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THE COLLEGE OF EARTH AND MINERAL SCIENCES

USBM Grant No. GO-1011729(MIN-42)

EVALUATION OF MINE ELECTRICAL SYSTEMS WITH RESPECT TO SAFETY, TECHNOLOGY, ECONOMICS AND LEGAL CONSIDERATIONS
VOLUME II

Robert Stefanko, Lloyd A. Morley, Atmesh K. Sinha

DEPARTMENT OF MINERAL ENGINEERING
THE PENNSYLVANIA STATE UNIVERSITY

USBM GRANT FINAL REPORT (Grant No. GO-1011729(MIN-42))

July 18, 1973

DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON, D. C.

THE PENNSYLVANIA STATE UNIVERSITY

UNIVERSITY PARK, PENNSYLVANIA

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APPENDIX I

EXPECTED POWER PARAMETERS
FOR CONTINUOUS MINING SECTIONS

APPENDIX I - EXPECTED POWER PARAMETERS FOR CONTINUOUS MINING SECTIONS

The following tables contain the average, maximum and minimum power parameter levels for several mining machines. Power factor is listed only for defined transducer output regions. The reasons for the undefined areas are provided in the Instrumentation Chapter. Several maximum voltage drops are included, and are computed from the no load line-to-line voltage. Again, the drops are from measurements at the low side of the load center. The machines are:

Continuous Miners;

F6A Alpine

76AM Jeffrey (d-c)

8CM Joy

8CM (10CM) Joy

9CM-2AH Joy

10CM Joy

CU-43-2H Joy

2 each CM26H Lee-Norse

CM28E Lee-Norse

Shuttle Cars;

18SC Joy

48S Torkar (a-c)

2 - 10SC Joys input to rectifier

2 - 16SC Joys input to rectifier

Roof Bolters;

LTDO-15 Fletcher

300 Galis

320 Galis

320A Galis

Fans;

Joy 25 hp Axivane Section Fan

Mine specifications are provided with the continuous miners, either at the table bottom, or on the following table. Cross referencing for each machine group (miner, shuttle cars, etc.) is also given.

Table 15. Expected Power Parameters for a F6A Alpine Miner Operating in Pennsylvania's Lower Freeport Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Hydraulic Circuit Motors				
Power	15kW	47kW	0.3kW	0.01	0.03 min.
Current		82A	0A		
Voltage		472V	467V	(Voltage Drop = 1.1%)	
Power Factor	Undefined	0.80	Undefined		
Job Type:	Starting Cutting Motors				
Power	27kW	66kW	0.8kW	0.03	0.06 min.
Current	61A	110A	3.3A		
Voltage	459V	469V	447V	(Voltage Drop - 5.3%)	
Power Factor	0.56	0.78	0.33		
Job Type:	Cutting and Loading (Combined)(Rated Load = 100 hp = 75kW)				
Power	19kW	53kW	9kW	0.57	1.46 min.
Current	42A	84A	35A		
Voltage	464V	464V	459V	(Voltage Drop = 2.8%)	
Power Factor	0.57	0.80	0.33	(Av. Load Factor = 0.25)	
Job Type:	Tramming				
Power	12kW	51kW	2.9kW	0.08	0.39 min.
Current	17A	67A	10A		
Voltage	470V	472V	467V	(Voltage Drop = 1.1%)	
Power Factor	0.86	0.95	0.35		

Machine and Mine Specifications:

Machine: Alpine F6A Miner
Rated Voltage: 440 Vac
Trailing Cable: 850 feet; 2/0 Type G; 600V
Circuit Motors: Cutting = 50 hp Tramming = 10 hp
Conveyor = 2 @ 10 hp Gathering = 2 @ 10 hp

Machine cutting about four feet of hard shale floor below the Lower Freeport seam in Pennsylvania, considerable amount of water present.

Table 16a. Expected Power Parameters for a Jeffrey 76AM (d-c) Continuous Miner Operating in Pennsylvania's Lower Kittanning Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Hydraulic Circuit Motors				
Power	86.2kW	143kW	Lampload	0.03	0.02 min.
Current	---	466A	Lampload		
Voltage	---	320V	310V	(Voltage Drop = 3.1%)	
Job Type:	Idling Hydraulic Circuit Motors Only (Rated Load = 50 hp =37.5kW)				
Power	17.5kW	21.5kW	15kW	0.04	0.15 min.
Current	55A	68A	48A		
Voltage	317V	317V	317V	(Av. Load Factor = 0.47)	
Job Type:	Starting Cutting Motors				
Power	---	159kW	15kW	---	0.08 min.
Current	---	526A	48A		
Voltage	---	309V	303V	(Voltage Drop = 5.3%)	
Job Type:	Cutting and Loading (combined)(Rated Load = 150 hp = 112.5kW)				
Power	101kW	121.5kW	68kW	2.37	1.41 min.
Current	324A	396A	214A	(Av. Load Factor = 0.90)	
Voltage	309V	317V	307V	(Voltage Drop = 4.1%)	
Job Type:	Tramming and Maneuvering				
Power	46kW	51.5kW	40kW	0.22	0.29 min.
Current	146A	164A	127A		
Voltage	315V	317V	314V		

NOTE: See Table 16b for Mine Specifications.

Table 16b. Machine and Mine Specifications for Table 16a.

Machine:	Jeffrey (76AM) Continuous Miner (Colmol).
Rated Voltage:	250Vdc
Trailing Cable:	500 feet; 2/0 Type G
Circuit Motors:	3 @ 50 hp (one each, for tramming, cutting and loading circuits).
Operation:	Retreating 40 by 50 foot pillars, rooms 16 feet wide.
Seam:	Lower Kittanning (B), Pennsylvania
Conditions:	44 inches thick, top and bottom conditions good to excellent, about 600 feet cover, very little convergence noted before retreat.
Production:	Averaged 180 tons per shift.
Supporting Equipment:	2 - Joy 18SC Shuttle cars ACME SPHRD-2 Roof bolter

NOTE: See Table 26 for Shuttle Cars.

Table 17a. Expected Power Parameters for a Joy 8CM Continuous Miner Operating in Pennsylvania's Pittsburgh Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Hydraulic Pump Motor				
Power	102kW	243kW	Lampload	0.03	0.02 min.
Current	---	>600A	Lampload		
Voltage	---	474V	436V	(Voltage Drop = 8.0%)	
Power Factor	Undefined				
Job Type:	Idling Hydraulic Pump Motor				
Power	44.5kW	45kW	44kW	0.16	0.21 min.
Current	83A	84A	81A		
Voltage	454V	458V	453V	(Voltage Drop = 4.4%)	
Power Factor	0.68	0.68	0.68		
Job Type:	Starting Cutting Motors				
Power	126kW	297kW	42kW	0.08	0.04 min.
Current	---	>600A	84A		
Voltage	---	448V	418V	(Voltage Drop = 11.8%)	
Power Factor	Undefined				
Job Type:	Starting Conveyor Motor				
Power	165kW	236kW	117kW		
Current	---	477A	222A		
Voltage	---	450V	445V	(Voltage Drop = 6.1%)	
Power Factor	Undefined				
Job Type:	Cutting and Loading (Combined rated load = 440 hp = 330 kW)				
Power	147kW	256kW	94kW		
Current	354A	570A	264A		
Voltage	445V	450V	425V	(Voltage Drop = 10.3%)	
Power Factor	0.55	0.61	0.46	(Av. Load Factor = 0.45)	
Job Type:	Tramming (Rated load = 130 hp = 97.5kW)				
Power	56.5kW	90kW	39kW	1.49	1.58 min.
Current	132A	147A	90A		
Voltage	465V	470V	460V	(Voltage Drop = 3.0%)	
Power Factor	0.65	0.76	0.53	(Av. Load Factor = 0.58)	
Job Type:	Maneuvering (Rated load = 130 hp = 97.5kW)				
Power	54kW	67.5kW	37kW	0.41	0.45 min.
Current	102A	129A	84A		
Voltage	458V	465V	455V	(Voltage Drop = 4.0%)	
Power Factor	0.60	0.62	0.53	(Av. Load Factor = 0.55)	

Table 17a. Expected Power Parameters for a Joy 8CM Continuous Miner Operating in Pennsylvania's Pittsburgh Seam. (Continued)

Parameter	Average	Max	Min	kWh	Time
Job Type:	Loading (Cutters off, rated load = 180 hp = 135kW)				
Power	70.5kW	85kW	56kW		
Current	147A	174A	132A		
Voltage	465V	465V	455V	(Voltage Drop = 4.2%)	
Power Factor	0.60	0.62	0.53	(Av. Load Factor = 0.52)	

NOTE: See Table 17b for Machine and Mine Specifications.

Table 17b. Machine and Mine Specifications for Table 17a.

Machine:	Joy 8CM Continuous Miner
Rated Voltage:	440Vac
Trailing Cable:	800 feet, 4/0 Type G, 600V
Circuit Motors:	Cutting = 2 @ 130 hp Pump = 130 hp Loading = 50 hp
Operation:	Five entry room and pillar development, 16 foot wide rooms and pillars on 85 x 85 foot centers.
Seam:	Pittsburgh, Pennsylvania
Conditions:	92 inches thick (one 8 to 9 inch shale parting) Excellent top and bottom conditions No water problems (bottom dry) About 300 feet cover Convergence appeared negligible
Production:	720 tons per shift
Supporting Equipment:	2 - Torkar Shuttle Cars Fletcher DDM-3 Roof Bolter

NOTE: See Table 27 for Shuttle Cars.

Table 18a. Expected Power Parameters for a Joy 8CM (Converted to 10CM) Continuous Miner Operating in Pennsylvania's Pittsburgh Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Hydraulic Pump Motor				
Power	60kW	195kW	Lampload	0.01	0.01 min.
Current	180A	>600A	Lampload		
Voltage	503V	505V	500V	(Voltage Drop = 1.0%)	
Power Factor	Undefined				
Job Type:	Idling Hydraulic Pump Motor				
Power	21kW	21kW	20kW	0.05	0.15 min.
Current	60A	60A	58A		
Voltage	500V	500V	500V	(Voltage Drop = 1.0%)	
Power Factor	0.40	0.41	0.40		
Job Type:	Starting Cutting Motors				
Power	120kW	295kW	21kW	0.04	0.02 min.
Current	304A	>600A	60A		
Voltage	495V	500V	480V	(Voltage Drop = 5.0%)	
Power Factor	0.46	0.58	0.40		
Job Type:	Starting Conveyor Motor				
Power	108kW	275kW	75kW	0.02	0.01 min.
Current	212A	426A	159A		
Voltage	498V	498V	490V	(Voltage Drop = 3.0%)	
Power Factor	0.59	0.76	0.55		
Job Type:	Cutting and Loading (Rated load = 350 hp = 262.5kW)				
Power	198kW	>(460)kW	73.5kW	3.08	0.93 min.
Current	315A	>600A	195A		
Voltage	490V	493V	486V	(Voltage Drop = 3.8%)	
Power Factor	0.74	0.91	0.44	(Av. Load Factor = 0.76)	
Job Type:	Cutting Only (Loading motor off, Rated Load = 300 hp = 225kW)				
Power	142kW	>(427)kW	61kW	2.08	0.88 min.
Current	252V	>600V	168V		
Voltage	494V	500V	490V	(Voltage Drop = 3.0%)	
Power Factor	0.66	0.84	0.42	(Av. Load Factor = 0.76)	
Job Type:	Tramming (Rated load = 100 hp = 75kW)				
Power	83kW	110.5kW	72.5kW	2.01	1.45 min.
Current	114A	120A	102A		
Voltage	500V	500V	500V	(Voltage Drop = 1.0%)	
Power Factor	0.84	0.85	0.82	(Av. Load Factor = 1.11)	

Table 18a. Expected Power Parameters for a Joy 8CM (Converted to 10CM) Continuous Miner Operating in Pennsylvania's Pittsburgh Seam. (Continued)

Parameter	Average	Max	Min	kWh	Time
Job Type:	Maneuvering (Rated load = 100 hp = 75kW)				
Power	71KW	108.5kW	28.5kW		0.70 min.
Current	114A	144A	71A		
Voltage	500V	500V	500V	(Voltage Drop = 1.0%)	
Power Factor	0.72	0.87	0.46	(Av. Load Factor = 1.11)	

NOTE: See Table 18b for Machine and Mine Specifications.

Table 18b. Machine and Mine Specifications for Table 18a.

Machine:	Joy 8CM(Cutter head converted to 10CM) Continuous Miner.
Rated Voltage:	440Vac.
Trailing Cable:	500 feet; 4/0 Type G-GC, 600V
Circuit Motors:	Cutting = 2 @ 100 hp Pump = 100 hp Conveyor = 50 hp
Operation:	Seven entry room and pillar development, 50 by 80 foot pillars, rooms 16 feet wide.
Seam:	Pittsburgh, Southwestern Pennsylvania
Conditions:	93 inches thick (some shale partings) Roof and floor conditions excellent Water problems minor, Approximately 300 feet cover, Convergence appeared negligible.
Production:	450 tons per shift
Supporting Equipment:	2 - Joy 10SC Shuttle Cars Galis 320A Roof Bolter 2 - Joy Axivane Section Fans

NOTE: Shuttle cars powered from trolley electrical system.

All operational curves provided in text, Chapter 2.

