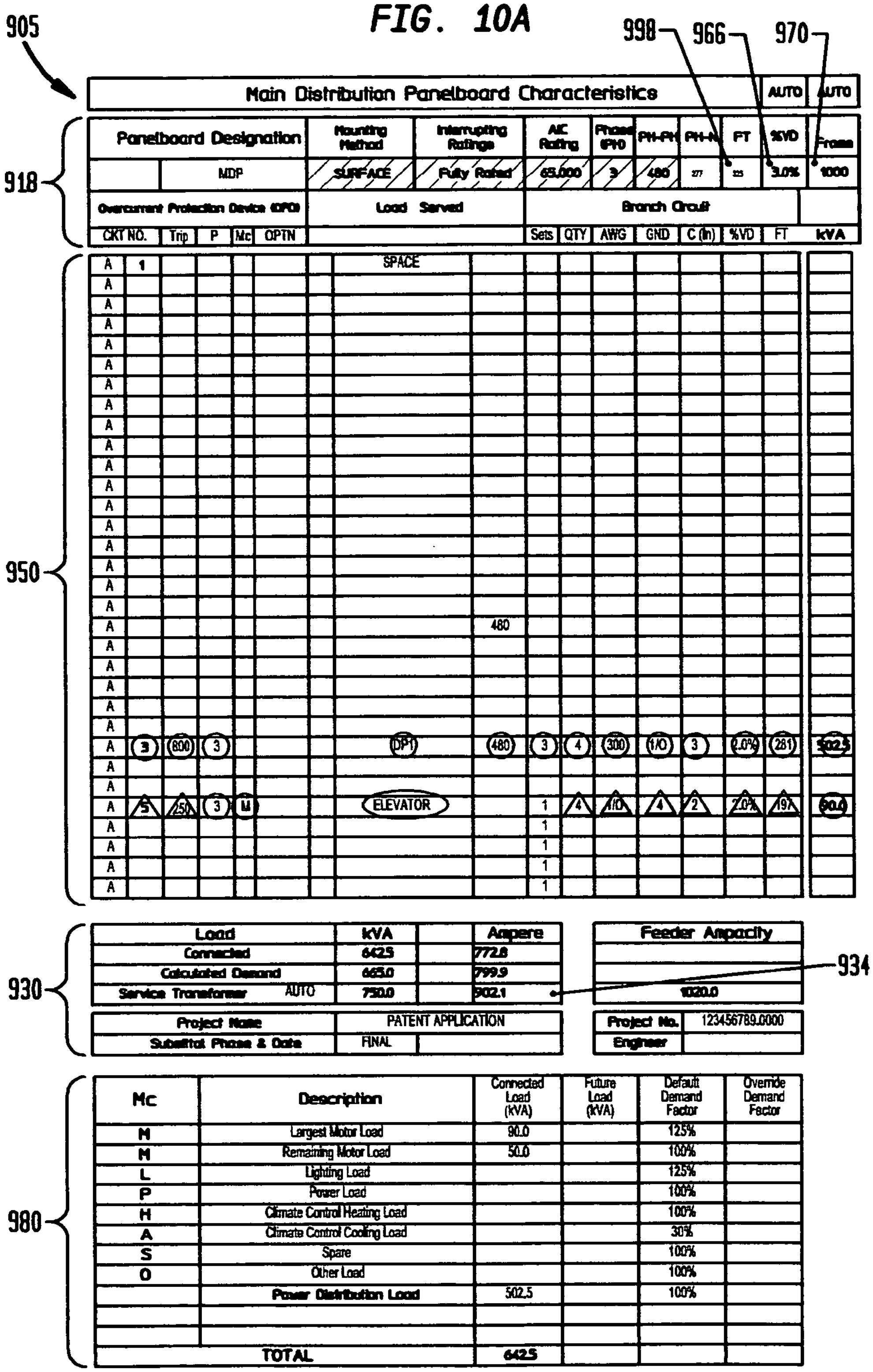
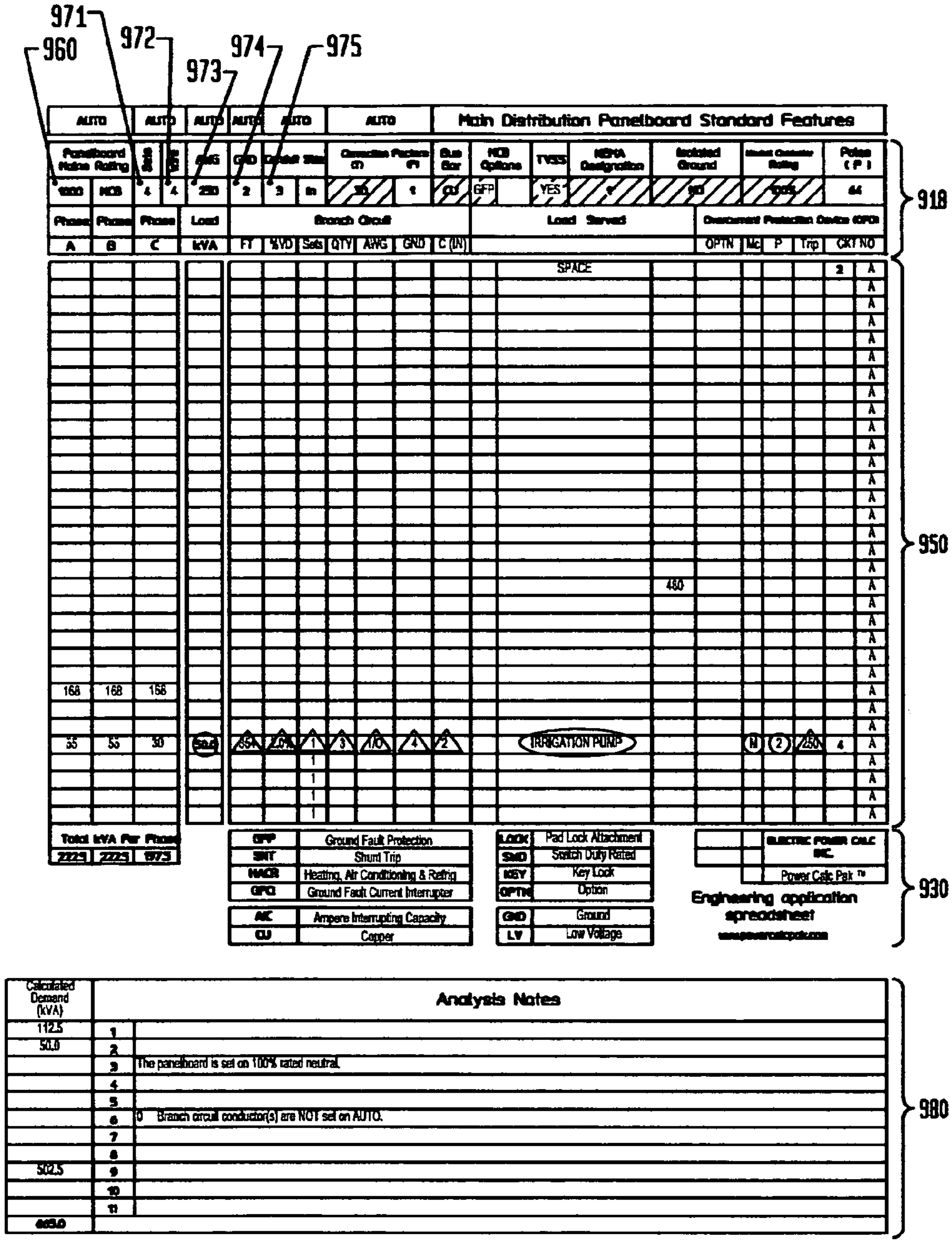

905
998
966
970
Main Distribution Panelboard Characteristics
AUTO
AUTO
918
Panelboard Designation
Mounting Method
Interrupting Ratings
AIC Rating
Phase (PH)
PH-PH
PH-N
FT
%VD
Frame
MDP
SURFACE
Fully Rated
65,000
3
480
277
3.0%
1000
Overcurrent Protection Device (OPD)
Load Served
Branch Circuit
CKT NO.
Trip
P
Mc
OPTN
Sets
QTY
AWG
GND
C (In)
%VD
FT
kVA
950
SPACE
480
DP1
ELEVATOR
930
Load
kVA
Ampere
Connected
642.5
772.8
Calculated Demand
665.0
799.9
Service Transformer
AUTO
750.0
902.1
Feeder Ampacity
1020.0
934
Project Name
PATENT APPLICATION
Submittal Phase & Date
FINAL
Project No.
123456789.0000
Engineer
980
Mc
Description
Connected Load (kVA)
Future Load (kVA)
Default Demand Factor
Override Demand Factor
Largest Motor Load
Remaining Motor Load
Lighting Load
Power Load
Climate Control Heating Load
Climate Control Cooling Load
Spare
Other Load
Power Distribution Load
TOTAL

FIG. 10B



971
972
960
973
974
975
918
950
930
980
AUTO
Main Distribution Panelboard Standard Features
Panelboard Mains Rating
AWG
GND
Conduit Size
Bus Bar
MCB Options
TVSS
NEMA Designation
Isolated Ground
Poles
Phase
Load
Branch Circuit
Load Served
Overcurrent Protection Device (OPD)
A
B
C
kVA
FT
%VD
Sets
QTY
AWG
GND
C (N)
OPTN
P
Trip
CKT NO
SPACE
480
IRRIGATION PUMP
Total kVA Per Phase
GFP
Ground Fault Protection
SNT
Shunt Trip
HACR
Heating, Air Conditioning & Refrig
GFCI
Ground Fault Current Interrupter
AIC
Ampere Interrupting Capacity
CU
Copper
LOCK
Pad Lock Attachment
SWD
Switch Duty Rated
KEY
Key Lock
OPTN
Option
GND
Ground
LV
Low Voltage
Power Calc Pak ™
Engineering application spreadsheet
Calculated Demand (kVA)
Analysis Notes
112.5
50.0
The panelboard is set on 100% rated neutral.
0 Branch circuit conductor(s) are NOT set on AUTO.
502.5

FIG. 11

FUSE	BREAKER	NEC 240-6 STD		
NEC 240-6 STD AMPS RATINGS			BREAKER	1/AMPS RATING
2	20	0.0001667	6000	0.0001667
4	20	0.0002000	5000	0.0002000
6	20	0.0002500	4000	0.0002500
8	20	0.0003333	3000	0.0003333
10	20	0.0004000	2500	0.0004000
12	20	0.0005000	2000	0.0005000
16	20	0.0006250	1600	0.0006250
18	20	0.0008333	1200	0.0008333
20	20	0.0010000	1000	0.0010000
25	25	0.0012500	800	0.0012500
30	30	0.0014286	700	0.0014286
35	35	0.0016667	600	0.0016667
40	40	0.0020000	500	0.0020000
45	45	0.0025000	400	0.0025000
50	50	0.0028571	350	0.0028571
60	60	0.0033333	300	0.0033333
70	70	0.0040000	250	0.0040000
80	80	0.0044444	225	0.0044444
90	90	0.0050000	200	0.0050000
100	100	0.0057143	175	0.0057143
110	110	0.0066667	150	0.0066667
125	125	0.0080000	125	0.0080000
150	150	0.0090909	110	0.0090909
175	175	0.0100000	100	0.0100000
200	200	0.0111111	90	0.0111111
225	225	0.0125000	80	0.0125000
250	250	0.0142857	70	0.0142857
300	300	0.0166667	60	0.0166667
350	350	0.0200000	50	0.0200000
400	400	0.0222222	45	0.0222222
500	500	0.0250000	40	0.0250000
600	600	0.0285714	35	0.0285714
700	700	0.0333333	30	0.0333333
800	800	0.0400000	25	0.0400000
1000	1000	0.0500000	20	0.0500000
1200	1200	0.0500000	20	0.0500000
1600	1600			
2000	2000			
2500	2500			
3000	3000			
4000	4000			
5000	5000			
6000	6000			

1010

RECOMMENDED CKT BKR
OVER RIDDEN

FIG. 12

1110

TABLE 310-16	74 DEG		90 DEG	
AMPS	AWG		AMPS	AWG
	16		14	18
	18		18	16
20	14		25	14
20	12		30	12
30	10		40	10
40	8		55	8
55	6		75	6
70	4		95	4
85	3		110	3
95	2		130	2
110	1		150	1
150	1/0		170	1/0
175	2/0		195	2/0
200	3/0		225	3/0
230	4/0		260	4/0
255	250		290	250
285	300		320	300
310	350		350	350
335	400		380	400
400	500	ADJUSTED	430	500
420	600		475	600
460	700		520	700
475	750		535	750
490	800		555	800
520	900		585	900
545	1000		615	1000
590	1250		665	1250
635	1500		705	1500
650	1750		735	1750
665	2000		750	2000

FIG. 13

1210

TAB 310-16	75 DEG		AC RESISTANCE FOR UNCOATED CU. WIRES			MAX R	TAB 310-16	90 DEG
AWG	AMPS	AREA(IN)	PVC	AL	STEEL		AWG	AMPS
1	130	0.1590	0.1600	0.1600	0.1600	0.1600	1	150
2	115	0.1182	0.1900	0.2000	0.2000	0.2000	2	130
3	100	0.0995	0.2500	0.2500	0.2500	0.2500	3	110
4	85	0.0845	0.3100	0.3100	0.3100	0.3100	4	95
6	65	0.0519	0.4900	0.4900	0.4900	0.4900	6	75
8	50	0.0373	0.7800	0.7800	0.7800	0.7800	8	55
10	35	0.0184	1.2000	1.2000	1.2000	1.2000	10	40
12	25	0.0117	2.0000	2.0000	2.0000	2.0000	12	30
14	20	0.0087	3.1000	3.1000	3.1000	3.1000	14	25
16		0.0097					16	18
18		0.0062					18	14
250	255	0.4026	0.0520	0.0570	0.0540	0.0570	250	290
300	285	0.4669	0.0440	0.0490	0.0459	0.0490	300	320
350	310	0.5387	0.0500	0.0380	0.0430	0.0500	350	350
400	335	0.5931	0.0330	0.0380	0.0350	0.0380	400	380
500	400	0.7163	0.0270	0.0320	0.0290	0.0320	500	430
600	420	0.8791	0.0230	0.0280	0.0250	0.0280	600	475
700	460	1.0011	0.0230	0.0280	0.0250	0.0280	700	520
750	475	1.0623	0.0190	0.0240	0.0210	0.0240	750	535
800	490	1.1234	0.0190	0.0240	0.0210	0.0240	800	555
900	520	1.2449	0.0190	0.0240	0.0210	0.0240	900	585
1000	545	1.3623	0.0150	0.0190	0.0180	0.0190	1000	615
1250	590	1.9532	NO	NO	NO		1250	665
1500	635	NO	NO	NO	NO		1500	705
1750	650	2.5930	NO	NO	NO		1750	735
2000	665	2.9013	NO	NO	NO		2000	750
1/0	150	0.1893	0.1286	0.1380	0.1290	0.1300	1/0	170
2/0	175	0.2265	0.1090	0.1000	0.1000	0.1000	2/0	195
3/0	200	0.2715	0.0770	0.6820	0.0790	0.0820	3/0	225
4/0	230	0.3278	0.0620	0.6670	0.0630	0.0670	4/0	260