Table 19. Expected Power Parameters for a Joy 9CM-2AH Continuous Miner Operating in West Virginia's Pittsburgh Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting All Motors				
Power	102kW	240kW	Lampload	---	---
Current	---	384A	Lampload		
Voltage	490V	495V	475V	(Voltage Drop = 4.0%)	
Power Factor	Undefined				
Job Type:	Cutting and Loading (Combined) (Rated Load = 345 hp = 258kW)				
Power	120kW	150kW	55kW	9.64	4.82 min.
Current	240A	300A	120A		
Voltage	480V	485V	480V	(Voltage Drop = 3.0%)	
Power Factor	0.60	0.60	0.55	(Av. Load Factor = 0.47)	
Job Type:	Tramming and Maneuvering				
Power	36kW	49kW	23kW	2.31	3.85 min.
Current	74A	90A	65A		
Voltage	490V	490V	490V		
Power Factor	0.57	0.65	0.42		

Mine and Machine Specifications:

Machine:	Joy 9CM-2AH Continuous Miner
Rated Voltage:	440 Vac
Trailing Cable:	500 feet, 4/0 Type G, 600V
Circuit Motors:	3 @ 115 hp (one each for tramming, cutting and loading circuits)
Operation:	Room and pillar, cutting butt
Seam:	Pittsburgh, West Virginia
Conditions:	60 inches thick
Production:	195 tons per shift
Supporting Equipment:	2 - Torkar 48-S6-36A1 Shuttle Cars Fletcher DOB 13 C8X Roof Bolter

Table 20a. Expected Power Parameters for a Joy 10CM Continuous Miner Operating in Ohio's Pittsburgh Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Hydraulic Pump Motor				
Power	56kW	200kW	Lampload	0.01	0.01 min.
Current	60A	240A	Lampload		
Voltage	1090V	1100V	1075	(Voltage Drop = 2.3%)	
Power Factor	Undefined				
Job Type:	Idling Hydraulic Pump Motor				
Power	20kW	20kW	20kW	0.02	0.07 min.
Current	35A	35A	35A		
Voltage	1085V	1085V	1085V	(Voltage Drop = 1.4%)	
Power Factor	0.30	0.30	0.30		
Job Type:	Starting Cutting Motors (Simultaneous, no delays)				
Power	196kW	780kW	20kW	0.07	0.02 min.
Current	200A	850A	35A		
Voltage	1040V	1085V	980V	(Voltage Drop = 10.9%)	
Power Factor	0.54	0.54	0.30		
Job Type:	Starting Conveyor Motor (all other motors running)				
Power	160kW	225kW	97kW	0.03	0.01 min.
Current	207A	250A	155A		
Voltage	1060V	1060V	1060V	(Voltage Drop = 3.6%)	
Power Factor	0.42	0.49	0.34		
Job Type:	Cutting and Loading (Rated load = 535 hp = 401kW)				
Power	181kW	258kW	76kW	4.22	1.4 min.
Current	220A	330A	165A		
Voltage	1055V	1060V	1050V	(Voltage Drop = 4.5%)	
Power Factor	0.45	0.54	0.25	(Av. Load Factor = 0.45)	
Job Type:	Idling all Motors except Conveyor				
Power	130kW	130kW	130kW	0.26	0.12 min.
Current	155A	155A	155A		
Voltage	1060V	1060V	1060V	(Voltage Drop = 3.6%)	
Power Factor	0.46	0.46	0.46		
Job Type:	Maneuvering (Pump Motor only)				
Power	40kW	52kW	30.5kW	0.43	0.65 min.
Current	42A	50A	35A		
Voltage	1090V	1090V	1085V	(Voltage Drop = 1.4%)	
Power Factor	0.50	0.55	0.46		

Table 20a. Expected Power Parameters for Joy 10CM Continuous Miner Operating in Ohio's Pittsburgh Seam. (Continued)

Parameter	Average	Max	Min	kWh	Time
Job Type:	Tramming (Rated load = 135 hp = 101 kW)				
Power	40kW	60kW	26kW	3.02	4.54 min.
Current	42A	58A	30A		
Voltage	1076V	1080V	1070V	(Voltage Drop = 2.7%)	
Power Factor	0.51	0.56	0.46	(Av. Load Factor = 0.40)	

NOTE: See Table 20b for Machine and Mine Specifications.

Table 20b. Machine and Mine Specifications for Table 20a.

Machine:	Joy 10CM Continuous Miner
Rated Voltage:	950 Vac
Trailing Cable:	550 feet, 1/0 Type G-GC, 1000V
Circuit Motors:	Cutting = 2 @ 175 hp Pump = 135 hp Conveyor = 50 hp
Operation:	Room and pillar development, rooms 16 feet wide and pillars on 50 foot centers. Miner cuts about 73 inches (leaving five inches of top coal).
Seam:	Pittsburgh, Southeastern Ohio
Conditions:	78 inches thick (some shale parting) coal rather friable, immediate roof composed of soft, faulted shale - numerous small roof falls, floor conditions good to excellent, water problems minor, cover approximately 600 feet, some convergence noted with apparent rib sloughing.
Production:	650 tons per shift
Supporting Equipment:	2 - Joy 10SC Shuttle Cars 2 - Galis 320 Roof Bolters Joy Axivane Section Fan

NOTE: See Table 28 for Shuttle Cars.

Table 21a. Expected Power Parameters for a Joy CU-43-2H ("Compton") Continuous Miner Operating in Pennsylvania's Lower Kittanning Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Hydraulic Circuit Motors				
Power	27kW	42kW	Lampload	0.01	0.01 min.
Current	---	90A	Lampload		
Voltage	---	455V	450V	(Voltage Drop = 1.1%)	
Power Factor	Undefined				
Job Type:	Idling Hydraulic Circuit Motors Only				
Power	14kW	18kW	11.4kW	0.48	2.07 min.
Current	74A	83A	72A		
Voltage	455V	455V	455V		
Power Factor	0.24	0.28	0.20		
Job Type:	Starting Cutting Motors				
Power	100kW	201.5kW	22kW	0.08	0.05 min.
Current	---	536A	72A		
Voltage	---	455V	430V	(Voltage Drop = 5.5%)	
Power Factor	0.26	0.38	0.16		
Job Type:	Cutting and Loading (Rated load* = 285/345 hp = 214/259kW)				
Power	73kW	171kW	31kW	2.56	2.10 min.
Current	221A	284A	174A		
Voltage	442V	447A	440A	(Voltage Drop = 3.3%)	
Power Factor	0.43	0.79	0.23	(Av. Load Factor*=0.34/ 0.28)	
Job Type:	Tramming and Maneuvering				
Power	26kW	46kW	11kW	0.19	0.43 min.
Current	84A	96A	72A		
Voltage	455V	455V	450V	(Voltage Drop = 1.1%)	
Power Factor	0.39	0.61	0.20		

* Miner has two-speed pump circuit motor.

NOTE: See Table 21b for Machine and Mine Specifications.

Table 21b. Machine and Mine Specifications for Table 21a.

Machine:	Joy CU-43-2H ("Compton") Continuous Miner.
Rated Voltage:	440 Vac
Trailing Cable:	800 feet, 2/0 Type G, 600V
Circuit Motors:	Cutting = 2 @ 115 hp Pump = 35/95 hp two-speed Loading = 2 @ 10 hp
Operation:	Three entry development for retreating longwall, 16 foot wide rooms and pillars 40 by 60 feet.
Seam:	Lower Kittanning (B), Pennsylvania
Conditions:	42 inches thick, weak roof, immediate floor poor (about two feet of fire clay with hard sandstone below), water present, cover about 400 feet, convergence rather severe.
Production:	50 tons per shift
Supporting Equipment:	2 - Joy 18SC Shuttle Cars Galis 300 Roof Bolter

NOTE: See Table 26 for Shuttle Cars.

Table 22. Expected Power Parameters for a Lee-Norse CM26H Continuous Miner Operating in Pennsylvania's Lower Freeport Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Hydraulic Circuit Motors				
Power	108.5kW	256kW	Lampload	0.08	0.04 min.
Current	---	>600A	Lampload		
Voltage	---	610V	580V	(Voltage Drop = 4.9%)	
Power Factor	Undefined				
Job Type:	Idling Hydraulic Circuit Motors				
Power	61kW	75kW	39kW	0.06	0.06 min.
Current	115A	120A	104A		
Voltage	600V	610V	600V	(Voltage Drop = 1.6%)	
Power Factor	0.51	0.60	0.36		
Job Type:	Starting Cutting Motors				
Power	108kW	308.5kW	54.5kW	0.18	0.06 min.
Current	---	>600A	112A		
Voltage	---	600V	575V	(Voltage Drop = 5.7%)	
Power Factor	0.50	0.60	0.42		
Job Type:	Cutting and Loading (Rated load = 400 hp = 300kW)				
Power	131.5kW	(376)kW*	89kW	0.66	0.30 min.
Current	224A	468A	204A		
Voltage	595V	600V	580V	(Voltage Drop = 4.9%)	
Power Factor	0.57	0.80	0.42	(Av. Load Factor = 0.44)	
Job Type:	Tramming and Maneuvering				
Power	71kW	158kW	40.6kW	0.40	0.34 min.
Current	132A	185A	108A		
Voltage	600V	603V	595V	(Voltage Drop = 2.5%)	
Power Factor	0.52	0.83	0.36		

* Power Strip Chart off-range, value in parenthesis calculated.

NOTE: See Table 24 for Machine and Mine Specifications.

Table 23. Expected Power Parameters for a Lee-Norse CM26H Continuous Miner Operating in Pennsylvania's Lower Freeport Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Hydraulic Circuit Motors				
Power	97.5kW	254kW	Lampload	0.07	0.04 min.
Current	---	>600A	Lampload		
Voltage	---	600V	570V	(Voltage Drop = 5%)	
Power Factor	Undefined				
Job Type:	Idling Hydraulic Circuit Motors				
Power	77.5kW	87.5kW	61kW	0.04	0.03 min.
Current	118A	120A	96A		
Voltage	592V	592V	592V		
Power Factor	0.64	0.71	0.62		
Job Type:	Starting Cutting Motors				
Power	162kW	>300kW	57.5kW	0.11	0.04 min.
Current	---	>600A	99A		
Voltage	---	592V	562V	(Voltage Drop = 6.3%)	
Power Factor	0.48	0.52	0.45		
Job Type:	Cutting and Loading (Rated load = 400 hp = 300kW)				
Power	136kW	291kW	73kW	5.42	2.39 min.
Current	219A	381A	168A		
Voltage	588V	595V	573V	(Voltage Drop = 4.5%)	
Power Factor	0.61	0.77	0.42	(Av. Load Factor = 0.45)	
Job Type:	Tramming and Maneuvering				
Power	67kW	108kW	29.5kW	1.54	1.38 min.
Current	115A	144A	99A		
Voltage	588V	595V	585V	(Voltage Drop - 2.5%)	
Power Factor	0.57	0.74	0.29		

NOTE: See Table 24 for Machine and Mine Specifications.

Table 24. Machine and Mine Specifications for Tables 22 and 23.

Machines:	Lee-Norse CM26H Continuous Miners, Both machines identical in specifications except operated in adjacent mine sections.
Rated Voltage:	550 Vac
Trailing Cable:	500 feet, 4/0 Type G, 600V
Circuit Motors:	Cutting = 2 @ 100 hp Loading = 100 hp Tramming = 100 hp
Operation:	Main entry development for room and pillar, three entry pattern with 40 by 80 foot pillars and 16 foot wide rooms.
Seam:	Lower Freeport, Pennsylvania
Conditions:	42 inches thick, roof rather shoft shale, hard shale bottom, severe water conditions, 400 feet of cover, considerable convergence after mining.
Production:	50 tons per shift
Supporting Equipment:	2 - Joy 18SC Shuttle Cars Fletcher LTDO-15 Roof Bolter

NOTE: See Table 26 for Shuttle Cars.

Table 25a. Expected Power Parameters for a Lee-Norse CM28E Continuous Miner Operating in Pennsylvania's Lower Freeport Seam.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting all Motors				
Power	---	212kW	Lampload	---	0.17 min.
Current	---	340A	Lampload		
Voltage	---	468V	435V	(Voltage Drop = 7.1%)	
Power Factor	0.45	0.52	0.35		
Job Type:	Idling Hydraulic Circuit Motors Only				
Power	25kW	31kW	24.5kW	0.03	0.06 min.
Current	120A	120A	120A		
Voltage	462V	468V	455V	(Voltage Drop = 2.8%)	
Power Factor	0.26	0.33	0.25		
Job Type:	Idling all Circuit Motors				
Power	80.5kW	80.5kW	80.5kW	0.11	0.08 min.
Current	240A	240A	240A		
Voltage	450V	450V	450V		
Power Factor	0.43	0.43	0.43		
Job Type:	Cutting and Loading (Rated load = 250 hp = 188 kW)				
Power	89.5kW	157.5kW	73kW	4.33	2.90 min.
Current	251A	305A	240A		
Voltage	448V	450V	445V	(Voltage Drop = 4.9%)	
Power Factor	0.46	0.67	0.39	(Av. Load Factor = 0.48)	

NOTE: See Table 25b for Machine and Mine Specifications.

Table 25b. Machine and Mine Specifications for Table 25a.

Machine:	Lee-Norse CM28E Continuous Miner
Rated Voltage:	440 Vac
Trailing Cable:	500 feet; 2/0 Type G, 600V
Circuit Motors:	Cutting = 2 @ 50 hp Loading = 2 @ 50 hp Tramming = 50 hp
Operations:	Three entry development for a retreating longwall panel, 16 foot wide rooms and pillars 40 by 60 feet. Machine cutting entire seam plus two feet of fire clay floor.
Seam:	Lower Kittanning (B), Pennsylvania
Conditions:	Same mine as 21b, different section, 42 inches coal, weak roof, immediate floor poor (about two feet of fire caly with hard sandstone below), water present, cover approximately 400 feet, convergence rather severe.
Production:	50 tons per shift
Supporting Equipment:	2 - Joy 18SC Shuttle Cars Galis 300 Roof Bolter

NOTE: See Table 26 for Shuttle Cars.