FIG. 14

1310

TABLE 250-66 NEC 1999

AMPS	AWG	GND WIRE (CU)	GND WIRE (AL)
110	1	6	4
95	2	8	6
85	3	8	6
70	4	8	6
55	6	8	6
40	8	8	6
30	10	8	6
20	12	8	6
20	14	8	6
	16	8	6
	18	8	6
255	250	2	1/0
285	300	2	1/0
310	350	2	1/0
335	400	1/0	3/0
400	500	1/0	3/0
420	600	1/0	3/0
460	700	2/0	4/0
475	750	2/0	4/0
490	800	2/0	4/0
520	900	2/0	4/0
545	1000	2/0	4/0
590	1250	3/0	250
635	1500	3/0	250
650	1750	3/0	250
665	2000	3/0	250
150	1/0	6	4
175	2/0	4	2
200	3/0	4	2
230	4/0	2	1/0

TABLE 250-122 (NEC 1999)

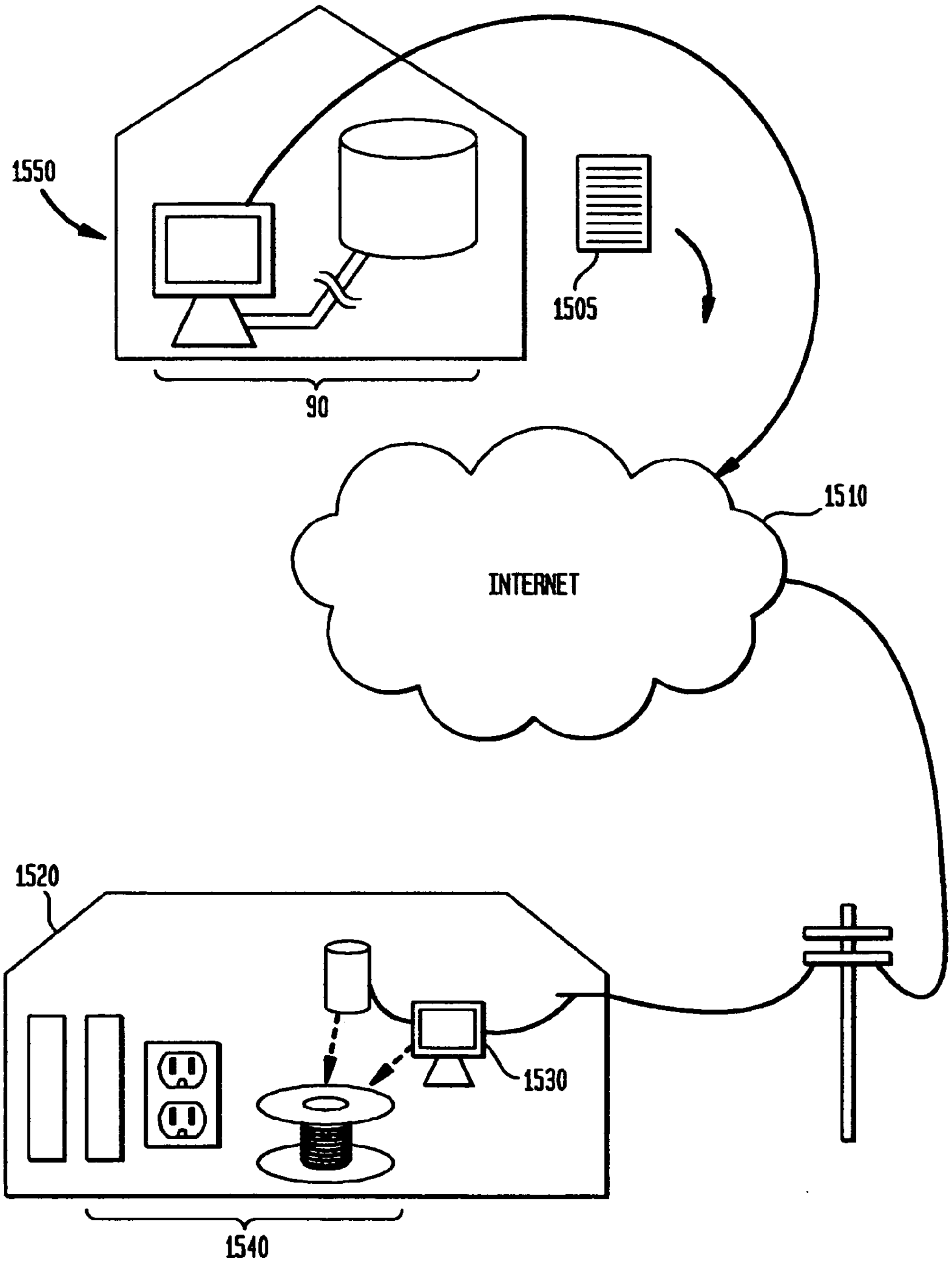
BREAKER	CU AWG	AL AWG
15	14	12
20	12	10
25	10	8
30	10	8
35	10	8
40	10	8
45	10	8
50	10	8
60	10	8
70	8	6
80	8	6
90	8	6
100	8	6
110	6	4
125	6	4
150	6	4
175	6	4
200	6	4
225	4	2
250	4	2
300	4	2
350	4	2
400	3	1
500	2	1/0
600	1	2/0
700	1	3/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	800
5000	700	1200
6000	800	1200

FIG. 15

1410

CONDUITS 1/40% OF AREA	TRADE SIZE	35% OF AREA	
0.0989	6	10.106	28.875
0.1429	5	7.000	20.00
0.2245	4	4.454	12.725
0.2886	3 1/2	3.465	9.9
0.3874	3	2.581	7.375
0.5952	2 1/2	1.680	4.8
0.8529	2	1.173	3.35
1.3937	1 1/2	0.718	2.05
1.9048	1 1/4	0.525	1.5
3.3613	1	0.298	0.85
5.4422	3/4	0.184	0.525
9.5238	3/4	0.105	0.3

FIG. 16



METHOD AND APPARATUS FOR AUTOMATING ELECTRICAL ENGINEERING CALCULATIONS

RELATED APPLICATIONS

This patent application is related to and claims priority from U.S. Provisional Application No. 60/380,317, filed Oct. 25, 2001, the contents of which are incorporated herein by reference in their entirety.

GOVERNMENT SPONSORSHIP

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BACKGROUND

Numerous software-based electrical power design systems are known for designing and simulating electrical power distribution network systems. In particular, software has been developed that models and assists with the design of large electrical power distribution facilities, i.e. facilities that distribute power on the power grids for regional areas of electrical power distribution. Such software may include simulation and design functions that assist in determining short circuit problems, load flows, transient stabilities, harmonics, arcing, power station management and other aspects of a large electrical power distribution system. Such software is typically data-intensive in that the user must have an intimate working knowledge and engineering expertise associated with the design and modeling of electrical power distribution systems to use the software. Operation of this software typically involves the user's entry of a significant body of data related to the intended system upon which the software assists in determining the system's design criteria. For example, design criteria for electrical power distribution network systems may include transformer sizes, transmission line wire sizes, transmission line phases and loads sizes, load flows, e.g. unbalanced load flows and voltage drop calculations, short circuit determinations, e.g. transient short circuit currents, interrupting duty calculations, and motor accelerations. Such detailed input is required to provide plots and graphical displays of power flows, and transient stability for the design and modeling of the electrical power distribution network system. Thus, due to the complex nature of large electrical power distribution network systems, the calculations performed by existing software are not typically automated. However, in certain aspects, the software may allow the designer to quickly identify problems and shortcomings of the intended electrical design based on the output from the software in combination with the electrical engineer's knowledge.

Other electrical system design software has been developed that provides a graphical means to lay out and model the performance of an electrical system. In particular, existing software provides assistance with the design of electrical systems within either power distribution environments associated with large electrical power plants or within buildings wherein the user will specify electrical requirement needs to be met and the software will provide related design criteria. Specifically, data related to the feeder circuits for a building or an electrical power plant may be provided to these software modules so that the engineer may manually determine the appropriate electrical characteristics of distribution panel boards (hereinafter all panel boards are referred to simply as "panels") complying with the design intentions of electrical building system. This software may include modeling features that enable the designer to graphically lay out the electrical panel board and its associated electrical loads according to standard electrical diagramming symbol formats, for example, for inclusion on a schematic. Such software may also provide libraries of components for use in the generation and creation of these electrical diagrams. From the electrical system schematics and layouts created with this software, electrical system modeling and analyses may be performed once all the required electrical system components and performance characteristics are determined and provided by the engineer. Such required data may include power flow and voltage drop calculations, fault analysis options, demand load analysis, feeder and transformer sizing calculations, motor starting calculations, and other high-level electrical design criteria. Thus these software modules are specifically programmed to address the schematic layout needs, the generation of reports and the analysis and resulting performance of new or existing, pre-designed, electrical power distribution systems.

Still other electrical design and analysis software provides a more fundamental modeling and reporting output regarding electrical power distribution systems within a building. This software provides layout, reporting and analysis of a lower-level electrical circuit design, for example at the electrical panel distribution level and building circuit level. Such software to date, however, has been limited in that it has not provided a designer of such power distribution centers with a bottom-up approach to the specification and design of such electrical power distribution systems.

Thus the need exists for electrical engineering design software that automates the design of an electrical power distribution system on a circuit-by-circuit, bottom-up basis, while also ensuring that the resulting system is in compliance with electrical codes. None of the existing software for electrical system design allow the users of such software to input individual circuit data from which information and design criteria related to those circuits is automatically created and upon which the higher level electrical power distribution system information may be automatically generated. For example, none of the existing software is capable of taking user-input branch circuit information and automatically creating distribution panel board information there from. Further, the software should have the capability to automatically recalculate all design information according to particular design criteria and/or electrical codes, particularly when the branch circuit information is modified dynamically. Finally, all the above calculations should involve information related to the design specification and selection of branch circuit components such as branch circuit panel board sizes, circuit breaker sizes and wiring specifications as well as and including distribution panel board information related thereto.

SUMMARY OF THE INVENTION

According to a preferred embodiment of the invention, a general-purpose computer-based system for designing an electrical power distribution system is provided having: a database having standards data associated with an electrical building standard; and a circuit design module for accepting power requirements for a plurality of branch circuits, each of the plurality of branch circuits having a set of branch circuit variables that defines a design for each of the branch circuits, the circuit design module determining branch circuit values for each of the branch circuit variables according to the standards data. According to further aspects of the invention, the power requirements include a load type, a kVA load, a voltage and a phase value for each of the branch circuits. In another aspect, the circuit design module automatically determines all of the branch circuit values. In still another aspect, the set of branch circuit variables includes at least one of each of: a branch circuit breaker size (TRIP), a branch circuit conductor size (AWG), a number of branch circuit conductors, a branch circuit ground conductor size (GND), a maximum branch circuit length (FT), and a branch circuit conduit size (IN). In further aspects of the invention, the electrical building standard is the National Electrical Code and the electrical building standard is the National Electrical Code and the standards data includes local variations to the National Electrical Code.

Another embodiment of the invention includes a panel design module that accepts the plurality of circuit designs from the circuit design module to determine a design of at least one panel, the panel having a set of panel variables that defines the design of the panel, the panel design module determining panel values for each of the panel variables according to the standards data. In variations of this aspect, the panel values are also determined according to the power requirements and the panel design module automatically calculates a connected load (kVA) based on the power requirements and determines a demand load for the panel design based on the standards data, the panel values being further determined by the demand load. In yet further refinements of this invention, the standards data used to determine the demand load is a load factor automatically determined by the panel design module from the electrical building standard; or the set of panel variables includes at least one of each of: a total panel capacity, a panel mains rating, a feeder conductor size, a number of feeder conductors, a maximum feeder length, a feeder ground conductor size, and a feeder conduit size. In still further aspects of the invention, the panel design module automatically determines all of the panel values and a set of user-specified panel variables is used in the design of the panel and the set of user-specified panel variables including at least one of: a panel voltage value, a panel mounting type, a panel interrupting ratings, an AIC rating, a number of phases, a temperature correction factor, a bus bar type, a TVSS device, a NEMA designation, an isolated ground, a neutral feeder conductor rating, and a number of poles.

In still another embodiment of the invention, the system includes a distribution panel design module that accepts the design of the panel from the panel design module to determine a design of at least one distribution panel, the distribution panel having a set of distribution panel variables that defines the design of the distribution panel, the distribution panel design module determining distribution panel values for each of the distribution panel variables according to the standards data. In additional aspects, the distribution panel values are also determined according to the power requirements and the distribution panel variables includes at least one of each of: a total distribution panel capacity, a distribution panel mains rating, a main feeder conductor size (AWG), a number of main feeder conductors, a maximum main feeder length, a main feeder ground conductor size, and a main feeder conduit size. In yet other aspects, the distribution panel design module automatically determines all of the distribution panel values or a set of user-specified distribution panel variables is used in the design the distribution panel, the set of user-specified distribution panel variables including at least one of: a distribution panel mounting type, a distribution panel interrupting ratings, an AIC rating, a number of phases, a temperature correction factor, a bus bar type, a TVSS device, a NEMA designation, an isolated ground, a neutral feeder conductor rating, a number of poles. In additional aspects the distribution panel design module automatically calculates a connected load based on the power requirements and determines a demand load for the distribution panel design based on the standard data, the distribution panel values for the distribution panel variables being further determined by the demand load. Still further, the standards data used to determine the demand load is a load factor automatically determined by the distribution panel design module from the electrical building standard. In a final aspect of this embodiment, a step-down transformer size for the load is automatically determined by the distribution panel module using the demand load.

According to another particularly preferred embodiment, the general-purpose computer-based system for designing an electrical power distribution system includes a database having standards data associated with an electrical building standard; a panel design module for accepting a phase and a voltage, the panel having a set of panel variables that defines the design of the panel; a circuit design module for accepting a kVA load, and a number of poles for each of a plurality of branch circuits, each branch circuit having a set of branch circuit variables that defines a design for the branch circuit; and wherein the circuit design module automatically determines branch circuit values for the branch circuit variables using the plurality of kVA loads, number of poles, and voltages, according to the standards data; and wherein and the panel design module automatically determines panel values for the panel variables using the plurality of branch circuit designs and the plurality of kVA loads, phases, and voltages, according to the standards data.

According to particularly preferred aspects of this embodiment, the electrical building standard is the National Electrical Code; and the set of branch circuit variables includes at least one of: a branch circuit breaker size, a branch circuit conductor size, a number of branch circuit conductors, a branch circuit ground conductor size, a maximum branch circuit length, and a branch circuit conduit size, and the set of panel variables includes at least one of: a total panel capacity, a panel mains rating, a feeder conductor size, a number of feeder conductors, a maximum feeder length, a feeder ground conductor size, and a feeder conduit size. In still further aspects, the panel design module automatically calculates a connected load based on the power requirements and determines a demand load for the panel design based on the plurality of kVA loads, the panel values being further determined by the demand load.

According to a particularly preferred method of the invention, a general-purpose computer-implemented method for designing an electrical power distribution system, includes the steps of defining a set of branch circuit variables that specify a branch circuit design according to an electrical building standard; and repetitively, inputting power requirements for a branch circuit; calculating branch circuit values for each of the branch circuit variables; comparing the calculated branch circuit values to a database of standard branch circuit data values associated with the electrical building standard; selecting automatically one of the standard branch circuit data values for each of the branch circuit values; and outputting the set of selected branch circuit values so as to specify the branch circuit design.

In further aspects of the preferred method, the branch circuit variables include: a branch circuit breaker size, a branch circuit conductor size, a number of branch circuit conductors, a branch circuit ground conductor size, a maximum branch circuit length, and a branch circuit conduit size; or the step of inputting power requirements includes inputting a kVA load, a voltage and a phase value for the branch circuit. In other refinements of the method, all of the repetitively performed steps are performed on a single branch circuit. In addition, the method may include displaying analysis notes, the analysis notes including at least one of an error message, a warning message, or a design suggestion associated with the branch circuit design or overriding one of the selected branch circuit values to specify the branch circuit design.

In another particularly preferred embodiment, the method includes defining a set of panel variables that specify a panel design according to an electrical building standard; determining a connected load from the input power requirement for the branch circuits; calculating panel values for each panel variable; comparing the calculated panel values to a database of standard panel data values associated with the electrical building standard; selecting automatically one of the standard panel data values for each of the panel values; and outputting the set of selected panel values so as to specify the panel design. In particular aspects of this embodiment the panel variables include: a total panel capacity, a panel mains rating, a feeder conductor size, a number of feeder conductors, a maximum feeder length, a feeder ground conductor size, and a feeder conduit size. In other aspects, all of the steps for specifying the panel design are performed concurrently with the steps for specifying the branch circuit designs; or all of the steps are repeated to so as to specify a plurality of panel designs. In still other variations, the method includes displaying analysis notes, the analysis notes including at least one of an error message, a warning message, or a design suggestion associated with the panel design, or overriding one of the selected panel values to specify the panel design, or wherein the step of calculating the panel values further includes determining a load factor or each of the branch circuits; and wherein the step of calculating the panel values includes using the load factor to calculate the panel values.

In still another particularly preferred embodiment, a general-purpose computer-implemented method for designing an electrical power distribution system, includes the steps of defining a set of branch circuit variables that specify a branch circuit design according to an electrical building standard; defining a set of panel variables that specify a panel design according to an electrical building standard; inputting power requirements for a branch circuit; determining a connected load from the input power requirement for the branch circuits; calculating branch circuit values and panel values for each of the branch circuit variables and panel variables respectively; comparing the calculated branch circuit values and panel values to a database of standard branch circuit data values and standard panel data values associated with the electrical building standard; selecting automatically one of the standard branch circuit data values for each of the branch circuit values and one of the standard panel data values for each of the panel values; and outputting the set of selected branch circuit standard values and the selected standard panel values so as to specify the branch circuit design and the panel design respectively.

In further aspects of the above recited method, all of the steps are repetitively performed to design the electrical power distribution system, or the method further includes inputting updated power requirements and wherein all of the steps are repetitively performed so as to output updated selected branch circuit values and updated selected panel values that specify the circuit designs and the panel design respectively. In still further aspects, the method includes generating an inventory of electrical components for the electrical power distribution system based on the selected branch circuit values and the selected panel values, or generating a cost estimate for the inventory from a pricing database associated with an inventory supplier. In some final aspects, the method may include reevaluating the power requirements within an optimization module, and repetitively performing all of the steps to optimize the selected branch circuit values and the selected panel values based with respect to the cost estimate; or generating a report of electrical components for the electrical power distribution system based on the selected branch circuit values and the selected panel values; or importing the report into an electrical component layout program.

In another particularly preferred embodiment, a computer-readable media for storing instructions for designing an electrical power distribution system, includes instructions for defining a set of branch circuit variables that specify a branch circuit design according to an electrical building standard; and repetitively: inputting power requirements for a branch circuit; calculating branch circuit values for each of the branch circuit variables; comparing the calculated branch circuit values to a database of standard branch circuit data values associated with the electrical building standard; selecting automatically one of the standard branch circuit data values for each of the branch circuit values; and outputting the set of selected branch circuit values so as to specify the branch circuit design.

In various aspects, the above method includes instructions for: defining a set of panel variables that specify a panel design according to an electrical building standard; determining a connected load from the input power requirement for the branch circuits; calculating panel values for each panel variable; comparing the calculated panel values to a database of standard panel data values associated with the electrical building standard; selecting automatically one of the standard panel data values for each of the panel values; and outputting the set of selected panel values so as to specify the panel design.

In further embodiments of the invention, a computer-readable media is provided for storing instructions for designing an electrical power distribution system, including instructions for: defining a set of branch circuit variables that specify a branch circuit design according to an electrical building standard; defining a set of panel variables that specify a panel design according to an electrical building standard; inputting power requirements for a branch circuit; determining a connected load from the input power requirement for the branch circuits; calculating branch circuit values and panel values for each of the branch circuit variables and panel variables respectively; comparing the calculated branch circuit values and panel values to a database of standard branch circuit data values and standard panel data values associated with the electrical building standard; selecting automatically one of the standard branch circuit data values for each of the branch circuit values and one of the standard panel data values for each of the panel values; and outputting the set of selected branch circuit standard values and the selected standard panel values so as to specify the branch circuit design and the panel design respectively.

In a final embodiment of the invention, a method of placing an order for an inventory of electrical building components with an inventory supplier is provided and includes: generating an inventory of electrical components for an electrical power distribution system based on a set of branch circuit values and a set of panel values, the branch circuit values and the panel values specifying a branch circuit design and a panel design respectively, the branch circuit values and the panel values selected according to an electrical building standard; generating a cost estimate for the inventory from a pricing database associated with the inventory supplier; and transmitting the inventory of electrical components to the inventory supplier for purchase. In particular aspects of this embodiment, the step of transmitting includes the step of transmitting a facsimile of the inventory to the inventory supplier over a telephone line; or the step of transmitting includes the step of transmitting the inventory to the inventory supplier in digital format over a web-based interface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an overall block diagram of the software modules and database(s) according to one embodiment of the present invention.

FIG. **2** is a power one line diagram of an electrical power distribution system according to one embodiment of the present invention.

FIG. **3** is a partial power plan for one physical portion of a building served with electrical power from the electrical power distribution system provided in FIG. **2**.

FIG. **4** is a screen shot of the branch circuit panel board module according to one embodiment of the present invention.

FIG. **5** shows a subset of the data within the database of the software system according to one embodiment of the present invention.

FIG. **6** is another screen shot of another branch circuit panel board module according to one embodiment of the present invention.

FIG. **7** is a screen shot of the distribution panel board module according to one embodiment of the present invention.

FIG. **8** is a screen shot of a building equipment module according to one embodiment of the present invention.

FIG. **9** is another screen shot of another building equipment module according to one embodiment of the present invention.

FIG. **10** is a screen shot of the main distribution panel board module according to one embodiment of the present invention.

FIGS. **11-15** show various other subsets of the data within the database of the software system according to one embodiment of the present invention.

FIG. **16** is a general diagram depicting the electronic transmission of electrical inventory requirements to a component supplier according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is a computer software package that is capable of automating the design and specification of electrical power distribution systems within one or more buildings or other structures. The method and apparatus of the present invention may be embodied in numerous software formats such as a Microsoft Excel spreadsheet or other data calculation tools, although persons of skill in the art would recognize the interchangeability of different coding methods by which to achieve the objects of this invention. Further, the software of the present invention may be coded in software in a number of different formats, including, for example, the spreadsheet described as the preferred embodiment herein, or as coded software modules programmed in C or HTML, for example. In one particular embodiment, an Excel spreadsheet is used to automate the electrical circuit calculations that determine the resultant electrical equipment within a building such that any changes to the lower-level electrical circuit specifications force a recalculation of all electrical specifications, including possibly a re-specification of necessary electrical equipment. The resultant changes are then automatically distributed throughout the remainder of the design of the electrical building characteristics and are reflected by changes in the overall electrical system design. One exemplary software package embodying the present invention is sold under the name Power Calc PaK by Electric PowerCalc, Inc. of Delray Beach, Fla.

Referring to FIG. **1**, the electrical power distribution system design software **90** of the present invention includes a branch circuit panel board module **10**, a building equipment module **20**, a distribution panel module **30** and a main distribution panel **40**. In one particularly preferred embodiment, each of these modules is displayed on separate spreadsheets within the program. With this functional arrangement, data input may be provided within a software module dedicated to the specification of one portion of an electrical circuit, the branch circuit panel board module **10** for example, and resultant changes calculated by that module may be passed to the other design modules for reinterpretation and re-specification of the overall electrical design. Also included within the software of the present invention are an overall project module, eNODE **50**, in which the user may enter overall project data related to the design of the electrical power distribution system. Finally, the software system of FIG. **1** includes an extensive database **60** of electrical engineering design information that is supplied to the software modules for making calculations and specifying electrical components. Database **60** may include, among other things, engineering equations **2** and design data **4** related to the design of the electrical power distribution system, tables of electrical standards data **1**, e.g. the National Electrical Code (NEC) standards data, and certain standard features **3** of the components of the electrical power distribution system, e.g. circuit panel board mounting type. Database **60** may also optionally include an inventory **5** of electrical components that may used to specify particular electrical parts and components to be used in the design of the electrical power distribution system.

In operation, data is entered by the user into each of the software modules such that a minimum set of electrical requirements needed to specify and define the electrical characteristics and elements of each module are provided by the user. This user-entered data is combined with and relies upon the engineering equations, design data and standards data contained within database **60** to calculate the remaining electrical power distribution system variables so as to fully specify a complete system. In this fashion, the design of the electrical power distribution system is specified in a bottom-up fashion. For example, users may first enter data into the branch circuit panel board module **10**. From that data, related information is pulled from database **60**, such as NEC data and engineering equations related to the specification of particulars operation of the branch circuit panel board. Then, the user-entered data and resultant, calculated data is automatically fed from the branch circuit panel board module **10** to the distribution panel board module **30**. Thus, in an automated, sequential fashion, each of the software modules of the software of the present invention are functionally interconnected and interrelated so as to provide an "upward" data flow in specifying the design of the system. Likewise, as higher-level modules are defined by the data entered into lower level modules, certain design characteristics and criteria may also be fed back down to the lower level modules in further specifying the design of the electrical power distribution system. For example, data entered into the branch circuit panel board module **10** may be calculated within that module, fed up to the distribution panel module **30**, at which point, additional calculations may be generated using the standards data and the equations within database **60**, and from which, supplemental data may be transferred back to the branch circuit panel board module **10** from the distribution panel module **30** as shown by path **70**. In this fashion, data flows throughout the software of the present invention so that user-specified input data at the lower level design modules, such as the building equipment module **20** and branch circuit panel board module **10**, are transmitted and bubbled upwards while corresponding data is transmitted and bubbled downward so as to define and completely specify an electrical power distribution system for a building.

Referring to FIG. **2**, the electrical power distribution system **100** that is automatically designed by the software of the present invention is shown. A plurality of branch circuit panels **110-112** are provided as shown in FIG. **2**. These branch circuit panels boards may be the type located within a building's internal electrical closets, e.g. along walls, within a house garage, or within an electrical room in a commercial building. Branch circuit panel boards **110-112** provide power to individual branch circuits **115** to which they are coupled. Branch circuits **115** may consist of individual, end-use circuits, for example wall outlets within a building, as well as other varied electrical consumption circuits, e.g. lighting, dryers, and small air conditioners. Also shown on FIG. **2**, larger electrical equipment, building equipment **120** and **130**, and **173** and **175** is also provided for within the electrical power distribution system of the building. Building equipment **120** may include, for example, a large, air handling unit **120** and exhaust fan **130** supplied by the distribution panel board **150** and condenser unit **122** supplied by distribution panel board **150** (not shown in FIG. **3**). The building equipment is typically fed through local circuit protection devices **134** which provide an electrical disconnect feature for the building equipment under electrical failure conditions.