Table 26. Expected Parameter Values for a Joy 18SC Shuttle Car.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Tramming Empty				
Power	4.5kW	12.3kW	1.0kW	0.05	0.67 min.
Current	14A	38A	2.8A		
Voltage	320Vdc	335Vdc	325Vdc		
Job Type:	Tramming Loaded				
Power	7.5kW	19.5kW	1.0kW	0.10	0.77 min.
Current	24A	62.5A	3.0A		
Voltage	313Vdc	320Vdc	312Vdc		
Job Type:	Loading				
Power	3.2kW	12.4kW	1.5kW	0.06	1.16 min.
Current	10A	39.6A	4.8A		
Voltage	316Vdc	322Vdc	312Vdc		
Job Type:	Unloading				
Power	3.5kW	5.3kW	1.6kW	0.04	0.69 min.
Current	11A	16.8A	5.0A		
Voltage	318Vdc	320Vdc	313Vdc		

Mine Specifications:	See Tables 15, 16b, 21b, 24 and 25b.
Machine:	Joy 18SC Shuttle Car
Circuit Motors	10 hp Conveyor 15 hp hydraulic pump 2 @ 15 hp traction
Rated Voltage:	250 Vdc
Trailing Cables:	500 feet; #2, Type G, 600V

Table 27. Expected Power Parameters for Type 48S Torkar.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Loading				
Power	13kW	56kW	10kW	0.17	0.77 min.
Current	34A	>150A	27A		
Voltage	453V	460V	435V		
Power Factor	0.49	0.50	<0.46		
Job Type:	Start Tramming Motor				
Power	---	57kW	---	---	0.01 min.
Current	---	>150A	---		
Voltage	---	460V	---		
Power Factor	---	<0.48	---		
Job Type:	Tramming, Loaded				
Power	21kW	54kW	8kW	0.18	1.05 min.
Current	60A	>150A	25A		
Voltage	450V	450V	420V		
Power Factor	0.45	0.49	<0.41		
Job Type:	Unloading				
Power	10.5kW	14kW	7kW	0.11	0.6 min.
Current	54A	86A	25A		
Voltage	450V	470V	450V		
Power Factor	0.25	0.34	0.21		
Job Type:	Starting Tramming Motor				
Power	38kW	46kW	11kW	0.16	0.25 min.
Current	96A	>150A	18A		
Voltage	455V	460V	420V		
Power Factor	0.50	0.77	<0.42		
Job Type:	Tramming Empty				
Power	11kW	16kW	7kW	0.22	1.2 min.
Current	41A	53A	27A		
Voltage	448V	450V	430V		
Power Factor	0.35	0.41	0.33		

Mine Specifications:	Table 17b.
Machine Specifications:	Torkar Type 48S Shuttle Car
Circuit Motor:	60 hp Single Motor Torque Converter - Seven Clutch Drive
Rated Voltage:	440 Vac
Trailing Cable:	#2, Type G Flat, 600V

Table 28. Expected Power Parameters for the Rectifier Input which Feeds Two (2) Joy 10SC Shuttle Cars.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Car No. 20 Loading and Car No. 17 Tramming				
Power	49.3kW	93.7kW	22.4kW	0.41	0.5 min.
Current	78A	141A	36A		
Voltage	500V	512V	500V		
Power Factor	0.73	0.75	0.72		
Job Type:	Both Cars Tramming				
Power	31.6kW	33kW	30.6kW	0.15	0.28 min.
Current	49.5A	51A	48A		
Voltage	512V	512V	512V		
Power Factor	0.72	0.73	0.72		
Job Type:	Car No. 17 Unloading and Car No. 20 Tramming				
Power	48kW	93.5kW	17.4kW	0.96	1.2 min.
Current	76A	146A	28A		
Voltage	500V	500V	500V		
Power Factor	0.73	0.74	0.72		

Mine Specifications:	See Table 20b.
Machine Specifications:	Ensign 200kW Rectifier Input: 480 Vac; Output: 300 Vdc Joy 10SC Shuttle Cars
Circuit Motors:	10 hp conveyor 15 hp hydraulic pump 2 @ 15 hp traction
Rated Voltage:	250 Vdc
Trailing Cables:	500 feet, #2, Type G, 600V.

Table 29. Expected Parameter Values of Input to Rectifier Bank, Two Joy 16SC Shuttle Cars on Load.

Parameter	Average	Max	Min
Overall Expected Values			
Power	9kW	27kW	0kW
Current	11A	28A	0A
Voltage	490V	490V	485V
Power Factor	0.97	1.00	0.30
Job Type:	One Shuttle Car Unloading Only		
Power	11kW	18kW	6kW
Current	13A	18A	8A
Voltage	490V	490V	490V
Power Factor	0.98	1.00	0.50

Machine Specifications:

Joy 16SC Cars

Circuit Motors: 10 hp conveyor
15 hp hydraulic pump
2 @ 15 hp traction

Rated voltage: 250 Vdc

Trailing Cables: 500 feet; #2, Type G, 600V

Table 30. Expected Parameter Values for a Fletcher LTDO-15 Roof Bolter.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Motor				
Power	23kW	50.5kW	0kW	0.01	0.01 min.
Current	---	>150A	0A		
Voltage	---	580V	570V		
Power Factor	Undefined				
Job Type:	Drilling and Bolting				
Power	13kW	19kW	9kW	0.34	1.58 min.
Current	25A	28A	23A		
Voltage	580V	582V	570V		
Power Factor	0.52	0.70	0.40		
Job Type:	Tramming				
Power	15kW	19kW	9.5kW	0.41	1.64 min.
Current	25A	29A	22A		
Voltage	575V	580V	560V		
Power Factor	0.60	0.68	0.42		

Mine Specifications: See Table 24.

Machine Specifications:

Fletcher LTDO-15 Roof Bolter

Motor: 40 hp

Rated Voltage: 440 Vac

Cable: 500 feet, #2, Type G, 600V

Table 31. Expected Parameter Values for Galis 300 Roof Bolter.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Hydraulic Circuit Motor				
Power	---	58kW	0.0	---	0.01 min.
Current	---	130A	0.0		
Volts	460V	460V	460V		
Power Factor	Undefined				
Job Type:	Idling Circuit Motor				
Power	9.5kW	9.5kW	9.5kW	0.05	0.29 min.
Current	26A	27A	25A		
Volts	460V	460V	460V		
Power Factor	0.46	0.49	0.44		
Job Type:	Bolting				
Power	16kW	27kW	9kW	0.06	0.25 min.
Current	32A	41A	26A		
Volts	460V	460V	460V		
Power Factor	0.62	0.82	0.41		
Job Type:	Drilling				
Power	25kW	31kW	23kW	0.36	0.87 min.
Current	39A	46A	36A		
Voltage	460V	462V	460V		
Power Factor	0.81	0.84	0.79		
Job Type:	Tramming and Maneuvering				
Power	13kW	28kW	9kW	0.37	1.71 min.
Current	29A	42A	26A		
Voltage	460V	460V	460V		
Power Factor	0.56	0.85	0.40		

Mine Specifications: See Table 21b.

Machine Specifications:

Galis 300 Roof Bolter

Motor: 40 hp

Rated Voltage: 440 Vac

Trailing Cable: 500 feet, #2, Type G, 600V

Table 32. Expected Power Parameters for Galis 320 Roof Bolter.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Drilling				
Power	18.8kW	28.16kW	12.64kW	0.135	0.43 min.
Current	36A	45A	29.5A		
Voltage	495V	495V	495V		
Power Factor	0.61	0.73	0.50		
Job Type:	Changing Steel				
Power	13.4kW	18.5kW	7.8kW	0.04	0.16 min.
Current	27.5A	30A	26A		
Voltage	495V	495V	495V		
Power Factor	0.57	0.72	0.35		
Job Type:	Drilling				
Power	24.1kW	28.6kW	17.1kW	0.06	0.16 min.
Current	39A	44A	33A		
Voltage	495V	501V	440V		
Power Factor	0.72	0.75	0.68		
Job Type:	Idling				
Power	8.6kW	11.5kW	7.43kW	0.07	0.45 min.
Current	26A	27A	25A		
Voltage	490V	490V	490V		
Power Factor	0.39	0.5	0.35		
Job Type:	Install Bolt				
Power	8.71kW	10.3kW	7.13kW	0.02	0.11 min.
Current	27A	31A	24A		
Voltage	490V	490V	490V		
Power Factor	0.38	0.39	0.35		
Job Type:	Maneuver				
Power	15.68KW	32.67kW	6.93kW	0.21	0.81
Current	33A	49A	25A		
Voltage	490V	500V	485V		
Power Factor	0.56	0.77	0.33		

Mine Specifications: See Table 20b.

Machine Specifications:

Galis 320 Roof Bolter

Motor: 40 hp

Rated Voltage: 440 Vac

Trailing Cable: 500 feet, #4, Type G-GC, 600V

Table 33. Expected Parameter Values for a Galis 320A Roof Bolter.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting Motors				
Power	---	58KW	Lampload	---	0.01 min.
Current	---	>150A	Lampload		
Voltage	---	505V	490V		
Power Factor	Undefined				
Job Type:	Tramming				
Power	10kW	21kW	5.5kW	0.04	0.27 min.
Current	41A	64A	33A		
Voltage	500V	503V	497V		
Power Factor	0.27	0.38	0.19		
Job Type:	Drilling				
Power	19kW	28.5kW	11kW	0.14	0.43 min.
Current	58A	81A	41A		
Voltage	500V	502V	497V		
Power Factor	0.38	0.41	0.31		
Job Type:	Torquing Bolt				
Power	10.5kW	23kW	6kW	0.01	0.07 min.
Current	42A	69A	35A		
Voltage	500V	505V	500V		
Power Factor	0.29	0.38	0.19		
Job Type:	Idling Motor				
Power	5kW	5kW	5kW	0.04	0.47 min.
Current	32A	32A	32A		
Voltage	500V	500V	500V		
Power Factor	0.18	0.18	0.18		

Mine Specifications: See Table 9.

Machine Specifications:

Galis 320A Roof Bolter

Motor: 30 hp

Rated Voltage: 440 Vac

Trailing Cable: 600 feet, #4, Type G, 600V

Table 34. Expected Power Parameters for a Joy Axivane Section Fan.

Parameter	Average	Max	Min	kWh	Time
Job Type:	Starting				
Power	51kW	60kW	0kW	0.07	0.08 min.
Current	120A	>150A	0A		
Voltage	495V	505V	495V		
Power Factor	Undefined				
Job Type:	Running				
Power	6kW	6kW	6kW	---	Continuous
Current	17A	17A	17A		
Voltage	500V	505V	498V		
Power Factor	0.40	0.40	0.40		

Mine Specifications: See Table 18b.

Fan Specifications:

Rated Voltage: 460Vac

Motor: 25 hp

Trailing Cable: 600 feet, #6, Type G

APPENDIX II

POWER PARAMETER DYNAMIC CURVES

APPENDIX II - POWER PARAMETER DYNAMIC CURVES

Contained in this appendix are several typical operational cycles for continuous miner section equipment. An operational cycle is the dynamic power parameter curve set during a combination of job types (for example, start motors, cut-load and stop motors). The curves here are produced by the same technique described in the strip chart section of the Instrumentation chapter. The figures, therefore, read right to left because they are tracings of actual strip chart output.

The following machine electrical parameters are provided. Table numbers in parentheses refer to Appendix I for mine information, and the curves covered in Chapter 2 (Figures 2 through 11) are not included. Multiple job types listed after the figure number are usually sequenced events.

Continuous Miners

F6A Alpine	(Table 15),	Figure 76.	Operational
76AM Jeffrey	(Table 16),	Figure 77.	Operational
8CM Joy	(Table 17),	Figure 78.	Tram-Cut
		Figure 79.	Cut
10CM Joy	(Table 20),	Figure 80.	Cut
		Figure 81.	Tram-Cut
CU-43-2H Joy	(Table 21),	Figure 82.	Cut
		Figure 83.	Tram-Cut
CM26H Lee-Norse	(Table 22),	Figure 84.	Cut
		Figure 85.	Tram
CM26H Lee-Norse	(Table 23),	Figure 86.	Tram-Cut
		Figure 87.	Tram
		Figure 88.	Cut
CM28E Lee-Norse	(Table 25),	Figure 89.	Cut

Shuttle Cars

18SC Joy	(Table 26),	Figure 90.	Operational
48S Torkar	(Table 27),	Figure 91.	Load-Tram Loaded
		Figure 92.	Unload-Tram Empty
10SC Joy	(Table 28),	Figure 93.	Rectifier Input

Roof Bolters

LTDO-15 Fletcher	(Table 30),	Figure 94.	Drill-Bolt
		Figure 95.	Tram
300 Galis	(Table 31),	Figure 96.	Drill
		Figure 97.	Bolt-Tram

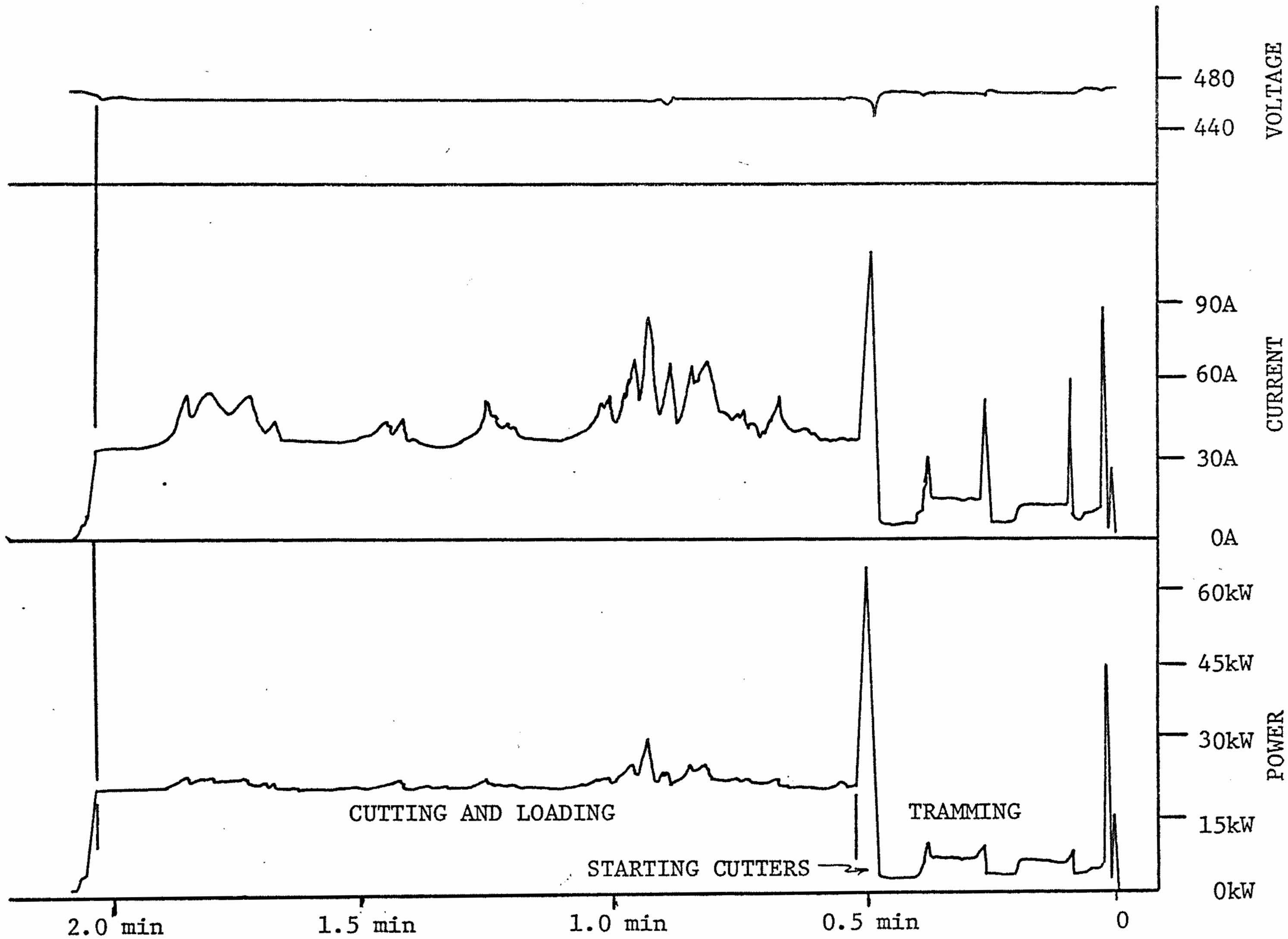

Figure 76a. Power, Current and Voltage Performance Cycles for a F6A Alpine Cutting Shale.