Downstream electrical equipment and circuits, such as branch circuit panel board **110** and building equipment **120** through **130** are then fed to distribution panel board **150** via a plurality of feeder circuits **140-147**. Distribution panel board **150** provides power to the branch panels and building equipment from the main distribution panel boards **180** (if provided or needed) further up the electrical power distribution system within the building. Distribution panel board **150** may also include feeder circuit protection **152-158** for each feeder circuit **140**, for example, with the overcurrent protection devices (circuit breakers) within distribution panel board **150**. Distribution panel board circuit breakers **152** through **158** may include various types of circuit breakers specifically tailored to the needs of the coupled branch circuit. For example, circuit breaker **155** shown in FIG. **2** is a 225 Amp, 3-pole circuit breaker provided as the overcurrent protection device for associated branch circuit panel board **112** along feeder **141**. Likewise, circuit breaker **158** is a 20 Amp, 2-pole overcurrent protection breaker associated with building equipment **130** fed through feeder **147**. In a similar fashion, each of feeder circuits **140** may be provided with certain electrical overcurrent protection elements within electrical distribution panel board **150**.

In operation, distribution panel board **150** provides a 480-volt feed capacity to the plurality of downstream branch circuit panel boards **110-112** and building equipment **120-130**. Often, downstream branch circuit panel board circuits and electrical building equipment operate at voltages lower than those provided by the distribution panel board. In such instances, step down transformers **160**, **162** may be used within the feeder circuits **142/143** or sub-feeder circuits **148/149** to step down the voltage so as to accommodate the lower voltage. For example, branch feeder circuit **142** is shown as distributing power from distribution panel board **150** at 480 volts, which is stepped down to a 208-volt feeder **143** by step down transformer **162** to supply branch panel board **111** with the required voltage.

Also optionally included within distribution panel board **150** is transient voltage surge suppression system device **165**. Transient voltage surge suppression system device **165** monitors and regulates the voltage levels within the distribution panel board **150** so as to suppress and control voltage spikes that are introduced within that portion of the electrical power distribution system by virtue of the operation of the branch circuits and building equipment. Likewise, transient voltage surge suppression system device **165** monitors the voltage arriving from up-stream electrical feeder circuits **170** so as to suppress downstream traveling voltage transients and insure the proper operation of distribution panel board **150**.

At one of the highest levels of the electrical power distribution system upon which the software of the present invention operates is main distribution panel board **180**. Typically, main distribution panel **180** provides voltage and current to a plurality of distribution panel boards **150** through feeder circuit **170**. Similar to distribution panel board **150**, main distribution panel board **180** may also include downstream electrical devices such as building equipment and other distribution panel boards for which the main distribution panel board supplies electrical power. For example, large building equipment such as an irrigation pump **175** or an elevator **173** may be connected through local circuit protection **187** and **184** respectively to main distribution panel board **180**. Again, as with distribution panel **150**, main distribution panel board **180** may contain overcurrent protection devices, or circuit breakers, that protect against electrical failures within the feeder circuit, the connections to the feeder circuit and the building equipment itself. Circuit breakers **182**, **185**, **188**, **189**, shown in FIG. **2**, are examples of such circuit breakers. Main distribution panel board **180** is provided with electrical power from upstream service transformer **190** via feeder circuit **192** and through overcurrent protection device **194**.

The electrical power distribution system within a building, as shown in FIG. **2**, is typically provided power from the outside by a commercial power company. This commercial-grade power is delivered by primary feeder **196**. Primary feeder **196** provides electrical power through service transformer **190** to main distribution panel board **180** within the building. In operation, the commercial power company provides electrical power at a significantly higher voltage than is required for the operation of branch circuits **115** within a building. For example, the outside power company may provide a 15-kV power feed which is stepped down by service transformer **190** to a 480 Volt feed to main distribution panel board **180**. From main distribution panel board **180**, the electrical power is further distributed to distribution panel board **150** through feeder circuits **170**. From distribution panels board **150**, individual branch circuit panels **110-112** and building equipment **120-130** may be fed either directly with 480 Volts or indirectly by further stepping down the voltage to 208 volts or 120 volts, for example through step down transformers **160** and **162**. Step down transformers may be used in this way throughout the electrical power distribution system of FIG. **2** so as to provide the required voltage at any point in the system. The power distribution system of FIG. **2** is, in general, well known and typical of the electrical power distribution systems found within buildings.

FIG. **3** provides the internal, electrical layout schematics of a building that is provided electrical power by the electrical power distribution system shown in FIG. **2**. Within building **200** are numerous branch circuits and building equipment for which electrical power is needed. In particular, branch circuit panel board **111** is shown with an electrical closet in the top left portion of building **200**. Branch circuit panel board **111** is the same as that shown on FIG. **2**. As an example, branch circuit panel board **111** feeds electrical power to stove **117**, also shown on the left side of building **200** and referred to in FIG. **2**. Among the plurality of branch circuits fed by branch circuit panel board **111** are various electrical circuits within building **200**. For example, these branch circuits may supply power through electrical outlets on the walls, on the building floor, within kitchen and dorm areas, and for any other electrical needs within the building. One particular branch circuit **215**, FIGS. **2** and **3**, serves electrical outlets on the floor of a multi-purpose room and are supplied electrical power by branch circuit panel board **111**.

From a circuit design perspective, each of the branch circuits within building **200** of FIG. **3** includes a subset of specific and necessary design information related to that branch circuit. According to the software of the present invention, the electrical engineer/system designer begins the overall design of the electrical power distribution system of FIG. **2** by supplying this minimum subset of information for each of the branch circuits to be designed, thus beginning the design of overall electrical power distribution system at the "lowest level" branch circuits shown in FIG. **3**. As each of the individual branch circuits' parameters are specified, the software of the present invention calculates and defines the electrical system requirements and specifies the electrical components required to hierarchically construct the associated branch circuit panel boards, distribution panel boards and main distribution panel boards. This is achieved by providing either or both of the user-specified values and subsequently calculated electrical characteristics from one level of the electrical power distribution system to the next for use in calculating its own variables. In this fashion, a bottom-up approach to the electrical design of the system is achieved by the software of the present invention. In one particularly advantageous aspect of the invention, individual changes made by the electrical engineer within a particular branch circuit cause the software to automatically re-calculate the variables needed by the upstream portions of the electrical power distribution system including changes to the branch circuit characteristics, the branch circuit panel boards and other upstream electrical distribution equipment. In a likewise fashion, the specification by the electrical designer of branch circuit panel boards **110**, **111** and **112** may also be modified in a real-time basis, and the software of the present invention automatically re-calculates the electrical design parameters necessary to specify and define the upstream distribution panel and main distribution panel boards. Furthermore, the addition of electrical equipment after the "finalization" of a design does not necessitate an entire re-calculation of the loads and tolerances of the overall electrical distribution system. For example, adding a piece of building equipment will automatically cause the software of the present invention to re-calculate and modify as necessary the design and specifications of the electrical power distribution system and will likewise automatically flag errors that may result from the addition of such equipment.

Central to the operation of the software of present invention is the specification and definition of the load types for each of the branch circuits that are supplied by electrical power by the branch circuit panel board. By defining and associating a particular load type with each physical branch circuit, the software of the present invention defines an associated set of branch circuit variables that completely specify the electrical design of that particular branch circuit. For example, as shown in FIG. **3**, branch circuit **215** consists of four, floor-based, electrical receptacles that are connected to branch circuit panel board **111** within building **200**. For this particular receptacle cluster, the following branch circuit variables are needed to define that branch circuit: overcurrent circuit protection device size (i.e. circuit breaker size), conductor size, conduit size, ground conductor size, and voltage drop. Certain branch circuit variables are calculated automatically by the software of the present invention according to the load input for a particular branch circuit. For example, with respect to the branch circuit **215** of FIG. **3**, the software of the present invention, following the user input of the maximum possible potential loads for the four electrical outlets, will calculate a maximum, permissible voltage drop for that branch circuit based on the engineering equations **2** and the design data **4** portions of database **60** (FIG. **1**). From the total load calculated for that branch circuit and the permissible voltage drop, the software within the branch circuit panel board module will consult database **60** (FIG. **1**) and select appropriately specified physical components for constructing the electrical power distribution system according to building standards data **1** within database **60**. In particular and with respect to the four floor-based electrical outlets of branch circuit **215**, the design data **4** portion of the database **60** is consulted to provide a maximum permissible voltage drop for the load type specified by the user (selected from a group provided by the software). The engineering equations **2** of database **60** are then used to calculate currents based on the user input information regarding the total load of the four outlets. This results in a calculation of the following branch circuit variables: a permissible length of a conductor or wire of particular size that may be used to electrically connect the four outlets, the actual ground conductor size used within that electrical circuit, the conduit size used to house the conductors and ground conductor, and the size of the overcurrent protection device (e.g. circuit breaker) needed within branch circuit panel board **111** to support that branch circuit load. In this fashion, the electrical circuit designer need only input end-use electrical requirements for a particular room, such as the number of electrical outlets, the specification of the building equipment, and other such load types, from which the software will automatically calculate the physical components needed to produce that circuit according to and in compliance with particular building codes, such as the NEC.

The physical presentation of the software according to the present invention will now be described with respect to FIGS. **4** through **10** which illustrate one particular embodiment of the present invention.

Referring to FIG. **4**, an exemplary spreadsheet **310** illustrating one embodiment of the branch circuit panel board module **10** (FIG. **1**) is shown. From a user-operability standpoint, the spreadsheet of FIG. **4** operates as any other spreadsheet in that it is programmed to either directly accept a user's data input within to each of the required fields or is programmed to provide a drop-down box from which the user selects a particular value from one of the preprogrammed, pre-specified values. Equations and databases within the spreadsheet are also programmed and provided as part of the module so that other output cells in the spreadsheet automatically provide results based on the user input provided above.

In the example of FIG. **4**, the branch circuit panel board spreadsheet embodies the characteristic electrical information for branch circuit panel board **111**, identified as PNL LA in FIG. **2** and branch circuit panel label LA within panel board designation field **315**. In operation, the user of the software activates the software to create an individual spreadsheet similar to that shown in FIG. **4** for the design of each of the branch circuit panel boards **110-112** within the electrical power distribution system. Certain fields within the branch circuit panel board module are populated by the user in advance of the specifying individual branch circuits so as to provide overall characteristics of the branch circuit panel board. These fields are indicated by the single line shaded areas within FIG. **4**. Subsequently, individual branch circuit data are provided by the user so as to specify electrical characteristics of each of the individual branch circuit panel board circuits that comprise that branch circuit panel board. These fields are indicated by the circled cell values within FIG. **4**. The operation of the spreadsheet with respect to the specification of overall panel characteristics will be discussed first.

In order to begin the specification of a particular branch circuit panel board, the user must first specify certain overall panel board information, or standard features, within spreadsheet header region **318**. In particular, the value for the panel board field **315**, shown as panel board LA in FIG. **4**, is provided by the user. Subsequently, the user specifies a panel board mounting method **320**, an interrupting ratings **322**, an amperage interrupting capacity (AIC) rating **324**, a branch circuit panel board phase **326**, a phase-to-phase voltage **328**, a mains rating type **332**, a temperature correction factor **334**, and a bus bar type **330**. In addition, the user may also specify the presence of a transient voltage surge suppression system device **336**, National Electric Manufacture Association designation (NEMA) **338**, the presence of an isolated ground **340** and a neutral conductor rating **342**. FIG. **5** illustrates one embodiment of this standard features data **3** within database **60**. The data provided in FIG. **5** show exemplary values for each of the above-mentioned user-selected input data which may be programmed in the branch circuit panel board module as selectable, drop-down boxes within each one of the cells shown in the spreadsheet of FIG. **4**. Following these initial user selections, other fields within header region **318** are automatically populated by the spreadsheet according to engineering equations **2** and design data **4** in combination with the previously described, user-specified input. Specifically, phase-to-neutral calculation **344** is made based upon the phase-to-phase voltage selected at **328**. Still other information within header region **318** is calculated automatically by the spreadsheet, but these values are dependent upon the information entered by the user within spreadsheet center portion **350**.

Prior to the entry of branch circuit information, the different branch circuit load types must be defined by the software of the present invention. Central to the specification of each branch circuit, the spreadsheet of FIG. **4** provides the user with pre-defined load types as shown in spreadsheet analysis section **380**. Each of the individual load types is identified by a single-letter designation in the macro field (MC) column **385** for which a description of the load type is provided in the description column **383**. Analysis section **380** also provides additional load-related fields such as the load kVA **384**, a default-demand factor, **386**, the demand kVA **388** and analysis notes section **390**. Several of the additional fields in the analysis section **380** are automatically populated with calculated values dependent upon spreadsheet data input by the user into center portion **350**. Other portions of the analysis section are pre-defined by the spreadsheet according to electrical standards data. For example, the default demand factor **386** is predefined, although this data may be overridden by the user in their specification to override the demand factor as shown in field **387**. Further, a section is provided within analysis section **380** for engineer analysis notes as shown in **390** which is automatically populated by the spreadsheet of FIG. **4** depending on the loads used within the specification of the branch circuit panel board. The details of these populated fields will follow a discussion of the center portion of spreadsheet **350**.

As provided in FIG. **4**, center region **350** of branch circuit panel board spreadsheet **310** is divided up and presented according to the actual physical layout of a branch circuit panel board used within the electrical power distribution system. In particular, the center region **350** of the spreadsheet of FIG. **4** is divided into three circuit panel board sections **400-404**. Center section **400** graphically represents the three bus bars used for power distribution within the branch circuit panel board. In the particular branch circuit panel board of FIG. **4** shows a three-phase panel board with three different buses each carrying a different phase (A, B, and C) of the three-phase branch circuit. The center region **350** of the branch circuit panel board spreadsheet is further divided into two column groups, a right column group **404** and a left column group **402**, with each row in the column groups graphically representing the actual circuit breaker connections to the load circuits within the branch circuit panel board. Left branch circuit panel board column group **402** identifies the odd number circuit breaker positions within the branch circuit panel board as identified by the circuit number identifiers shown in circuit number field **410**. Similarly, the right branch circuit panel board column group **404** identifies the even numbered circuit breaker positions within the branch circuit panel board as identified by circuit number field **414**. Thus, each line entry within center section **350** indicates an individual connection of a circuit breaker to one bus from the three phases within the central portion **400** of the branch circuit panel board. For example, branch circuit **1** in the left branch circuit panel board column group **402** enables a circuit breaker connection only to phase A of the center, three-pole bus structure. Likewise, branch circuits **3** and **5** in the left branch circuit panel board column group **402** only permit a circuit breaker to be connected to phases B and C respectively of center bus, three-pole bus structure. The branch circuits within right column group **404** of the branch circuit panel board function similarly. In this fashion, the layout of the spreadsheet mimics the actual, physical layout of the branch circuit panel board, thereby making it easier for installation personnel to correctly identify the proper circuit breakers and loads associated with a particular circuit breaker panel without the need for additional wiring diagrams or schematics that provide the same information as that contained on the branch panel spreadsheet.

Referring to center region **350** of the branch circuit panel board spreadsheet, the software user/electrical system designer specifies the characteristics of the desired branch circuits, by providing key data within the fields of center section **350**. By way of reference, certain user input data within branch circuit panel board spreadsheet **310** is indicated by circled values within the spreadsheet cells. Other, calculated values are similarly represented by values with triangles around them within the spreadsheet cells. In particular each branch circuit design may be completed by entering data within a single data line entry area, e.g. **351**, to define that particular branch circuit within that associated branch circuit panel board. As shown at entry **351**, corresponding to branch circuit **215** (LA-**14**) of FIG. **3**, the designer defines branch circuit **215** by adding the power requirements or kVA of electrical loads within that circuit and inputs that sum in corresponding kVA field **354**. In addition, the user specifies the load macro type for the circuit. The load macro type is defined as one of a pre-determined set of loads provided in macro field (MC) column **382** of the analysis section **380**. In the example of branch circuit **215** of FIG. **3**, the system designer selects macro type R for receptacle load and inputs that value into field **356** of line **351**. In addition, the system designer specifies the number of electrical poles within the branch circuit as shown in the P field **358** of branch circuit entry **351**. Once the necessary, user-defined fields are input, e.g. total kVA, load type, and the number of poles, the software of the present invention refers to the standards data **1**, engineering equations **2** and the design data **4** within database(s) **60** to automatically calculate and determine the physical characteristics of the electrical equipment needed to fully specify and construct branch circuit **215** of FIG. **3**.

As shown in FIG. **4**, several output values are provided by the software of the present invention based on the above-mentioned inputs for branch circuit entry **351**. The first calculated value is the circuit breaker trip value, shown in field **360** of branch circuit **351**. In the example of branch circuit **351**, the single pole, floor receptacle circuit having a 1.2 kVA load is determined to have a circuit breaker trip value of 20 Amps. Further, the spreadsheet automatically calculates and determines the following circuit characteristics using the engineering equations **2**, standards data **1** and design data **4** within database **60**: the wiring conductor size of #**12** (AWG) as shown in the AWG field **362**, the ground conductor size of 12 as shown in GND field **364**, the conduit size of ¾ in. as shown in C (IN) field **366**, the percentage voltage drop of 3% as shown in the %VD field **368** and the maximum run-length distance of 90 ft. for the branch circuit conductor to satisfy the percent voltage drop indicated as shown in the FT field **370**. In this fashion, a complete specification of a particular branch circuit is automatically provided by the spreadsheet of the present invention following the identification and input of a minimum set of input electrical data, i.e. load value, load type and number of poles, from which the desired electrical circuit variables are determined.

To complete the specification of the branch circuit panel board, the electrical system designer/spreadsheet user continues to input the minimum required data within center portion **350** for each of the plurality of branch circuits supported by that panel board. Following the input of the minimum set of data for each desired branch circuit, the remaining branch circuit variables are automatically calculated by the branch circuit panel board spreadsheet. As another example, the user may specify a branch circuit **117** for a stove **117** (FIG. **3**) by entering specific data in lines **352**-**354**. In the particular example of FIG. **4**, the user specifies the total 3.0 kVA load in the kVA field **354** for each of the three different phases (branch circuits) associated with the stove. Further, the three-pole nature of the stove circuit is input on branch circuit line **352** in the P field **342**, and the load type is identified as power load (P) in the macro field (MC) column **385**. As with branch circuit **351**, the branch circuit panel board module automatically calculates the circuit breaker trip value of 35 Amps with the wiring size of #**8** AWG, a ground conductor size of #**10** AWG, a conduit size of 1 in. and a percentage voltage-drop of 3%, resulting in a maximum run length of 92 feet.

After the user has input the necessary data for each branch circuit shown in center portion **350**, the software of the present invention provides a summation function and summarizes the information related to each of the different load types in analysis region **380**. Specifically, all of the loads and associated branch circuits of a particular load type are summed and reported within analysis region **380** to provide a total kVA load for each load type. In the example of FIG. **4**, lighting loads identified with macro code L in both macro field (MC) columns **382** show a total load of 9.0 kVA, which is a summation of all L-type loads within center region **350**.

Depending on the default demand factor which is pre-specified by the software according to electrical engineering constraints and standards data, e.g. electrical code requirements, a demand load or kVA is calculated by the software for the purpose of creating and calculating a total load for the branch circuit panel board. In the case of lighting loads L, which are permitted to have a 125% demand factor, the total demand of 11.3 kVA is provided by the software. After calculating all of the total demand kVAs, the spreadsheet/ branch circuit panel board module **10** of FIG. **1** sums the total demand of 58.1 kVA as shown at the bottom of analysis region **380** in demand kVA field **388**. Optionally, the software enables a user to override the predetermined demand factors by entering an override value in field **387**. Such an override would depend upon independently determined electrical design considerations which are often at the discretion of the user/electrical system designer responsible for designing a particular branch circuit panel board. Finally, the software of the present invention provides analysis notes **390** in analysis region **380** according to electrical engineering considerations associated with a particular load type. For example, if an inappropriate number of poles are selected for a particular branch circuit entry, then a note identifying the design error will automatically appear in the analysis notes section within field **390** associated with that particular load type. In alternative programming embodiments according to the present invention, the user may either be prohibited from or cautioned against further computations and advancement of the spreadsheet information until that error is rectified.

Once the total demand kVA is calculated within analysis section **380**, this data is used to populate the fields within footer section **430** for other reporting purposes. In particular, the total calculated demand of 58.1 kVA from line **420** field **388** is presented in field **432** and from which is calculated the 161.3 total amperes required by the branch circuit panel board as shown in field **434**. Also presented within footer section **430** are the total load (connected) of 56.7 kVA for the branch circuit panel board, as calculated in line **420** of field **384** and shown in footer section **436**. From the total potential connected load, the total potential 157.4 amperes needed for the branch circuit panel board are calculated by the software and presented in field **438**. Both the connected and calculated demand values are provided as an informational tool in aiding the system design engineer to provide data and to show local officials compliance with the associated electrical building codes.

Finally, the spreadsheet calculates the need for a step-down transformer, and if needed, will automatically calculate the minimum size step-down transformer required to provide the necessary amperes for the branch circuit panel board. In the example shown in FIG. **4**, the calculated demand kVA is used to determine a step-down transformer kVA value of 75 kVA which provides a maximum demand amperage of 208.2, field **435**. Once the step-down transformer size and the current carrying capacity of the step-down transformer has been determined, certain fields of header portion **318** within the branch circuit panel board module are determined to size the branch circuit panel board appropriately. As shown in FIG. **4**, the step-down transformer requires that 208.2 amperes, field **435**, be available which results in a minimum panel board mains rating value of 300 as shown in field **440**. From this panel board mains rating, standards data and electrical codes are used to automatically determine and calculate values for the electrical conductor specification **350** AWG, field **442**. Further, the #**2** ground conductor size, field **444**, the 3½ in. conduit size, field **446**, the number of sets of wires, field **448**, and the physical number of wires, field **450**, are all determined or otherwise calculated. In addition, a **400** panel board frame size, field **454**, a maximum permissible voltage drop of 2%, field **456**, and a corresponding maximum conductor run length of 115 ft., field **458**, are also determined or calculated by the spreadsheet according to the panel board mains maximum rating provided in field **440**. Finally, based upon the conductor size provided in field **442**, a calculated maximum feeder capacity of 310 Amps, field **439**, is reported as the total feeder current capacity required for the feeder circuit associated with the branch circuit panel board of FIG. **4**, i.e. feeder circuit **143** of FIG. **2**.

As those of skill in the arts of electrical engineering and software programming will recognize, the software of the present invention provides an automated calculation mechanism by which individual characteristics of particular branch circuits within a particular branch circuit panel board may be easily modified. By altering one piece of input data, the associated calculations pertaining thereto and all subsequent determinations and calculations throughout the entire spreadsheet are repeatedly performed to provide a real-time output reflecting the updated input data. For example, if an additional branch circuit is specified within the branch circuit panel board, then the corresponding loads, conductor sizes and all other associated physical electrical characteristics needed to create that branch circuit would be provided by the software according to the present invention. Further, the software would then revise the previously-calculated total load values, total demand load values, required panel board mains rating sizes, panel board frame sizes, etc. so as to further refine the specification of that particular branch circuit panel board. It is precisely this iterative, bottom-up, automated approach to the specification of both the individual branch circuit characteristics and the branch circuit panel board that has been heretofore lacking from software of other electrical engineering calculation software programs.

FIG. **5** provides an exemplary subset of the data contained within database(s) **60** including a number of the user-specified field and software determined/calculated fields as described above with respect to the branch circuit panel board module in FIG. **4**. As an example, a listing of the various branch circuit load type values **505-507** is shown. These load types reflect those presented to the engineer/user in field **382** of FIG. **4**. Various physical attributes of the branch circuit panel boards are also provided including mounting types, shown in field **320** and having values of "surface" (value **508**) or "recessed" (value **509**), and phase-to-phase voltage values, shown in field **328** and having values of 480V, 208V, 240V. Similarly, the data shown in FIG. **5** and contained in database(s) **60** include all the various categories and corresponding values for many of fields provide in FIG. **4**. Further, these data categories include both user-selectable inputs, such as the load type, field **382**, as well as program generated outputs, such as wire AWG, field **362**. In addition, certain data fields, for example, panel board frame in field **455**, may be set to be either automatically selected, i.e. the AUTO value **515** shown in field **455**, or the user may override the automatic selection to specify one of the remaining values. As an example, the branch circuit panel board panel frame field **454** of FIG. **4** is shown as set to automatic in field **455**. If the user/engineer so desires, he or she may set field **455** in the branch circuit panel board module to automatically select the appropriate panel board frame size based on the calculated panel board mains rating provided in field **440**. These automatic calculations and selections are performed by the software of the present invention based on the engineering equations **2**, and other data within database(s) **60**. However, the user may also select one of the alternative, defined values within the database field **455** of FIG. **5** as the value entry for branch circuit panel board frame field **455**, either by under-specifying the panel, e.g. a 250 Amp panel board shown as value **512** FIG. **5**, or by over-specifying the panel board, e.g. a 600 Amp panel as shown as value **514**. According to one embodiment of the invention, these values are presented to and selected by the user in the form of drop-down boxes within the spreadsheet of FIG. **4**. In this manner, and similar to other auto-selected fields, the user may either accept a pre-determined calculated value based on standard engineering calculations and electrical code data or may specify a user-selected value in contravention of the software's automatic selection.

Referring to FIG. **6**, a second branch circuit panel board spreadsheet is provided, as part of branch circuit panel board module **10**. The branch circuit data of FIG. **6** shows the data associated with an additional branch circuit panel board **110** of FIG. **2**. With respect to branch panel board HA **110** as designated in panel board designation field **554**, one of the user-specified fields within header **518**, the phase-to-phase voltage field **560** has been selected to be identical to the voltage provided by the distribution panel board **150** of FIG. **2**, i.e. 480 volts. As with branch circuit panel board **111**, the spreadsheet of FIG. **6**, permits the user to input various loads in center section **550** such that the branch circuit panel board module automatically calculates the total load kVA for that panel board and provides the corresponding branch circuit and branch circuit panel board characteristics necessary to carry that load. This panel board is unlike the branch circuit panel board **111** of FIG. **2** as further shown in **310** of FIG. **4** in which the phase-to-phase voltage of 208V, field **328**, was different from the voltage provided by distribution panel board **150** of FIG. **2**. In branch circuit panel board of FIG. **2**, a step-down transformer, **162** of FIG. **2**, is required on 480V feeder **142** to provide a 208V feeder **143** to the branch circuit panel board. The requirement for this transformer is populated automatically by the software branch panel board circuit module **310** as shown by the AUTO value in field **539** of FIG. **4**. In contrast, a step-down transformer is not needed for feeder circuit **140** of FIG. **2** to provide power to branch circuit panel board **110**, as reflected by the lack of a step down transformer determination field area in the branch circuit panel board shown in FIG. **6**. Consequently, and unlike the determination made in the spreadsheet of FIG. **4** for branch circuit panel board **111**, the panel board mains rating is directly determined by the software of the present invention from the calculated demand amperes needed to support the panel; in this case, 234.3 Amps, as indicated at **534** of FIG. **6**, are determined to be needed, which results in a panel board mains rating of 300 Amps, being automatically selected by the program, as indicated at **547** of FIG. **6**.

In a like fashion, the software of the present invention would include as many spreadsheets as necessary for defining each branch circuit panel board in the overall electrical power distribution system shown in FIG. **2**, in addition to specifying the physical characteristics of the components needed to construct each of the branch circuits and branch circuit panel boards.