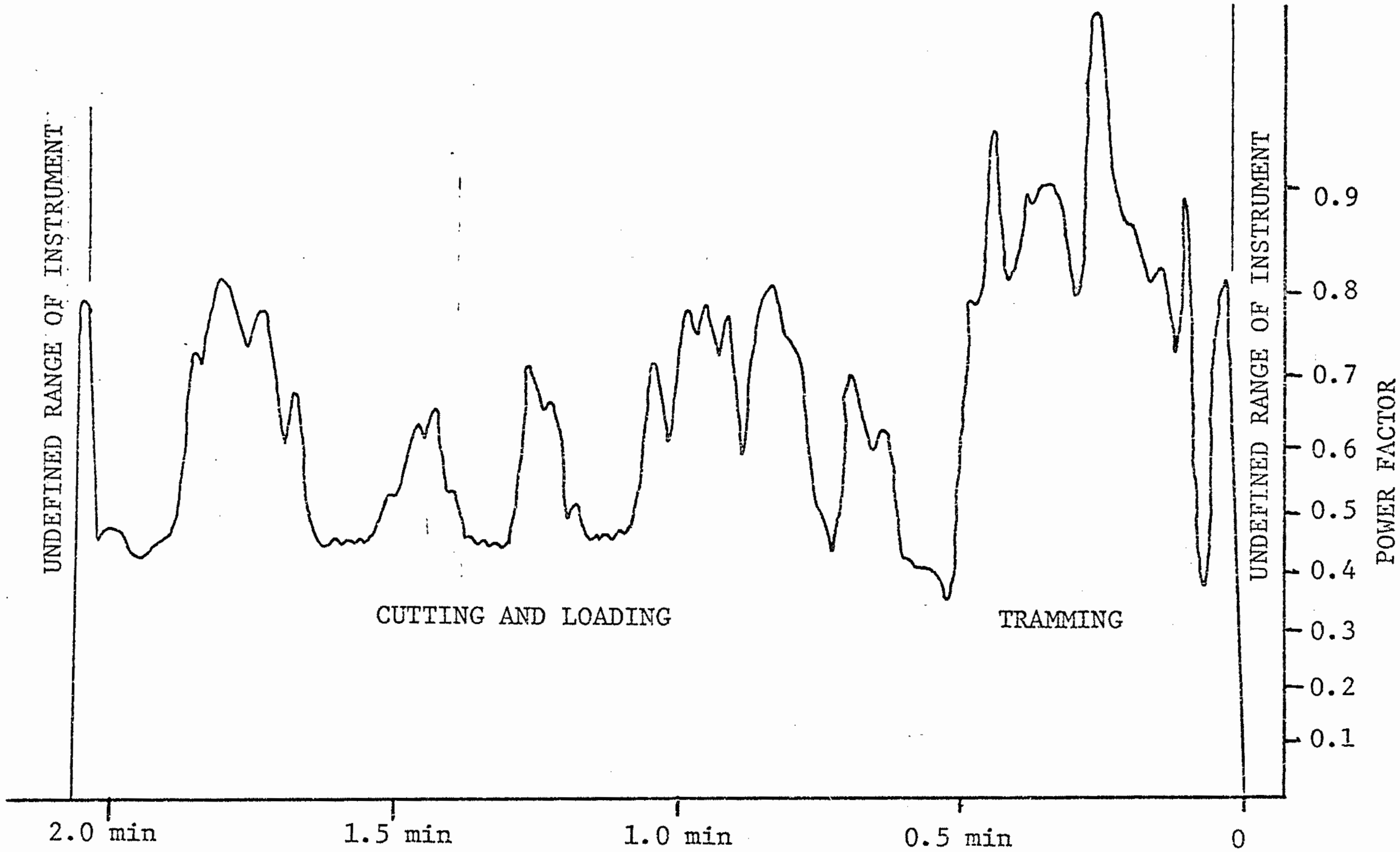

Figure 76b. Power Factor Performance Cycle for a F6A Alpine Cutting Shale.

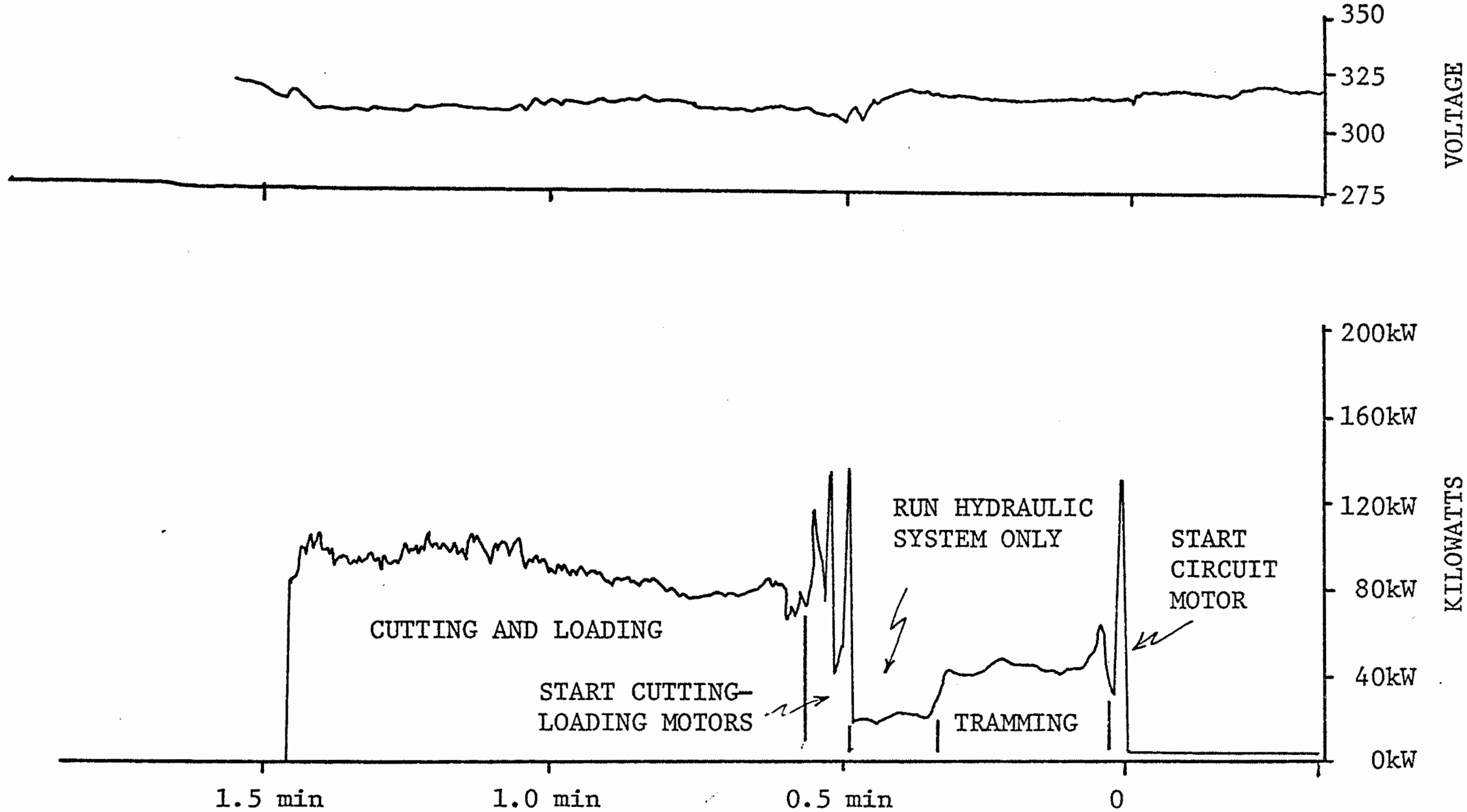

Figure 77a. Power and Voltage Operational Cycles for a Jeffery 76AM Continuous Miner (d-c).

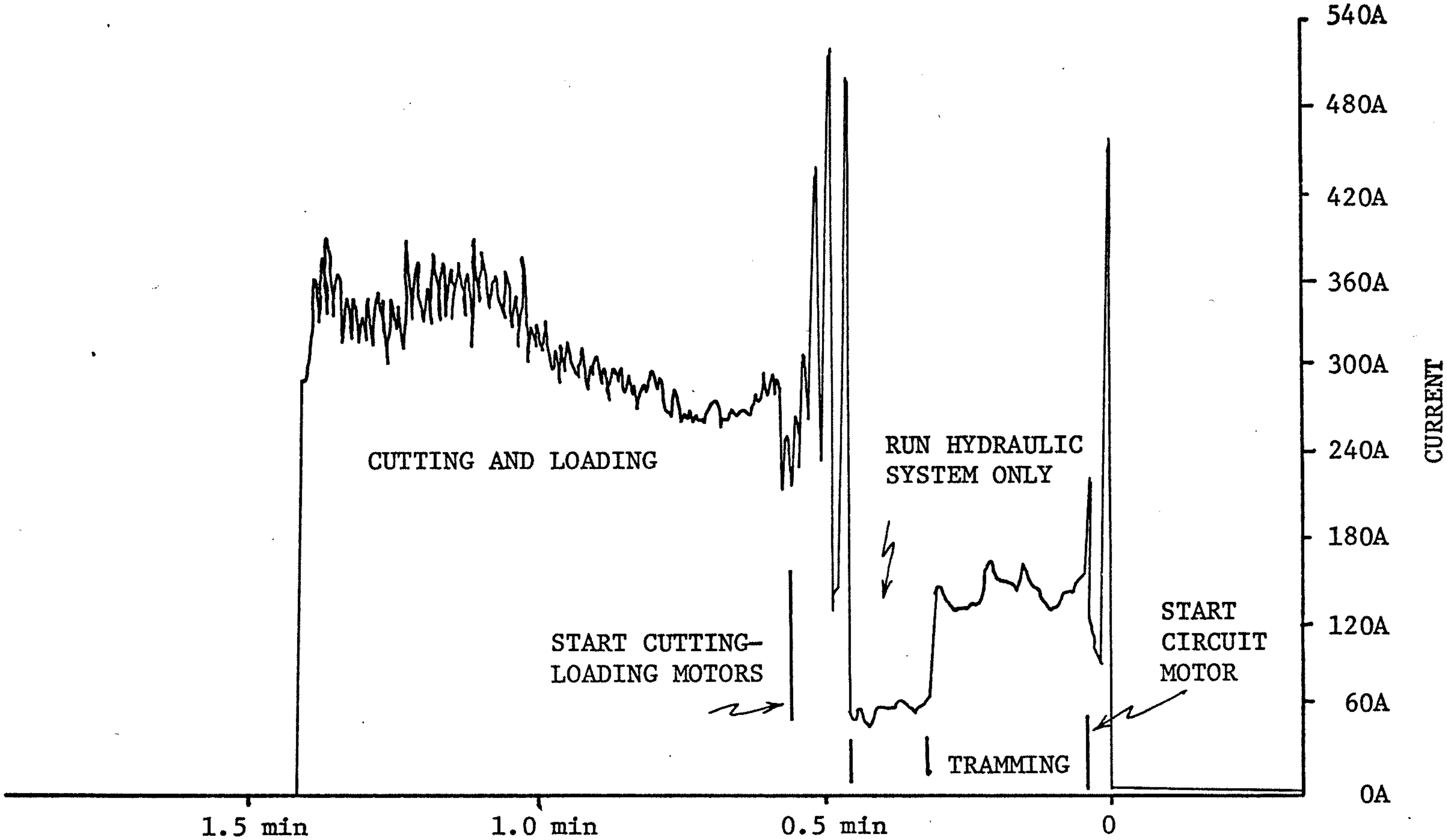

Figure 77b. Current Operational Cycle for a Jeffery 76AM Continuous Miner.