FIG. **7** provides an embodiment of the distribution panel board module **30** (FIG. **1**) and the associated software. The distribution panel board module contains many of the same fields and associated calculations as presented in the branch circuit panel board module **10** in that the user specifies much of the same minimum subset of data related to the distribution panel board **150** of FIG. **2**. This minimum subset of data may be the same or may be different from the minimum subset of data needed to specify each branch circuit depending on the electrical considerations in the design of the electrical power distribution system **100** of FIG. **2**. For example, the load types shown in field **682** of FIG. **7**, which are different from those in fields **382** and **582** of FIGS. **4** and **6** respectively, may require a different data subset which the software uses to determine the physical components necessary to construct the circuits that support those loads. Details of the minimum subset with respect to the particular example of FIG. **7** are provided below. Unlike the branch circuit panel board module, however, much of the minimum subset of data involved with the distribution panel board module of FIG. **7** is automatically transferred by the software from associated branch circuit panel board modules and values for corresponding circuit fields are automatically calculated based upon process described below. In this fashion, the design of the overall system is automated by the software and is performed on a "bottom level up" basis.

As with branch circuit panel board module, certain user-selected values are input to the distribution panel board module and are indicated by the shaded fields within the module of FIG. **7**. In particular, the distribution panel board module consists of a header region **618**, a center region **650**, a footer region **630** and an analysis section **680**. In the example shown in FIG. **7**, panel designation DP**1** is used to designate distribution panel board **150** of FIG. **2** in panel board designation field **615**. Similarly the user/engineer specifies other values for data field within header region **618** to defining the characteristics of distribution panel DP**1** include: the mounting method **620**, the interrupting ratings **622**, the AIC rating **624**, the number of phases **626**, and the phase-to-phase voltage for the distribution panel board **628**. Further, the user may specify a current temperature correction factor **634**, a bus bar type **631**, the presence of a transient voltage surge suppression system device **636**, the NEMA designation for the distribution panel board **638**, the presence of an isolated ground for the panel **640**, and the neutral conductor rating **642**. As with the branch circuit panel board module of FIGS. **4** and **6**, data values from database(s) **60** may be presented by the software in the form of drop-down boxes from which the user/engineer selects the desired parameters. Similar to the discussion above, many of these fields may be automatically provided for by the software by selecting an AUTO value from a particular field within the spreadsheet. For example, the activation of AUTO selection field **655** of panel board frame **670** will result in the software automatically selecting an appropriate value for the panel board frame based on the NEC data and calculations presented in the spreadsheet, in this case the total calculated demand amperes, field **685**. Alternatively, the user may override the automatic selection by selecting a particular pre-defined value from the database **60**.

Like the branch circuit panel board of FIGS. **4** and **6**, center region **650** is also laid out so as to mimic the physical configuration of the distribution panel board itself in that a center field **600** identifies the three bar buss for that distribution panel board to support the three-phased buses associated with the distribution panel board. Further, the left distribution panel board column group **602** contains data related to the circuit breakers associated with the odd circuit breaker positions within the distribution panel board. Likewise, right distribution panel board column group **604** provides for the even numbered circuit breaker positions within the distribution panel board for connection to the central bus. As a general rule, the inputs to each panel board supported by the distribution panel board are shown in circles. The general outputs from the distribution panel board are shown in triangles.

The data within center region **650** of the distribution panel board module is automatically populated by the software of the present invention directly from the data generated within each of the individual branch circuit panel board modules as shown in FIGS. **4** and **6**. Again, inputs on any sheet are shown in circles, whether provided manually by the software user or by other portions of the design software. Likewise, outputs from any sheet are shown in triangles. For example, distribution panel board entry **654**, as identified by the HA value in the load served field **661**, is automatically populated with the information from branch circuit panel HA **110** as calculated in the branch circuit panel board spreadsheet of FIG. **6**. In particular, the total calculated demand of 194.8 kVA, as shown in field **532** of FIG. **6**, is input by the software into field **632** of FIG. **7**. Likewise, the automatically-calculated data within the header of panel board HA is input by the software into distribution panel board entry **654** within the distribution panel board module, including the maximum conductor run length (237 ft. of field **557** of FIG. **6**) in field **658**, the percentage voltage drop (2.0% of field **556** of FIG. **6**) in field **656**, the number of sets of conductors (1 of field **548** of FIG. **6**) in field **648**, the quantity of conductors (4 of field **558** of FIG. **6**) in field **651**, the AWG rating of the conductors (350 of field **542** FIG. **6**) in field **642**, the ground conductor size (4 of field **544** FIG. **6**) in field **644**, and the conduit size (3½ in. of field **546** of FIG. **6**) in field **646**. In addition, the total panel board mains rating (300 of field **547** of FIG. **6**) is provided as the electrical break trip value shown in field **647** within distribution circuit panel board entry **654**. Similar to the branch circuit panel board module, the distribution panel board spreadsheet automatically calculates a total connected load values, field **684**, for each of the different load types, field **682**, based on the data imported from the associated branch circuit panel board modules. After calculating a default-demand factor for each load, field **686**, which may be overridden by the user, a total demand of 502.5 kVA is calculated as shown in field **688**. Similar to the analysis field of the branch circuit panel board modules, analysis notes may automatically be generated in field **690** by the software so as to notify the user of improper input or data for the branch circuit panel board or outputs from the distribution panel boards.

To complete the spreadsheet, fields within footer region **630** are calculated by the distribution panel board spreadsheet based on the data concerning the total connected loads and total demand loads **684** and **688** respectively. Specifically, the distribution panel board module uses the calculated demand kVA values to determine an appropriate ampere rating for the distribution panel board as shown in field **685**. This value is then used by the distribution panel board module to calculate a panel board mains rating, 800 in field **670**, according to the electrical standards data and other engineering calculations. As with the branch circuit panel board, this panel board's calculated amperes is then used to calculate and determine the other electrical characteristics and physical requirements of the distribution panel board, including the maximum conductor length, 421 ft. of field **698**, the overall panel board frame size, 800 of field **67**, the number of sets of feeder conductors, 3 of field **671**, the number of feeder wires necessary, 4 of field **672**, the AWG rating of the feeder wires, 300 of field **673**, the ground conductor size, 2 of field **674**, and corresponding feeder conduit size, 3 in. of field **675**.

As a user-friendly feature of the software of the present invention, the capability exists to independently add additional branch circuit information on a circuit-by-circuit basis, apart from the automatic population of branch circuit data from associated branch circuit panel board modules. For example, the exhaust fan **130** of FIG. **2** is shown in circuit entry line **692** on the left-hand side of the distribution panel board module. The data for this distribution panel circuit may be entered by the user by specifying certain minimum circuit characteristics such as the total load, value 2 kVA at **689**, the number of poles for that circuit, value 2 at **694**, and the load type, value M at **690**. From this minimum set of information, just as with the branch circuit panel board module, the various electrical characteristics necessary to create that circuit that feeds the distribution panel board circuit are automatically calculated by the distribution panel board spreadsheet. In particular, the trip value **20** at entry circuit **692**, the number of sets of conductors, 1 at **696**, the number of conductors necessary for the feeder circuit, 3 at **695**, the AWG rating of the conductors, 12 at **697**, the ground conductor size, 12 at **698**, the conduit size, ¾ in. at **699**, the maximum allowable voltage drop, 2.0% at **693**, and the corresponding maximum conductor length, 576 ft. at **691**, are all calculated automatically by the spreadsheet based upon the user-input data. In this fashion, the distribution panel board is more flexible in that it may accept data from other modules such as the branch circuit panel board module as well as independent, user-specified, circuit data.

Building equipment module **20** provides another example of a circuit to be included within the distribution panel board module **30** of FIG. **1**. In the electrical power distribution system of FIG. **2**, such building equipment may include air conditioning unit **120** which might draw power from distribution panel board DP**1** **150**. FIG. **8** provides one spreadsheet embodiment **705** for calculating the electrical component specifications for connecting this building equipment. Specifically, the building equipment module includes header portion **718**, a center portion **750**, a footer portion **730**, and an engineer's notes section **780**. In the header portion **718**, certain user-input information is required to define the set of variables that permit the spreadsheet to calculate the remaining building equipment variables. This information is shown in the shaded fields in FIG. **8**. In particular, the user must provide the distribution voltage, 480V at **728**, and the distribution panel board designation to which the building equipment is to be connected, panel board DP**1** at **729**. In addition, the user must provide the number of phases required by the piece of building equipment, 3 at **730**. Further input by the user, are a building equipment identifier (Building Equipment Name) **715**, which indicates the piece of equipment being added, in the example of FIG. **8**. The user then specifies a component identifier for each piece of building equipment, e.g. the above-mentioned air conditioning unit AHU 1 of field **715**, including the subcomponents thereof, e.g. a HEATING COIL and FANs **1-3** of field **707-710**. Further, for each subcomponent (e.g. the HEATING COIL) the user/engineer specifies a load type, HTR of **756**, the phase-to-phase voltage, 480V at **711**, the number of phases, 3 of **752**, and the total power required, 20 kVA of **753**. Alternative specifications of the power required may also be provided for by the software, from which standard equations and calculations may be used to arrive at common units of electrical power. For example, the horsepower requirements for the FANs are input as the power requirement **754** from which the Amps required to run the fans are determined by the software from the date and standards information within database(s) **60**. From all the input data, the software of the present invention consults database **60**, including the building electrical characteristic codes and engineering equations, to determine the rated current capacity needed for each of the different elements as shown in NEC field **760**. In addition, separate cooling and heating electrical loads may be calculated by the software based upon the ampere rating **760** of a subcomponent to accommodate different functioning modes of the various building equipment components. In the example of FIG. **8** FAN**1** may be used for both heating and cooling cycles as identified in field **758** from which different electrical current requirements for different operative cycles are provided by the software in fields **762** and **764**. Based upon this information, total calculated demand loads (in kVA) may be calculated for heating cycles, cooling cycles, or any other appropriate operative cycle for a building equipment element or subcomponent thereof as shown in fields **766** and **768**. The building equipment module then sums all such power requirements to provide total cooling and heating cycle demand loads as identified in fields **769** and **770**.

The above-calculated building equipment total demand loads are then used to populate footer portion **730** of the building equipment module. As with the branch circuit panel board module **10** and the distribution panel board module **30**, footer region **730** is used to calculate and compare the final output electrical parameters needed to create the appropriate feeder circuit connections and overcurrent protection so as to properly connect the building equipment to the distribution panel board. In particular, the number of sets of conductors, 1 at **771**, the number of conductors, 3 at **772**, the feeder conductor size, 4 at **773**, the ground conductor rating, 8 at **774**, the conduit size, 1¼ in. at **775** and the fuse size for overcurrent protection, e.g., element **134** of FIG. **2**, are automatically calculated by the building equipment module. Based upon different operating constraints of the building equipment, for example, whether cooling cycles or heating cycles are being accounted for, the building equipment module selects the most demanding requirements for the building equipment and appropriately selects output values for each of these calculated values according to the maximum load condition for the system. As shown in line **732** of field **775** of the footer portion, for example, the more rigorous standard of 1¼ inch conduit size will be selected by the module as between the cooling cycle conduit size, determined to be a minimum of 1¼ inches, and the heating cycle conduit size, as determined to be a minimum of ¾ of an inch. Likewise, other data within the building equipment module are populated along the RESULTS line. In alternative embodiments of the software, the fields in footer portion **730** may programmable so as to be overridden by a user selection. Finally, engineering analysis notes are provided in section **780** of the building equipment module that notifies the user of error conditions and possible warnings regarding the connection of the building equipment. Optionally, the software may be programmed to prevent further data entry if these errors are not corrected in order to continue the design process.

As with the branch panel board module data, the building equipment spreadsheet **705** provides its data to the distribution panel board module as shown in the distribution panel board spreadsheet of FIG. **7** at line **700** of the left distribution panel board column group **602**. As described above, this data is used by the distribution panel board module to calculate the necessary electrical characteristics of the building equipment including the proper sizing and selection of electrical components needed to construct the associated feeder circuits.

Referring to FIG. **9**, another example of a building equipment spreadsheet associated with building equipment module **20** of the software of the present invention is provided. Specific to FIG. **9**, the data associated with condenser unit **122** of FIG. **2**, as identified by the indicator CU1 **815**, is calculated and specified. Much of the data in this building equipment module is similar to that shown in FIG. **8** with respect to the inputs, calculations and the outputs provided. In particular, a minimum set of user-defined inputs are provided as needed to derive outputs populated as shown on results line **832**. Further, these results are also fed back to the distribution panel board module of FIG. **7** as input CU-**1** shown in field **829** of FIG. **7**, for further calculation and specification of appropriate electrical components for distribution panel board **150**.

FIG. **10** provides one embodiment of the main distribution panel board module **40** (FIG. **1**) as a spreadsheet that which defines the electrical characteristics of the main distribution panel board **180** (FIG. **2**). Main distribution panel board module **905** and its associated characteristics are very similar to those provided in distribution panel board spreadsheet **605** shown in FIG. **7**. Specifically, the user/engineer inputs certain overall data into a header section **918** (shaded fields) which is used in conjunction with data fed from the distribution panel board spreadsheet(s), branch circuit panel boards, and building equipment, as fed into center section **950**, so as to automatically calculate and provide the electrical specifications needed to create the connections for the main distribution panel board within the electrical power distribution system. Again, the layout of center section **950** mimics the actual physical layout of a main distribution panel board. Individual distribution panel board inputs, branch circuit panel board inputs and building equipment inputs are provided on a line-by-line basis within the main distribution panel board spreadsheet such that the main distribution panel board spreadsheet calculates and sums the total required demand kVA and amperes required for specifying the entire design of the main distribution panel board. As with the branch circuit panel board and distribution panel board specifications, analysis section **980** provides a list of selectable load types, which may require minimum subsets of input data different from those required for the branch and distribution panel boards to fully specify the electrical connections to the main distribution panel board. Analysis section **980** also provides and calculates default demand factors from which total demand loads are calculated. Analysis section also provides a section in which the software may provide automatic engineering warnings and announcements related to the various load types.

Similar to the discussion above with respect to branch circuit panel board **111** (FIG. **2**), the software of the present invention may be programmed to determine the need for a service transformer **190** (FIG. **2**) to connect the main distribution panel board **180** to the outside power primary circuit **196**. Such a determination results from the voltage provided on the primary lines and a calculation of the total required amperes in footer section **930** of the main distribution panel board. Once the main distribution panel board module has calculated the appropriate service transformer size based upon the electrical engineering calculations and electrical codes contained within database **60**, certain fields are automatically calculated within the header section **918**, so as to fully specify the electrical design characteristics of the main distribution panel board. For example, as shown in FIG. **10**, a panel board mains rating of 1000, field **960** has been determined as the minimum rating based upon a calculated service transformer value of 902.1 Amps calculated in field **934**. Further, a panel board frame size, 1000 at **970**, a maximum permissible voltage drop, 3.0% at **966**, and a corresponding maximum transformer feeder conductor length, 323 feet at **998**, are provided as outputs of the main distribution panel board spreadsheet. Further, the number of sets of conductors, 4 at **971**, the number of feeder wires necessary, 4 at **972**, the conductor size, 250 at **973**, the ground conductor size, 2 at **974**, and the conduit size for the transformer feeder, 3 in. at **975**, are automatically calculated by the main distribution panel board spreadsheet. As such, the entire electrical specification of the physical and electrical parameters of the main distribution panel board may be provided to engineers and design personnel such that an appropriately sized main distribution panel board may be constructed and laid out according to building codes and accepted electrical engineering practices and equations.

Next will be described the series of steps performed by the software of the present invention in an exemplary calculation and determination of branch circuit variables and panel board value selections for a particular branch circuit. In these steps, numerous logical determinations, table look-ups and engineering calculations are required to be performed to make these determinations and further specify the physical characteristics of the electrical components of the branch circuit. It should be recognized within this world of equations, electrical standards and programmed decision making, that much of the implementation of the software of the present invention results in design choices being made that are at the discretion of the engineer and software programmer. Thus while one particular programming embodiment is described below, an infinite variation of alternative implementations are possible. Further, it is impractical to provide more than one example of a sample branch circuit calculation given the numerosity of the logical determinations and equation solving performed by the software described in this application. In essence, the panoply of calculations, determinations, table look-ups and discretionary judgments that are automatically calculated and programmed within the software are well known to those of skill in the arts of electrical engineering and software programming and are not critical to the basic invention(s) herein.

Referring back to branch circuit **215** of FIG. **3**, i.e., branch circuit LA-**14** of building **200**, is shown as having four floor-based electrical outlets or receptacles for which a branch circuit is to be created. As previously described and shown in the branch circuit panel board spreadsheet of FIG. **4**, three independent inputs are required from the user of the software of the present invention in order to make the remaining electrical calculations necessary to describe fully the entire branch circuit. First, the user/engineer must provide a load type **356**, in this case, a "receptacle load" identified by the designation R in load selection field **382**. Second the user/engineer must specify the number of poles used by this branch circuit. With reference to branch circuit **215** at FIG. **3**, a single pole circuit shown as being input in field **358**. Finally, the user/engineer specifies the total kVA load of branch circuit **215**. For the kVA load, the user must add the individual loads required by each of the four receptacles to obtain a total kVA. In the example of FIG. **4**, a load of 1.2 kVA has been arbitrarily determined. Once this minimum set of three branch circuit variables has been input by the user, the software of the present invention automatically calculates the remaining characteristics needed to specify the physical, electrical components needed to create that particular branch circuit.

The data pertaining to branch circuit **215** of FIG. **3** is provided on circuit line **351** of FIG. **4** where the above-mentioned minimum user inputs are identified as circled values. Based on the user selectable input provided at field **351**, the software determines that the single pole determination provided in field **358** requires two conductors, one hot and one neutral, to carry the current that completes branch circuit **215**. The software provides this at field **363** in line **351** of branch circuit **215** in FIG. **4**. Further, based upon the 1.2 kVA load and the user-specified single pole circuit, which necessitates a phase-to-neutral voltage of 120 volts as determined by the spreadsheet from the datum shown at **344** of FIG. **4**, it can be determined that a maximum of 10.0 Amps are required to be carried by branch circuit **215**. This can be calculated from the electric power formula I=Electrical Load (kVA) times 1000/L-N Voltage (Line-Neutral) which is contained within the engineering equations library **2** of database **60**. At this point, the software of the present invention refers to the trip rating table according to NEC standard **240-6**, shown in FIG. **11**. This table would typically be contained within the standards data **1** within database **60** in FIG. **1**. From this table, the software determines that the inverse of 10.0 Amps results in a value that corresponds to a trip rating of 20 Amps, line **1010**. This results in the selection of a 20 Amp circuit breaker for the branch circuit panel board to provide protection for branch circuit **215**. Next, the electrical circuit size is determined based upon the previously determined circuit breaker size of branch circuit **215** and the user-specified temperature correction factor, field **334** of FIG. **4**. Standard, values for the user-selectable temperature correction factors are provided in field **380** of FIG. **5**. As shown in NEC table **310-16** provided in FIG. **12**, a 20 Amp circuit breaker at 30 degrees results in the selection of a conductor size of 12, line **1110**. This conductor size is also referred to as the AWG rating in NEC terminology. Although **14** is also an acceptable AWG rating, the particular embodiment of the software described herein is programmed to choose the more conservative value for circuit variables where a choice of more than one value is available according to the standard. The software of the present invention then automatically inputs the AWG value of 12 into field **362** of branch circuit line **351** (FIG. **4**).

Next, the maximum conductor length is determined based on voltage drop selected by the user in field **456**. According to NEC standards and good engineering practice, any particular stage of the electrical power distribution circuit of FIG. **2** may suffer a voltage drop of no greater than 5%. Thus if the user specifies a maximum of 2.0% voltage drop in the feeder to the branch circuit panel board, as selected by the user in field **456** of FIG. **4**, then the software of automatically determines that a 3% voltage drop may be accepted within each of the individual branch circuits. Thus, the software automatically populates the voltage drop field **368** with 3.0% for each of the branch circuits. Once the maximum permissible voltage drop for each branch circuit is determined, the maximum conductor length for branch circuit **215** may be calculated by the software. In particular, the maximum conductor length is provided by the formula: L=VD×1000/2×R×I, where VD=voltage drop, L=conductor length, R=conductor resistivity, and I=load current. Since the maximum current capacity of the branch circuit conductor (10.0A) and the maximum voltage drop (3.0%) have already been determined, the maximum conductor length can be determined by the software once the resistivity of the conductor is determined. In this regard, the software of the invention refers to NEC table **310-16** shown in FIG. **13** to determine that an AWG gauge wire of **12** at a temperature of 30 degrees has a maximum resistivity of 2.00, line **1210** of FIG. **13**. It should be noted that the conductor resistivity is partially dependant upon the type of conduit in which the conductor is housed. This is reflected in the three different resistivities, one each for PVC, AL and steel, provided in NEC table **310-16** in FIG. **13**. As mentioned above, the software of the present invention will make the most conservative determination in selecting circuit values where multiple choices are available. Thus, a maximum resistivity column is created within database **60** as shown in FIG. **13** from which all resistivities are selected. Thus once the resistivity is determined, the software calculates the maximum conductor length to be 90 feet which is displayed in the branch circuit panel board **310** at field **370** of line entry **351**. Those of skill in the art will realize that this conductor length represents the maximum wire run length from the branch circuit panel board LA **111** in FIG. **2** to the farthest of the electrical receptacles in branch circuit **215**.

Next, the ground conductor, size is determined by the software with the aid of NEC tables **250-66** and **250-122** provided in FIG. **14**. According to precise adherence to the NEC code, two different tables are used to determine the proper ground conductor size depending on whether the ground conductor is to be used for the mains or service line or somewhere else within the electric power distribution system. In the example of branch circuit **215**, the ground conductor determination is made with the assistance of NEC table **250-122**. Further, the selection of a ground conductor size, like the power conductor determination above, is dependant upon the circuit breaker size, in this case **20**. In addition, the ground wire conductor size is dependant upon the type of metal used for the branch circuit panel board bus bar, and thus the ground conductor wire. Thus, for branch circuit **215** having circuit breaker size **20**, field **360**, and a copper bus bar, field **330**, the ground wire conductor size is selected by the software to be **12**, line **1310** of FIG. **14**. This is provided by the software in field **364** for branch circuit **215** on line **351** in FIG. **4**.

Next, the conduit size for the conductors is determined by the software based upon the number of conductors and the AWG rating of each conductor as provided above. Referring back to FIG. **13**, the NEC code provides a cross sectional area for each conductor based on the AWG size of the conductor. For the 12 AWG hot and neutral conductors, line **1210** of FIG. **13** shows the cross sectional area of the conductor to be 0.0117 in. Commensurate with the conservative nature of the software of the present invention, one additional conductor cross section is added to the sum of the conductors' cross sections within a branch circuit as a safety margin for fit. Given the two conductors determined above, field **363** of FIG. **4**, plus a third "safety conductor" the total conductor cross section is determined to be 0.0351. Based on the NEC rules and formulae for conduits, as provided in FIG. **15**, the software determines that 1/(sum of the total conductor area/0.4) is 11.396 which results in the selection of a ¾ in. conduit, line **1410**. This selection is presented at field **366** in line **351** for branch circuit **215**.

Once all branch circuits are specified as described above, the branch circuit panel board spreadsheet is completed by the software as follows. First, the branch circuit loads for each of the load types in field **382** are summed and displayed by the software in field **384** of FIG. **4**. Second, each of the total loads values are multiplied by the default demand factor for that load type, field **386**, to arrive at a total demand kVA for each load type, field **388** of FIG. **4**. The default demand factors for particular load types may be selected by the software of the present invention according to standards data within database **60** or alternatively, may be overridden by the user/engineer. Third, the total demand kVAs are then summed to provide a final, total demand kVA for the entire branch circuit panel board, field **388**. After calculation of the total demand kVA, for example 58.1 kVA of FIG. **4**, the total demand kVA is provided by the spreadsheet within the footer region **430**, field **432**. The software then applies electrical power equations to arrive at the total number of amperes required for the branch circuit panel board, e.g. 161.3 amps in field **434**. For the engineer's reference, and strictly for the purpose of comparing the total possible demand load to the total probable demand load, the total, load kVA, unmitigated by the demand factor, is also calculated and presented in the footer region **430**, e.g. 56.7 kVA at field **436**. Depending on the presence of a step-down transformer, which may modify the total required amperes as shown at field **435** in the spreadsheet of FIG. **4**, the spreadsheet then determines the total number of amperes needed by branch circuit panel board **111** and compares this to NEC tables to arrive at a main panel board rating. In the example of FIG. **4**, the engineer and software have determined that a transformer is needed, see field **539**, and the total required amperes are calculated to be 208.2A. The next highest mains panel board rating of 300 (Amp), field **440** FIGS. **4** and **5**, is then selected by the software to support that particular calculated demand load.

Next, the software calculates a number of electrical characteristics involving the feeder circuits **143** of branch circuit panel board **111** of FIG. **2** based upon the total number of amperes by that panel board. These calculations result in the determination of feeder wire characteristics. Specifically, the number of sets of wires **448**, the number of wires **450**, the rating of the wires **442**, the ground conductor size, **444** and the conduit size **446** respectively, are determined according to NEC tables and formulas similar to the previously described process involving the branch circuits. As is well known in the art, the determination of feeder circuit characteristics may need to be performed according to different NEC tables and codes, as well as different engineering calculations in arriving at the appropriate data, although many of the calculations are similar to those used to determine the branch circuit values. In addition, certain physical characteristics of the branch circuit panel boards are determined according to standard manufactured sizes, and not necessarily NEC-determined values. In particular, the panel board frame, field **454**, is selected according to a table of standard manufacturer panel board sizes and in accordance with the calculated panel board mains rating and standard frame size formulas, field **440**. Finally, the maximum length of feeder wire is calculated, field **458**, to determine a maximum length of 115 feet for the feeder conductors to the branch circuit panel board.

Similar to the specification of a minimum subset of circuit variables for branch circuits, minimum subsets of circuit variables for a distribution panel board may be provided so as to fully define the electrical characteristics and physical electrical components needed to construct the distribution panel board and the associated feeder circuits. As shown in FIG. **7**, e.g. line **654**, the distribution panel board requires the kVA input of each of the individual feeder circuits from the branch circuit panel boards so as to calculate a total connected load for each of the different branch circuit panel board load types. In addition, distribution panel board **605**, FIG. **7**, sums each of the individual branch circuit panel board load types so as to arrive at a total connected and total calculated demand load, fields **684** and **688** for the distribution panel board. These calculations are performed in a manner similar to those calculated for the branch circuit panel board described above. From a total calculated demand load, e.g. 502.5, the total demand amperes are calculated, e.g. 604.4 field **685**. As is known by those skilled in the art and similar to the analogous branch circuit panel board calculations illustrated above, the software of the present invention performs the additional calculations needed to arrive at the conduit sizing, panel board mains rating and maximum feeder length for the distribution panel board in accordance with NEC code and standard electrical engineering calculations.

One particular advantage of the software embodiment of this particular invention is that the output data created by the software may be exported to other software modules which provide analysis functions and other circuit determination functions so as to determine a proper operation of the circuit. While the present invention is focused on a bottom-up, specification of the components of an electrical power distribution system, an overall electrical circuit evaluation for each one of the individual branch and feeder circuits, as well as the main and distribution panel board operation, are adequately covered and well-known in the art. Those of skill in the art will appreciate that the data within this invention is easily exported from the spreadsheets of the current program and provided, for example in PDF format, to other standard programs that can perform electrical simulation analyses to determine the proper operation of the circuits and panel boards.