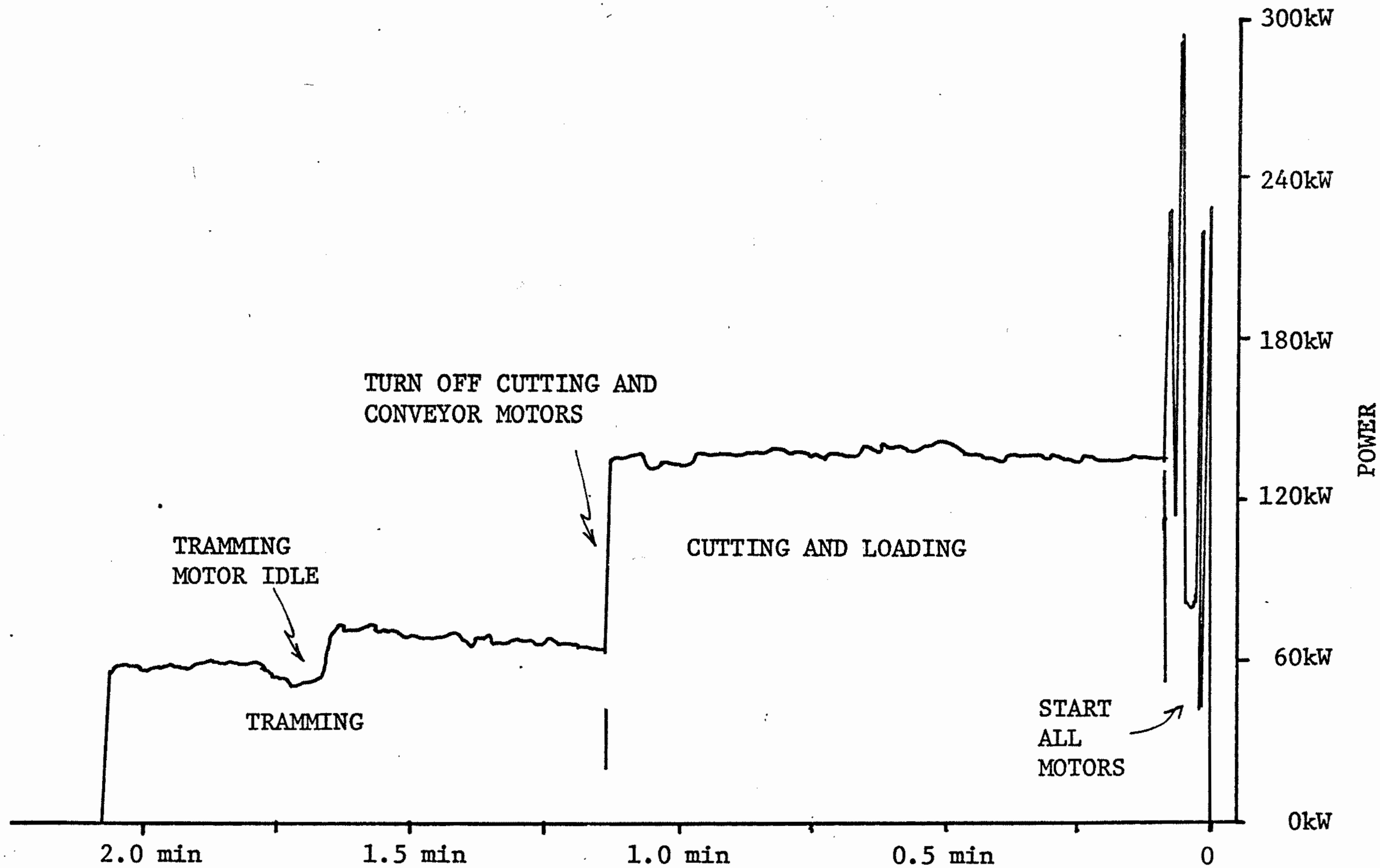

Figure 78a. Cutting, Loading and Tramming Power Cycle for a Joy 8CM Continuous Miner (440V).

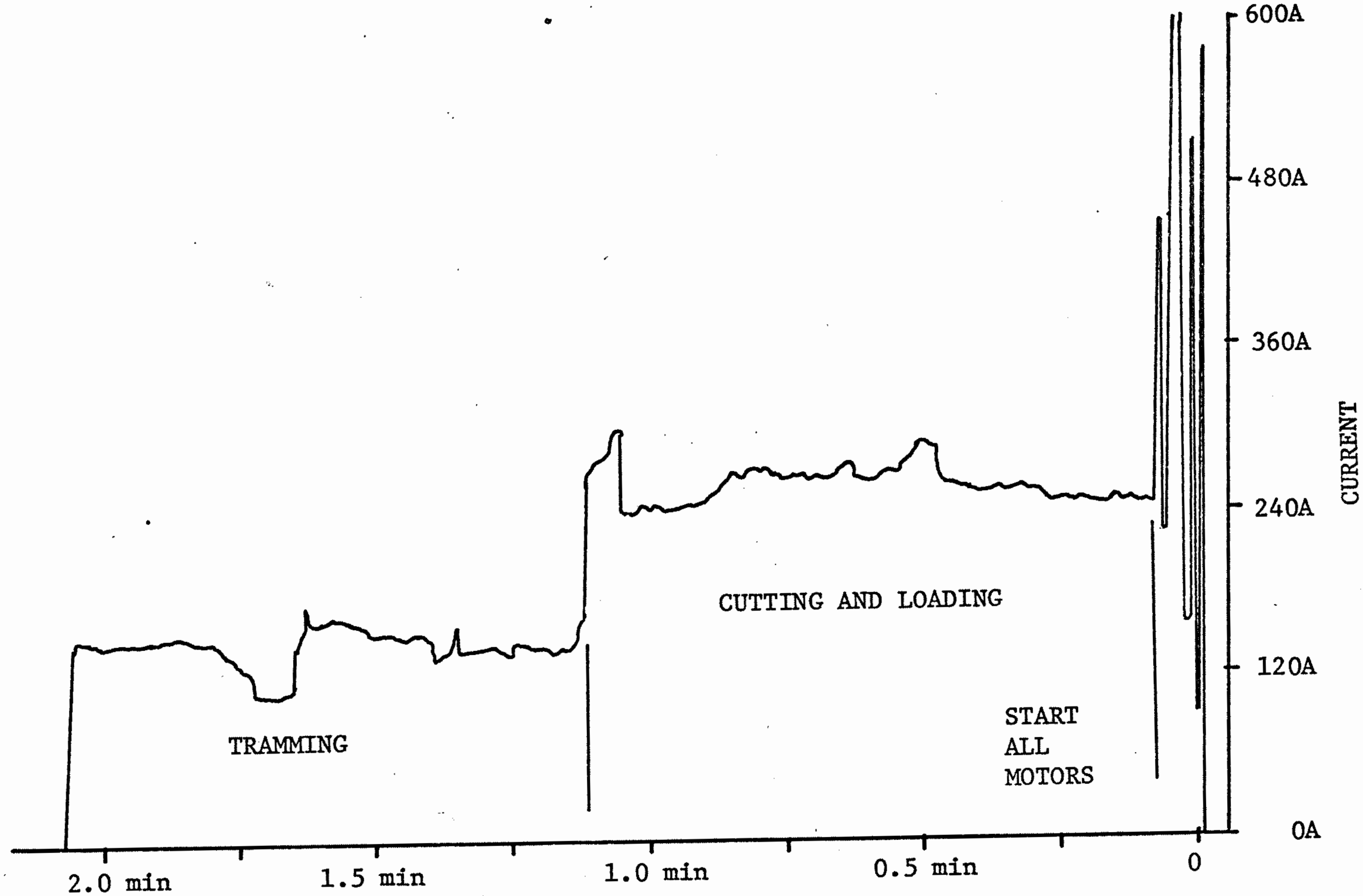

Figure 78b. Cutting, Loading and Tramming Current Cycle for a Joy 8CM Continuous Miner (440V).

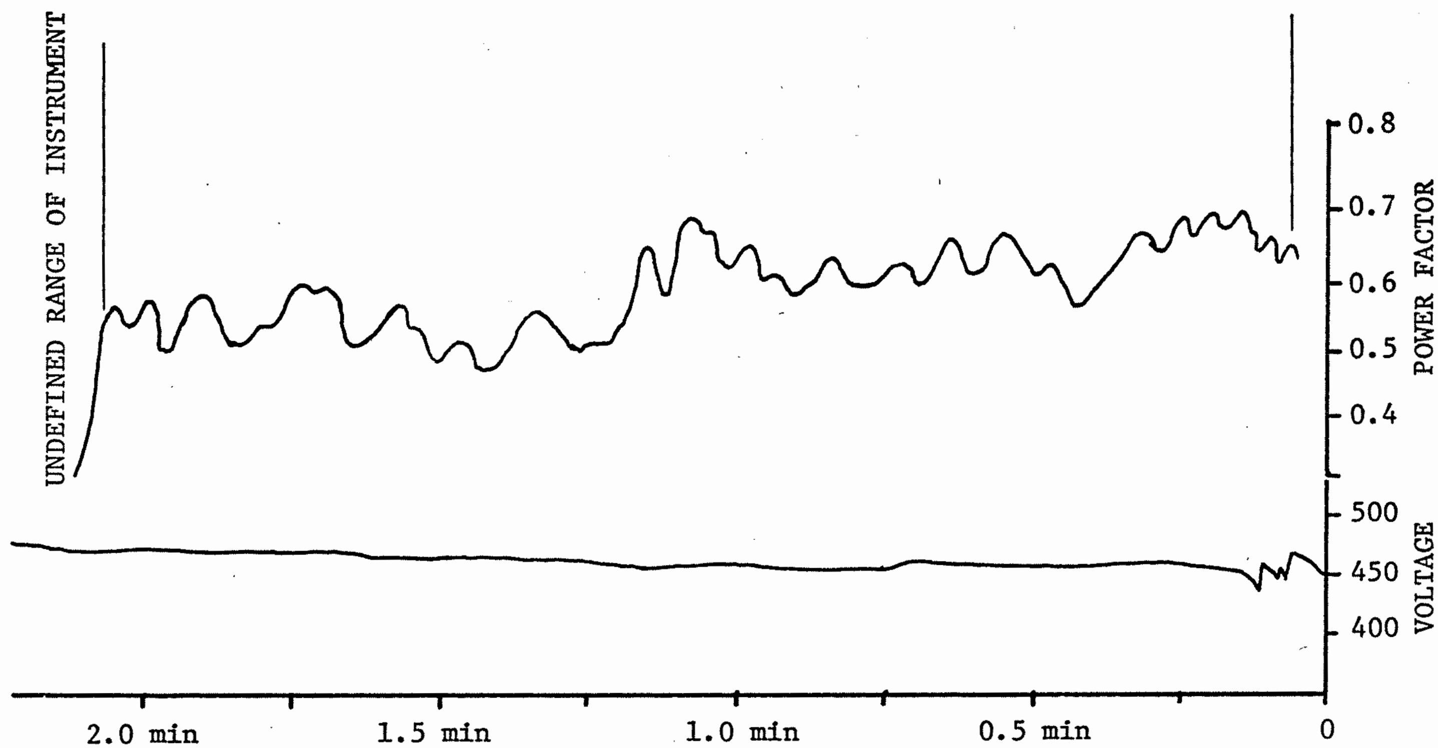

Figure 78c. Cutting-Loading-Tramming Voltage and Power Factor Cycles for a Joy 8CM Continuous Miner (440V).

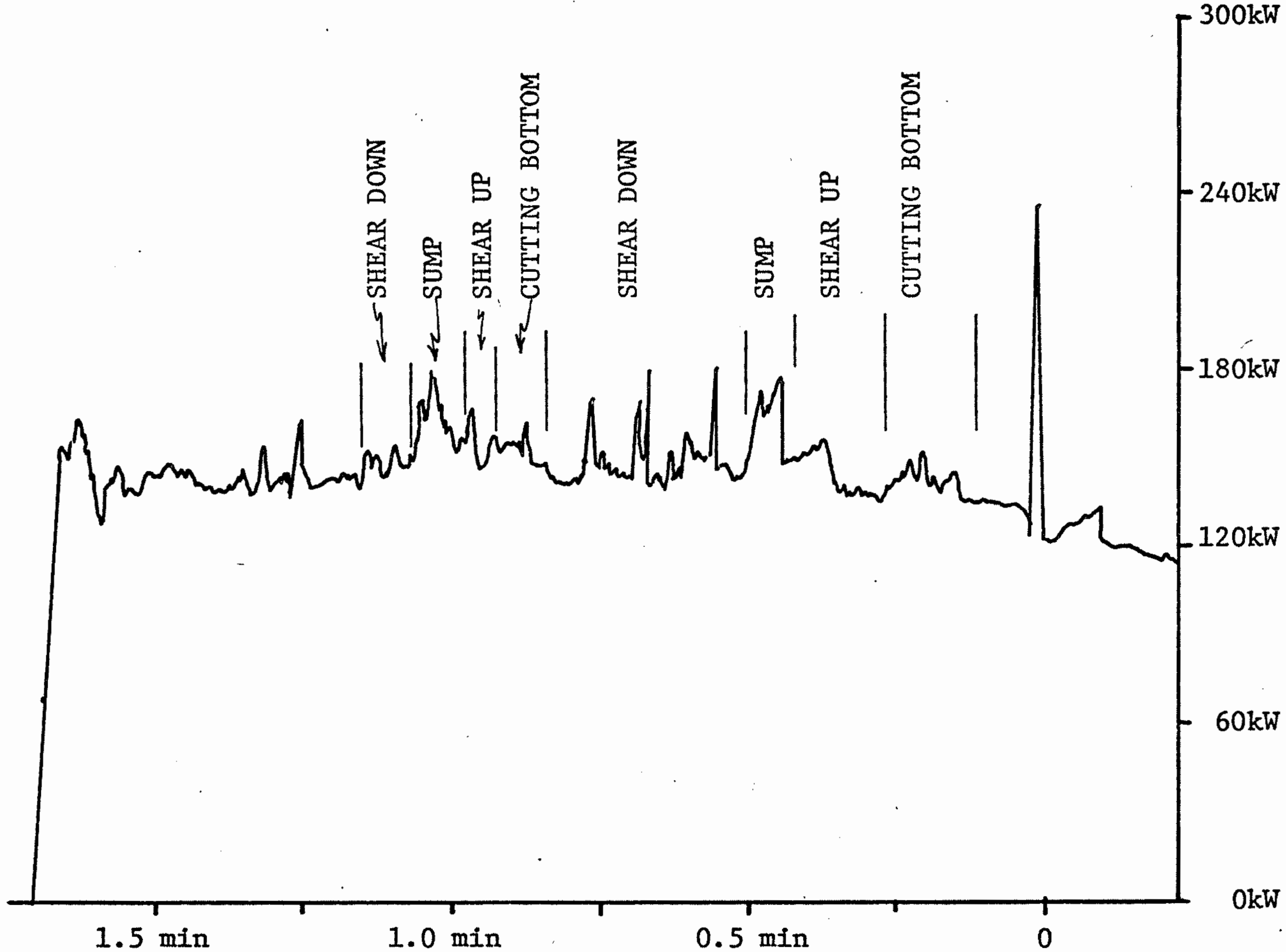

Figure 79a. Joy 8CM Continuous Miner (440V) Power Operational Curve During Cutting.