As a further advantage of the software of the present invention, and unlike any other heretofore known software, its output data consist of the physical specifications for the electrical components required to construct an electrical distribution system. As such, this specification of physical, electrical components, may be easily translated into standard inventory lists that are capable of being remotely transmitted to distribution warehouses so that the necessary electrical components are automatically delivered to a construction site. FIG. **16** provides one example of such an arrangement. For example, a user of the software system **90** may specify the minimum set of variables for each of a set of branch circuits, thereby constructing a branch circuit panel board according to the description given above. Once the conductor lengths, panel board sizes, conduit sizes and all other physical specifications for the electrical system components have been specified, actual electrical component parts lists **1505** may be generated by system **90**, possibly with the aid of an inventory database **5** that may be part of database(s) **60**, FIG. **1**. This parts list may then be transmitted over the internet **1510**, possibly through a web-based interface, directly to a supplier of electronic components **1520**. At the suppliers, the received parts list may be correlated with the standard parts lists by the suppliers own computer systems **1530**. These computer systems can them perform a check for the requested parts against existing inventory within the supplier's establishment **1540**. As a result of this comparison, an inventory list derived from and fully-satisfying the list of needed electrical components may be generated to construct the electrical distribution system. Such inventories, for example, may be provided by standard electrical contracting houses, Home Depot, or other distributors of electrical equipment. Once the inventory list is created by the electrical component distribution company, the components may then be automatically picked and shipped to the desired location, or directly to the job site **1550**. This direct delivery approach minimizes the time, effort and expense in generating independent inventory lists and reduces the lag time in constructing the actual electrical power distribution systems.

As an alternative to the electrical component supplier generating the inventory list, the electrical suppliers themselves may publish electronic inventories with prices. Users of the software of the present invention would then be able to download the inventory lists directly to their databases **60** so that standard component lists may be generated directly by the user/engineer. Price comparison among different suppliers would be facilitated with this arrangement since the user would be in possession of the end parts list of needed components.

As is well known in the art, the software of the present invention may be embodied in a number of formats, including storage on a hard disk drive, or imprinting onto a CD-ROM, floppy disc or ZIP drive. Alternatively, the software of the present invention may be provided on a web-based interface for download and use on either a project-by-project basis, or alternatively, as a repetitively useable fully-licensed software package. As appreciated by those of the skill in the art, modifications to existing electrical circuits may be easily updated once the software for the present invention is populated with appropriate data for existing electrical power distribution systems, thereby simplifying the addition of additional branch circuits and/or the expansion of the electrical system to additional branch circuit panel boards, distribution panel boards and/or main distribution panel boards.

Although various preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and/or substitutions are possible without departing from the scope and spirit of the present invention as disclosed in the claims. In this regard, the invention of the present invention is not limited in any way in the use of any particular existing other heretofore developed standards data, design criteria, engineering equations or other data. Although the NEC has been used as an example throughout the specification, other existing standards may be used instead of, or in combination with the NEC data. One such alternative standard is the SI (Standards International) system used in Europe. Further, different building standards and design data may be used such as the Canadian building standard.

The invention claimed is:

1. A general-purpose computer-based system for designing an electrical power distribution system for a building, said system comprising:

a standards database containing standards data associated with an electrical standard for buildings;

a panel design module for accepting a minimum subset of panel board data for a panel, said panel having a set of panel variables that, in combination with said minimum subset of panel board data, defines said panel;

a circuit design module for accepting a minimum subset of branch circuit data for each of a plurality of branch circuits, said branch circuits for distributing electrical power within said building, each branch circuit having a set of branch circuit variables that, in combination with said minimum subset of branch circuit data, defines said branch circuit;

wherein said circuit design module determines branch circuit values for said branch circuit variables using said minimum subset of branch circuit data in connection with said standard data; and

wherein said panel design module determines panel values for said panel variables using said branch circuit values for said plurality of branch circuits, said minimum subset of panel board data, and said standards data; and

wherein said panel design module automatically recalculates at least one panel value for a corresponding panel variable in connection with said standards data when another one of said previously determined panel values is changed.

2. The general-purpose computer-based system of claim **1** wherein said minimum subset of branch circuit data include at least one of: a load type, a kVA load, a voltage or a phase value for each of said branch circuits.

3. The general-purpose computer-based system of claim **1** wherein said set of branch circuit variables includes at least one of: a branch circuit breaker size, a branch circuit conductor size, a number of branch circuit conductors, a branch circuit ground conductor size, a maximum branch circuit length, a branch circuit conduit size, or a voltage drop.

4. The general-purpose computer-based system of claim **1** wherein said minimum subset of panel board data includes at least one of: a panel voltage value, a panel mounting type, a panel interrupting rating, an ampere interrupting capacity rating, a number of phases, a temperature correction factor, a bus bar type, a TVSS device, a National Electrical Manufacturers Association designation, an isolated ground, a neutral feeder conductor rating, or a number of poles.

5. The general-purpose computer-based system of claim **1** wherein said set of panel variables includes at least one of: a total panel capacity, a panel mains rating, a feeder conducting size, a number of feeder conductors, a number of feeder sets, a maximum feeder length, a feeder ground conductor size, a feeder conduit size or a voltage drop.

6. The general-purpose computer-based system of claim **1** wherein said electrical standard for building is an electrical code.

7. The general-purpose computer-based system of claim **1** wherein said electrical standard for buildings is an electrical code and said standards data includes local variations to the electrical code.

8. The general-purpose computer-based system of claim **1** wherein said minimum subset of branch circuit variables includes a load type and said panel design module determines a demand load as part of said panel definition based on said standards data and said load type, said panel values being further determined by said demand load.

9. The general-purpose computer-based system of claim **1** further comprising a building equipment module for accepting a minimum subset of building equipment data for each of a plurality of building equipment, each building equipment constituting one of said branch circuits within said building, wherein said building equipment module determines branch circuit values for said branch circuit variables on said branch circuits containing building equipment using said minimum subset of building equipment data in connection with said standards data.

10. The general-purpose computer-based system of claim **9** wherein said building equipment includes at least one of: a fan, a heating coil, a pump, a compressor, a motor-driven equipment or an air conditioner.

11. A method for designing an electrical power distribution system for a building using a computer-based system, said computer-based system performing the steps of:

specifying a set of branch circuit variables that define a branch circuit, said branch circuit for distributing electrical power within said building;

specifying a set of panel variables that define a panel;

inputting a minimum subset of panel board data, and repetitively

inputting a minimum subset of branch circuit data for a said branch circuit;

calculating branch circuit values for each of said branch circuit variables based on said minimum subset of branch circuit data using a standards database containing standards data associated with an electrical standard for buildings;

calculating panel values for each of said panel variables based on said minimum subset of panel board data and said calculated branch circuit values using said standards data;

changing at least one of said previously calculated panel values; and

recalculating automatically another one of said panel values for a corresponding panel variable in connection with said standards data and in response to said changed panel value.

12. The method of claim **11** wherein said step of changing at least one of said previously calculated panel values further comprises manually overriding by a system user said previously calculated panel value.

13. The method of claim **11** wherein said step of changing at least one of said previously calculated panel values further comprises replacing said previously calculated panel value with a subsequently calculated panel value.

14. The method of claim **11** further comprising displaying analysis notes, said analysis notes including at least one of an error message, a warning message, or a design suggestion associated with said branch circuit.

15. The method of claim **11** wherein said step of specifying a set of branch circuit variables includes specifying a load type, said step of calculating panel values includes calculating a demand load based on said load type and said standards data and wherein said panel values are calculated using said demand load.

16. The method of claim **11** further comprising

specifying a minimum set of building equipment variables that define a building equipment on one of said branch circuits;

inputting a minimum subset of building equipment data for said building equipment;

calculating building equipment values for said building equipment variables based on said minimum subset of building equipment data using said standards database containing standards data; and

calculating branch circuit values for each of said branch circuit variables for said branch circuit containing said building equipment.

17. The method of claim **11** wherein the steps of claim **11** are performed by said computer-based system in accordance with at least one computer program stored in a computer-readable media, said computer program having a plurality of code sections that are executable by said computer-based system.

18. The general-purpose computer-based system for designing an electrical power distribution system for a building, said system comprising:

a standards database containing standards data associated with an electrical standard for buildings;

a panel design module for accepting a minimum subset of panel board data for a panel, said panel having a set of panel variables that, in combination with said minimum subset of panel board data, defines said panel;

a circuit design module for according a minimum subset of branch circuit data for each of a plurality of branch circuits, said branch circuits for distributing electrical power within said building, each branch circuit having a set of branch circuit variables that, in combination with said minimum subset of branch circuit data, defines said branch circuit; and

wherein said circuit design module determines branch circuit values for said branch circuit variables using said minimum subset of branch circuit data in connection with said standards data;

wherein said circuit design module automatically recalculates at least one branch circuit value for a corresponding branch circuit variable in connection with said standards data when another one of said previously determined branch circuit values is changed; and

wherein said panel design module determines panel values for said panel variables using said branch circuit values for said plurality of branch circuits, said minimum subset of panel board data, and said standards data.

19. The general-purpose computer-based system of claim **18** wherein said minimum subset of branch circuit data include at least one of: a load type, a kVA load, a voltage or a phase value for each of said branch circuits.

20. The general-purpose computer-based system of claim **18** wherein said set of branch circuit variables includes at least one of: a branch circuit breaker size, a branch circuit conductor size, a number of branch circuit conductors, a branch circuit ground conductor size, a maximum branch circuit length, a branch circuit conduit size, or a voltage drop.

21. The general-purpose computer-based system of claim **18** wherein said minimum subset of panel board data includes at least one of: a panel voltage value, a panel mounting type, a panel interrupting rating, an ampere interrupting capacity rating, a number of phases, a temperature correction factor, a bus bar type, a TVSS device, a National Electrical Manufacturers Association designation, an isolated ground, a neutral feeder conductor rating, or a number of poles.

22. The general-purpose computer-based system of claim **18** wherein said set of panel variables includes at least one of: a total panel capacity, a panel mains rating, a feeder conductor size, a number of feeder conductors, a number of feeder sets, a maximum feeder length, a feeder ground conductor size, a feeder conduit size or a voltage drop.

23. The general-purpose computer-based system of claim **18** wherein said electrical standard for buildings is an electrical code.

24. The general-purpose computer-based system of claim **18** wherein said electrical standard for buildings is an electrical code and said standards data includes local variations to the electrical code.

25. The general-purpose computer-based system of claim **18** wherein said minimum subset of branch circuit variables includes a load type and said panel design module determines a demand load as part of said panel definition based on said standards data and said load type, said panel values being further determined by said demand load.

26. The general-purpose computer-based system of claim **18** further comprising a building equipment module for accepting a minimum subset of building equipment data for each of a plurality of building equipment, each building equipment constituting one of said branch circuits within said building, wherein said building equipment module determines branch circuit values for said branch circuit variables on said branch circuits containing building equipment using said minimum subset of building equipment data in connection with said standards data.

27. The general-purpose computer-based system of claim **18** wherein said building equipment includes at least one of: a fan, a heating coil, a pump, a compressor, a motor driven equipment or an air conditioner.

28. A method for designing an electrical power distribution system for a building using a computer-based system, said computer-based system performing the steps of:

specifying a set of branch circuit variables that define a branch circuit, said branch circuit for distributing electrical power within said building;

specifying a set of panel variables that define a panel;

inputting a minimum subset of panel board data, and repetitively

inputting a minimum subset of branch circuit data for a said branch circuit;

calculating branch circuit values for each of said branch circuit variables based on said minimum subset of branch circuit data using a standards database containing standards data associated with an electrical standard for buildings;

changing at least one of said previously calculated branch circuit values;

recalculating automatically another one of said branch circuit values for a corresponding branch circuit variable in connection with said standards data and in response to said changed branch circuit value; and

calculation panel values for each of said panel variables based on said minimum subset of panel board data and said calculated and recalculated branch circuit values using said standards data.

29. The method of claim **28** wherein said step of changing at least one of said previously calculated branch circuit values further comprises manually overriding by a system user said previously calculated branch circuit value.

30. The method of claim **28** wherein said step of changing at least one of said previously calculated branch circuit values further comprises replacing said previously calculated branch circuit value with a subsequently calculated branch circuit value.

31. The method of claim **28** further comprising displaying analysis notes, said analysis notes including at least one of an error message, a warning message, or a design suggestion associated with said branch circuit.

32. The method of claim **28** wherein said step of specifying a set of branch circuit variables includes specifying a load type, said step of calculating panel values includes calculating a demand load based on said load type and said standards data and wherein said panel values are calculated using said demand load.

33. The method of claim **28** further comprising

specifying a minimum set of building equipment variables that define a building equipment on one of said branch circuits;

inputting a minimum subset of building equipment data for said building equipment;

calculating building equipment values for said building equipment variables based on said minimum subset of building equipment data using said standards database containing standards data; and

calculating branch circuit values for each of said branch circuit variables for said branch circuit containing said building equipment.

34. The method of claim **28** wherein the steps of claim **28** are performed by said computer-based system in accordance with at least one computer program stored in a computer readable media, said computer program having a plurality of code sections that are executable by said computer-based system.

35. Computer-readable media storing program code that when executed by a processor within a computer-based system for designing an electrical power distribution system for a building, said program code performs the steps of:

specifying a set of branch circuit variables that define a branch circuit, said branch circuit for distributing electrical power within said building;

specifying a set of panel variables that define a panel;

inputting a minimum subset of panel board data, and repetitively

inputting a minimum subset of branch circuit data for said branch circuit;

calculating branch circuit values for each of said branch circuit variables based on said minimum subset of branch circuit data using a standards database containing standards data associated with an electrical standard for buildings;

calculating panel values for each of said panel variables based on said minimum subset of panel board data and said calculated branch circuit values using said standard data;

changing at least one of said previously calculated panel values; and

recalculating automatically another one of said panel values for a corresponding panel variable in connection with said standards data and in response to said changed panel value.

36. Computer-readable media storing program code that when executed by a processor within a computer-based system for designing an electrical power distribution system for a building, said program code performs the steps of:

specifying a set of branch circuit variables that define a branch circuit, said branch circuit for distributing electrical power within said building;

specifying a set of panel variables that define a panel;

inputting a minimum subset of panel board data, and repetitively

inputting a minimum subset of branch circuit data for a said branch circuit;

calculating branch circuit values for each of said branch circuit variables based on said minimum subset of branch circuit data using a standards database containing standards data associated with an electrical standard for buildings;

changing at least one of said previously calculated branch circuit values;

recalculating automatically another one of said branch circuit values for a corresponding branch circuit variable in connection with said standards data and in response to said changed branch circuit value; and

calculating panel values for each of said panel variables based on said minimum subset of panel board data and said calculated and recalculated branch circuit values using said standards data.

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