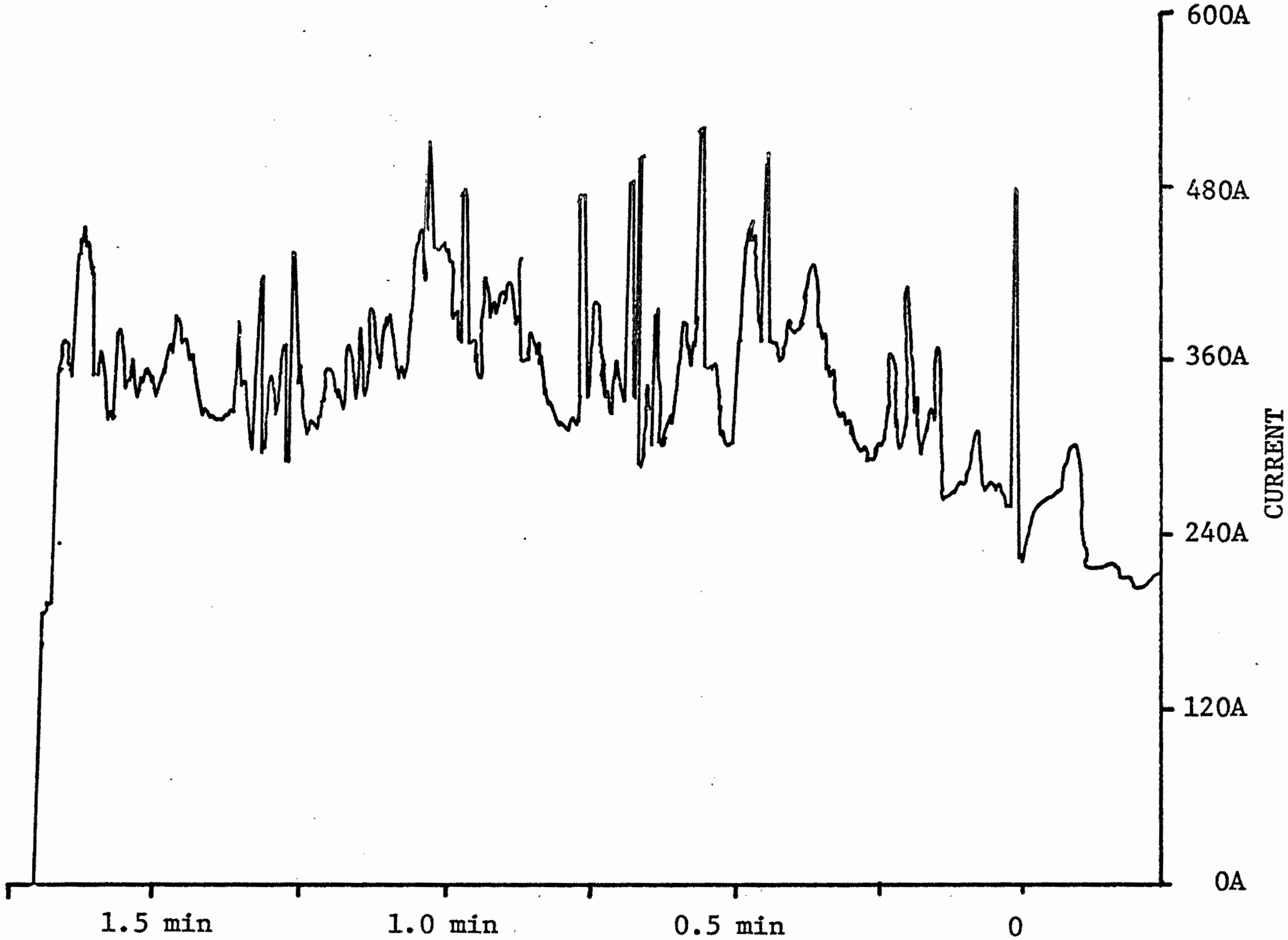

Figure 79b. Joy 8CM Continuous Miner (440V) Current Operational Curve During Cutting.

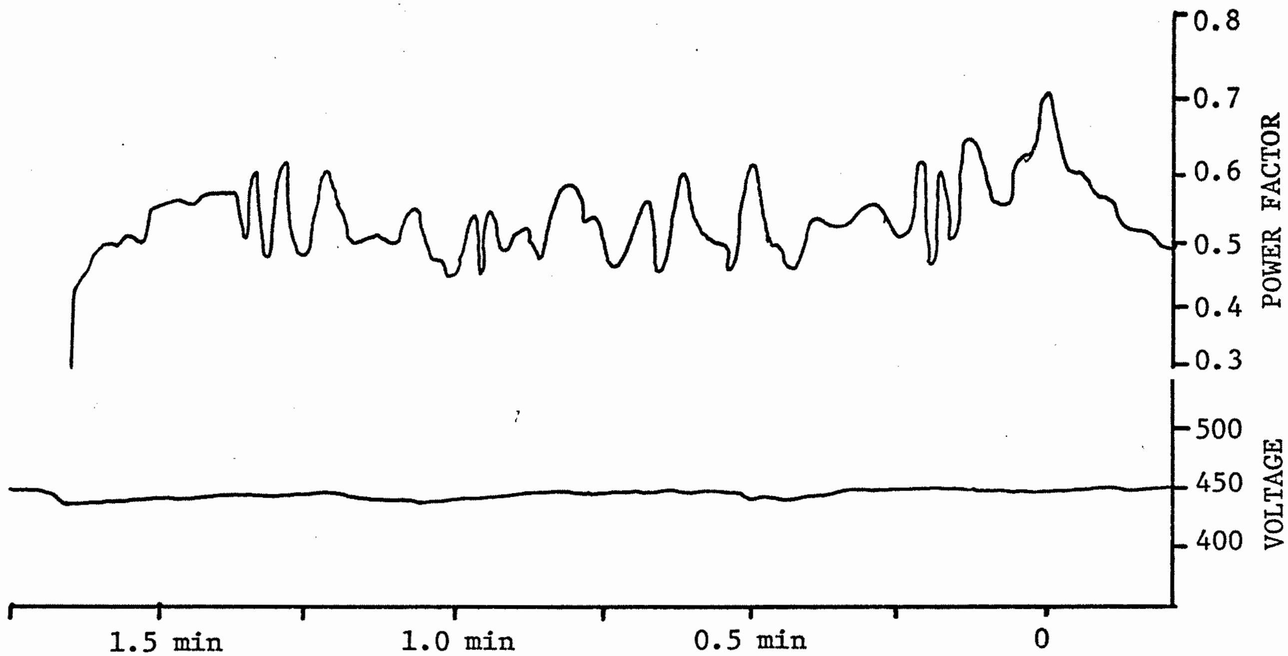

Figure 79c. Joy 8CM Continuous Miner (440V) Voltage and Power Factor Operation Curves During Cutting.

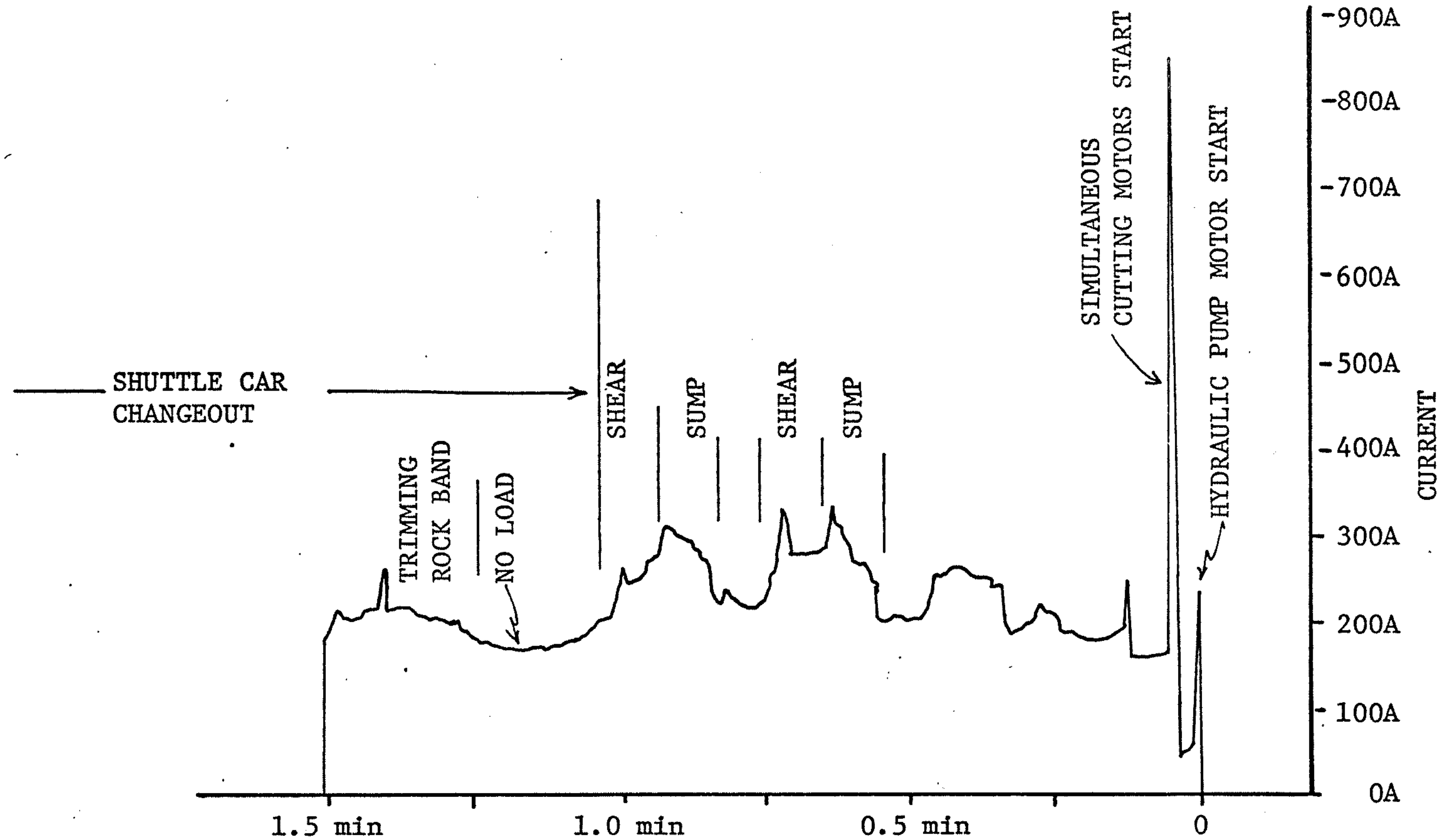

Figure 80a. Current Operational Curve for a Joy 10CM Continuous Miner During Cutting.

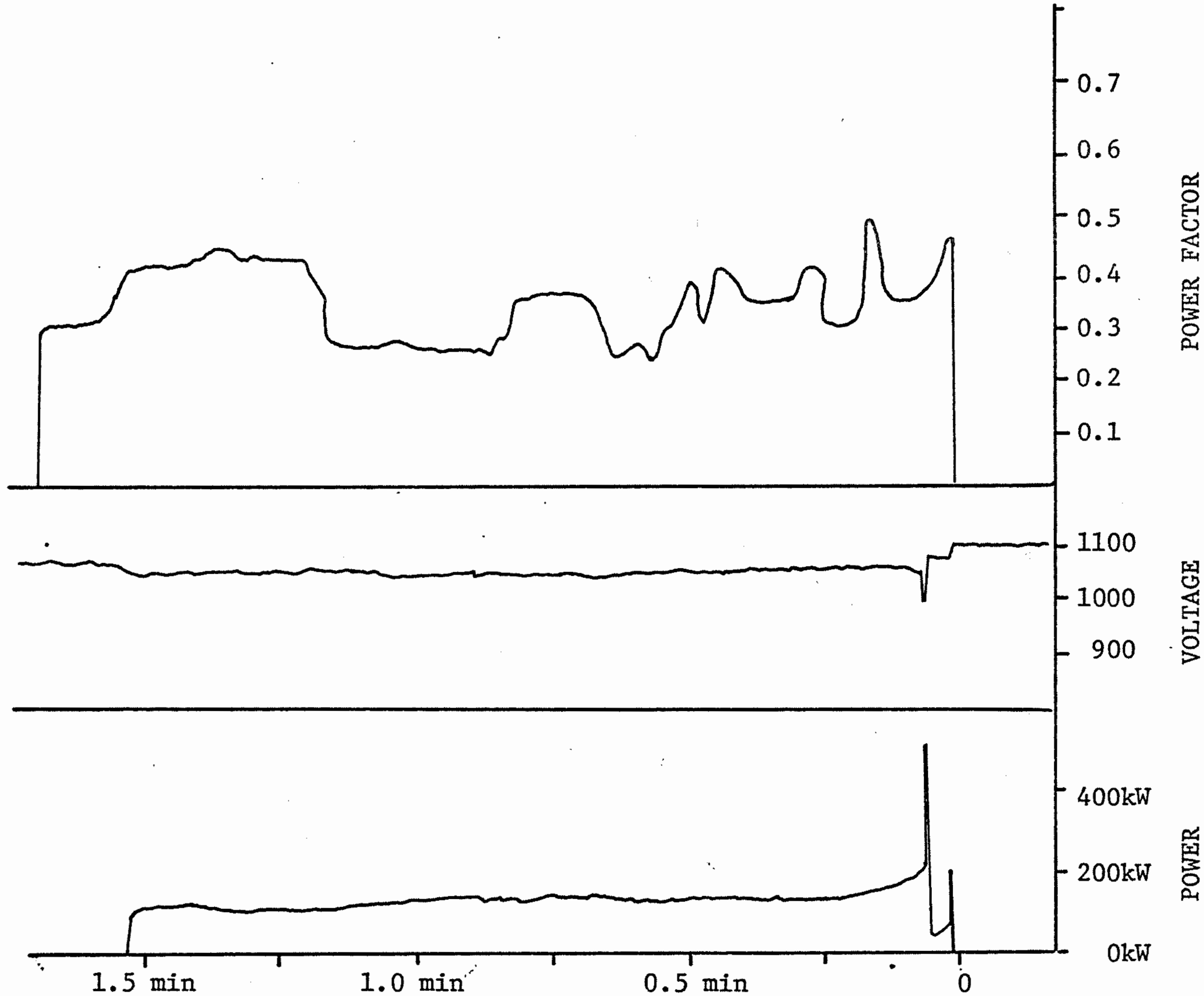

Figure 80b. Power Factor, Voltage and Power Curves for a Joy 10CM Continuous Miner During Cutting.

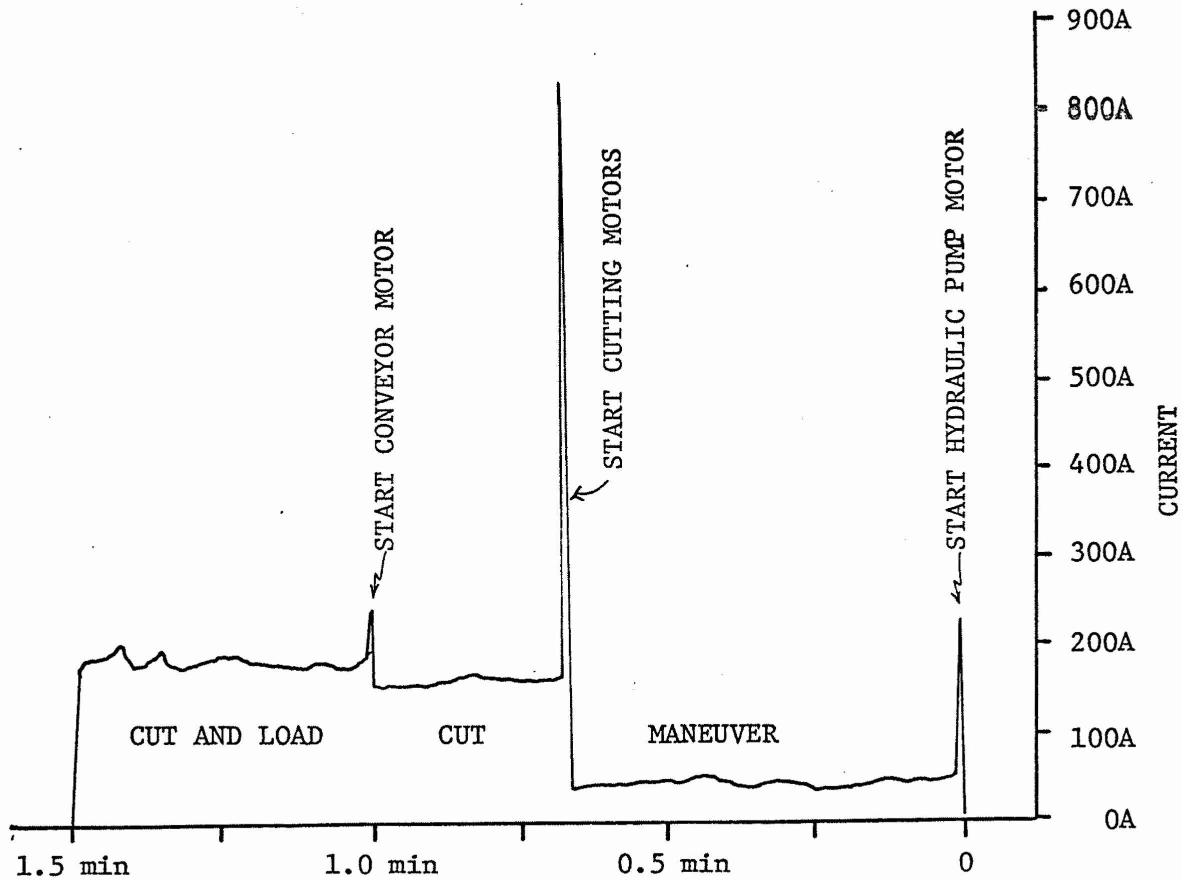

Figure 81a. Combined Tramming-Cutting Current Performance Cycle for a Joy 10CM Continuous Miner (950V).

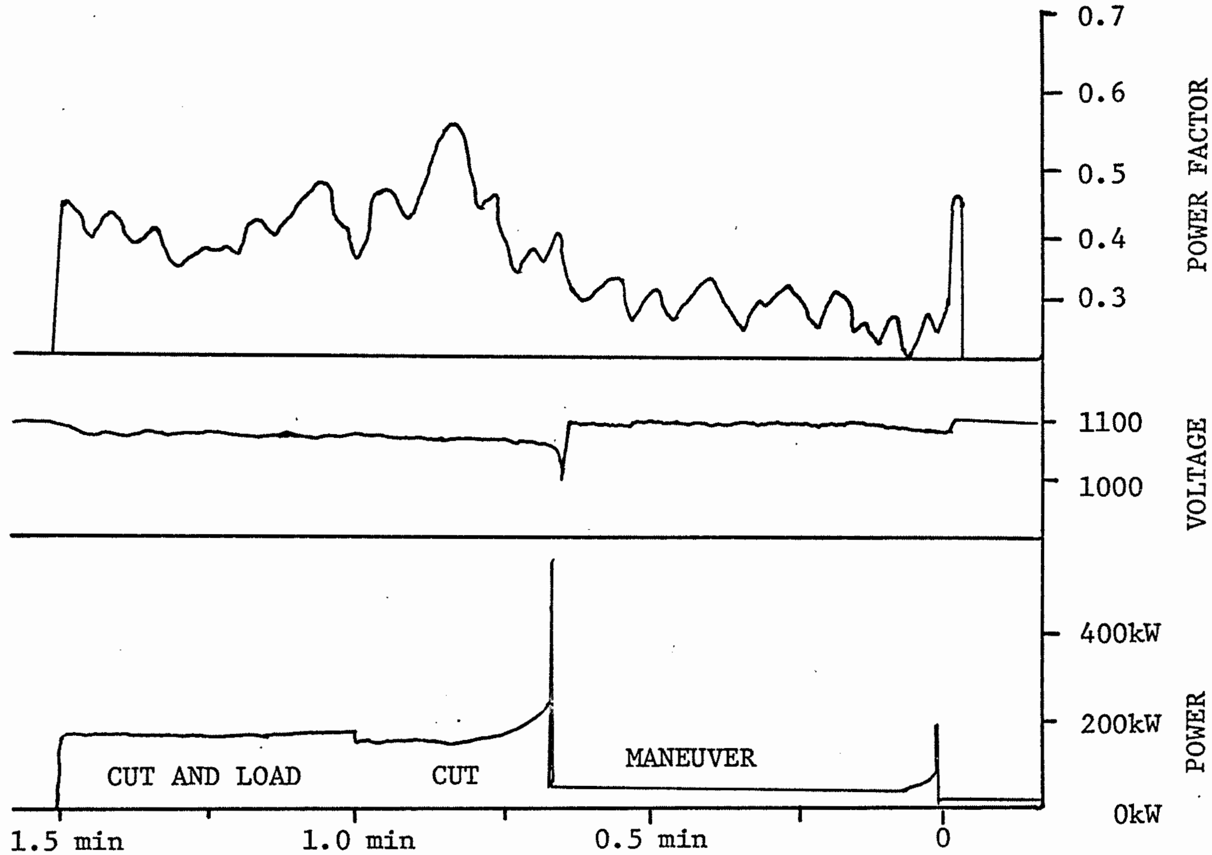

Figure 81b. Power, Voltage and Power Factor Performance Cycles for a Joy 10CM Continuous Miner (950V) During Combined Tramming-Cutting.

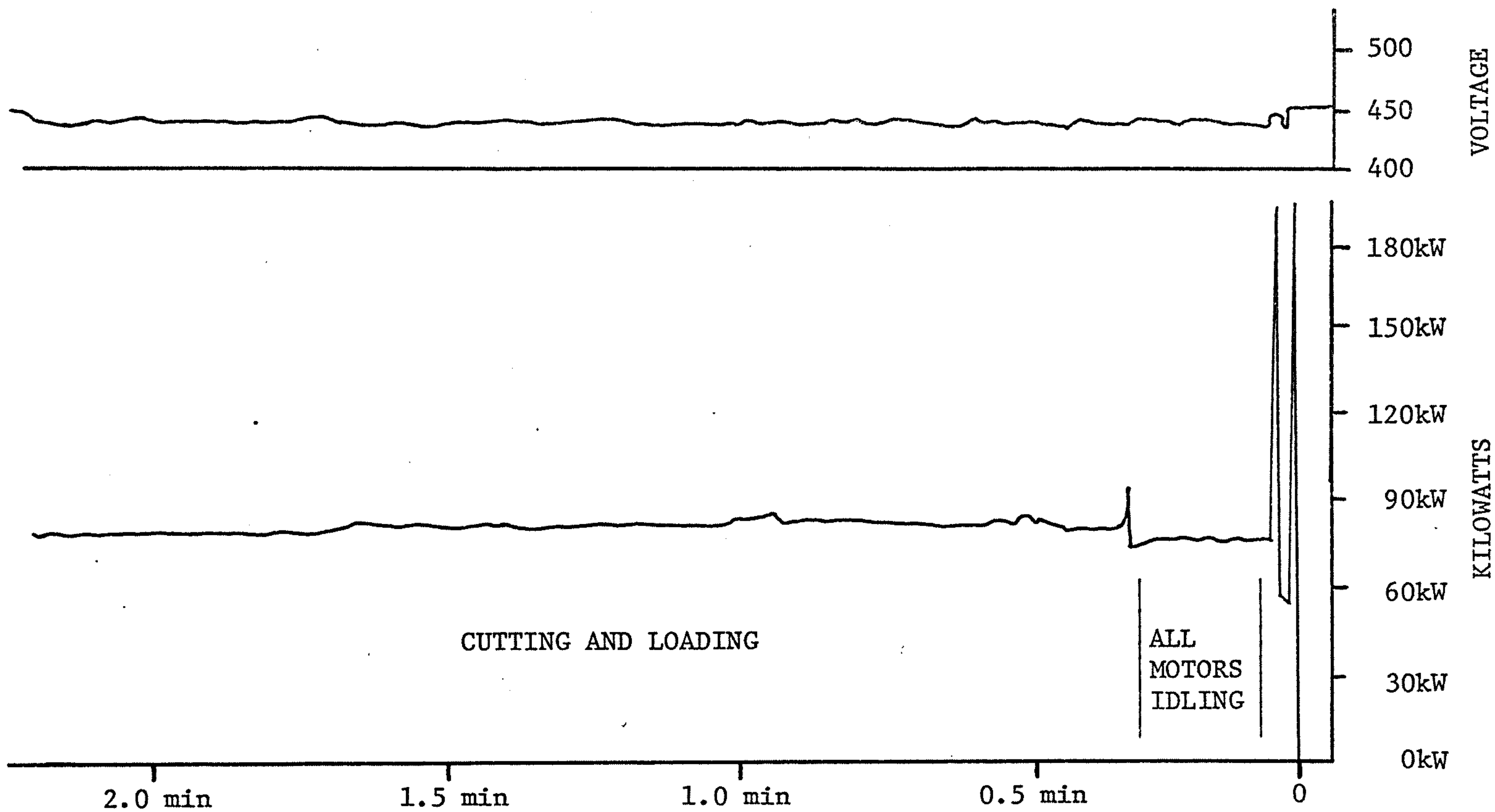

Figure 82a. Normal Cutting-Loading Power and Voltage Operational Cycle for a Joy CU-43-2H (Compton) Continuous Miner (440V).

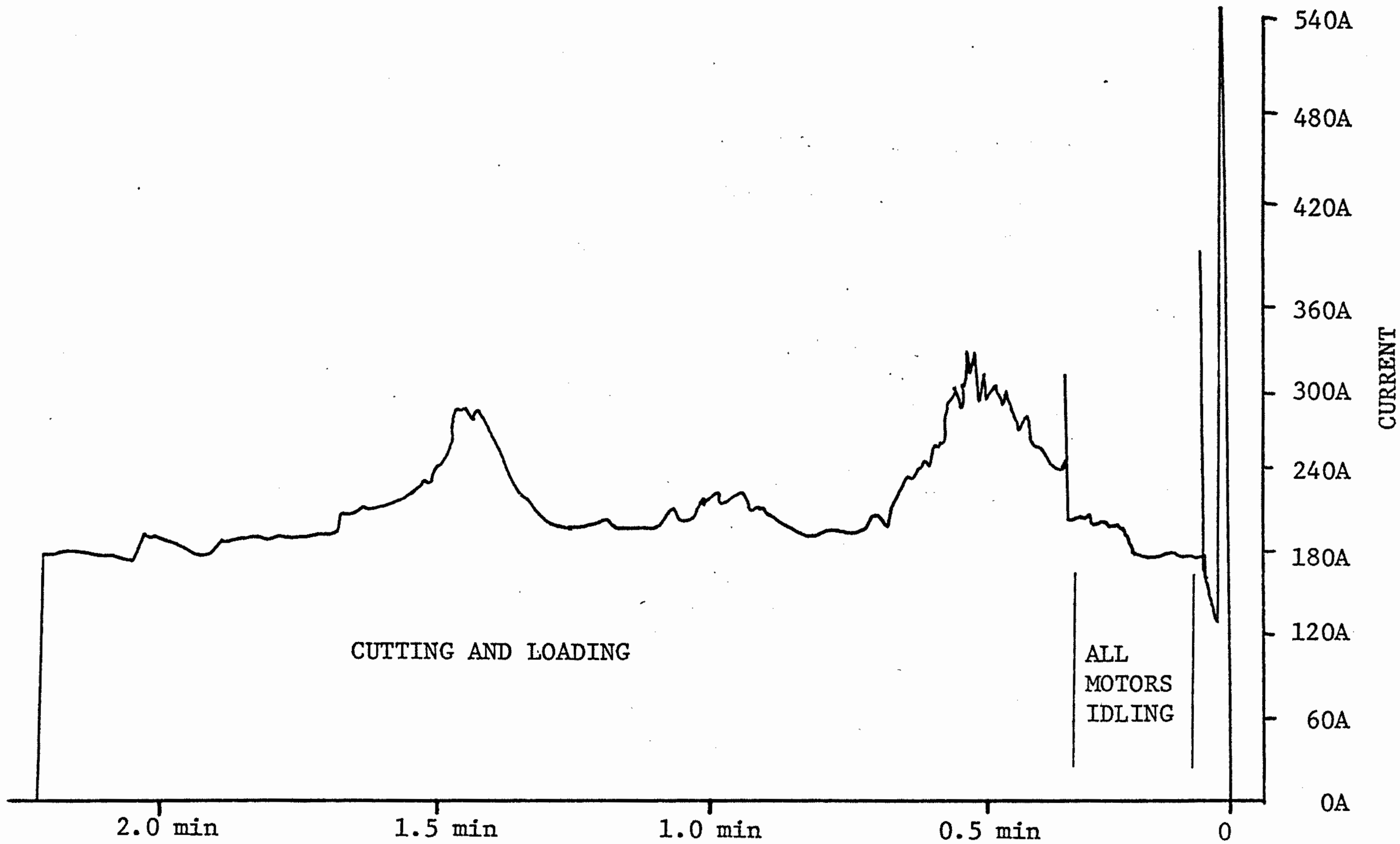

Figure 82b. Normal Cutting-Loading Current Operational Cycle for a Joy CU-43-2H (Compton) Continuous Miner (440V).

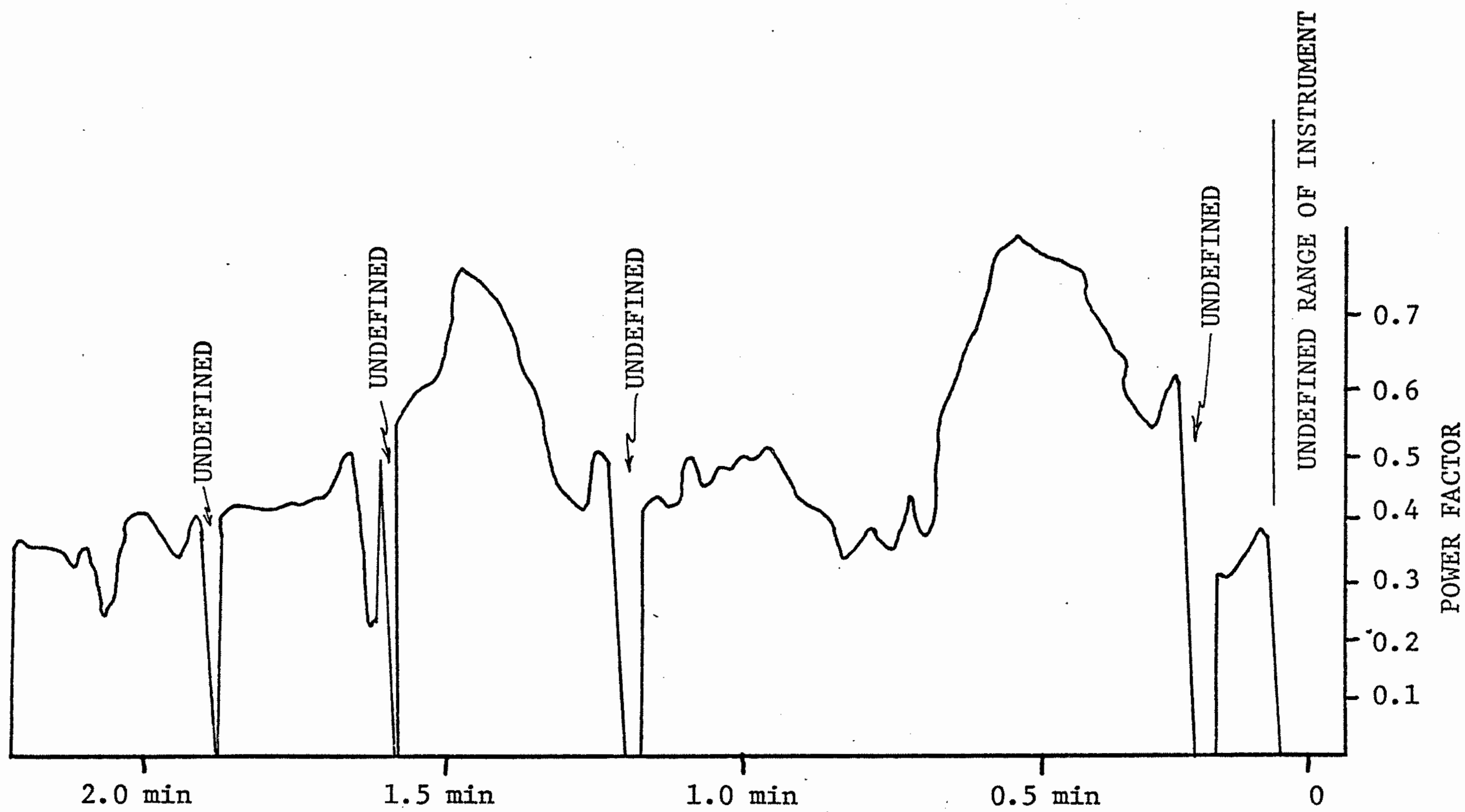

Figure 82c. Normal Cutting and Loading Power Factor Operational Cycle for a Joy CU-43-2H (Compton) Continuous Miner (440V).

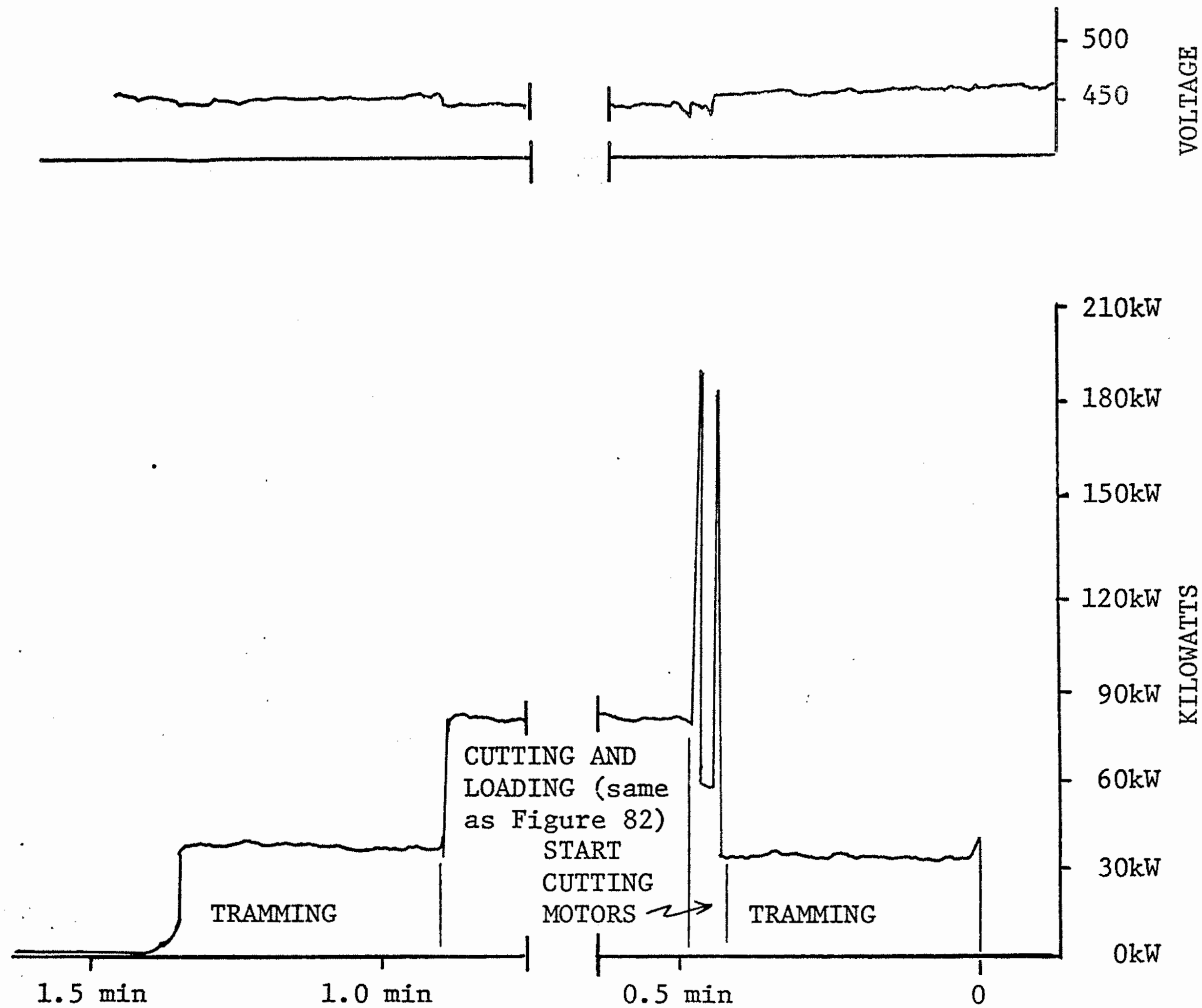

Figure 83a. Combined Tramming and Cutting-Loading Normal Power and Voltage Cycles for a Joy CU-43-2H (Compton) Continuous Miner (440V).

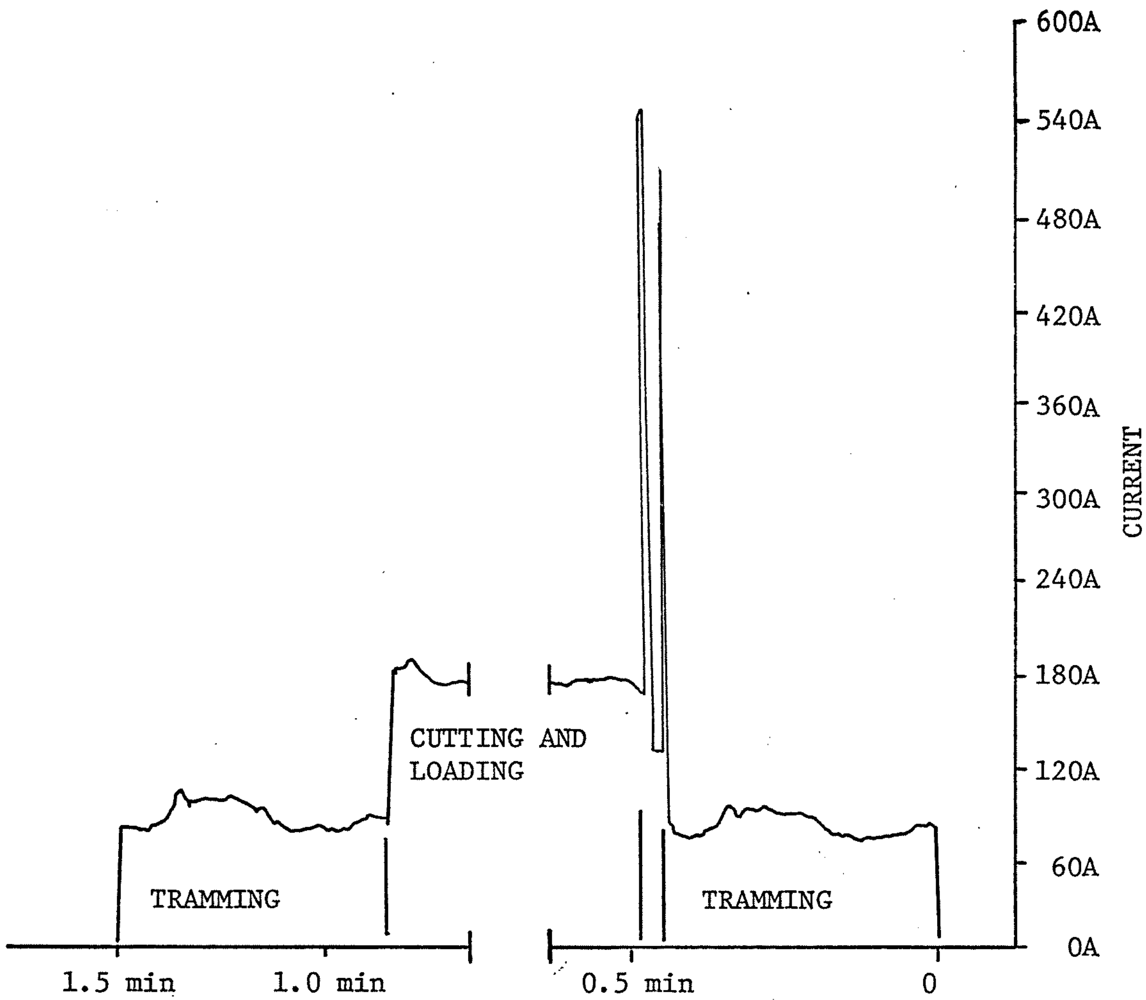

Figure 83b. Combined Tramming and Cutting-Loading Normal Current Cycle for a Joy CU-43-2H (Compton) Continuous Miner (440V).

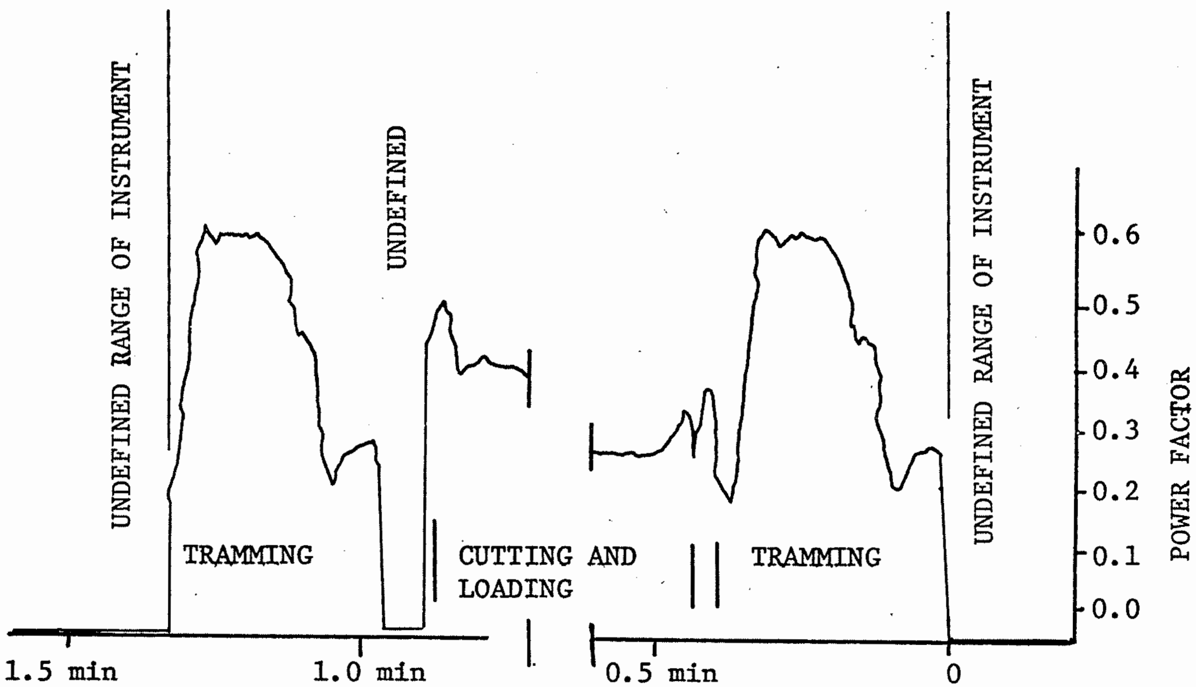

Figure 83c. Combined Tramming and Cutting-Loading Normal Power Factor Cycle for a Joy CU-43-2H (Compton) Continuous Miner (440V).

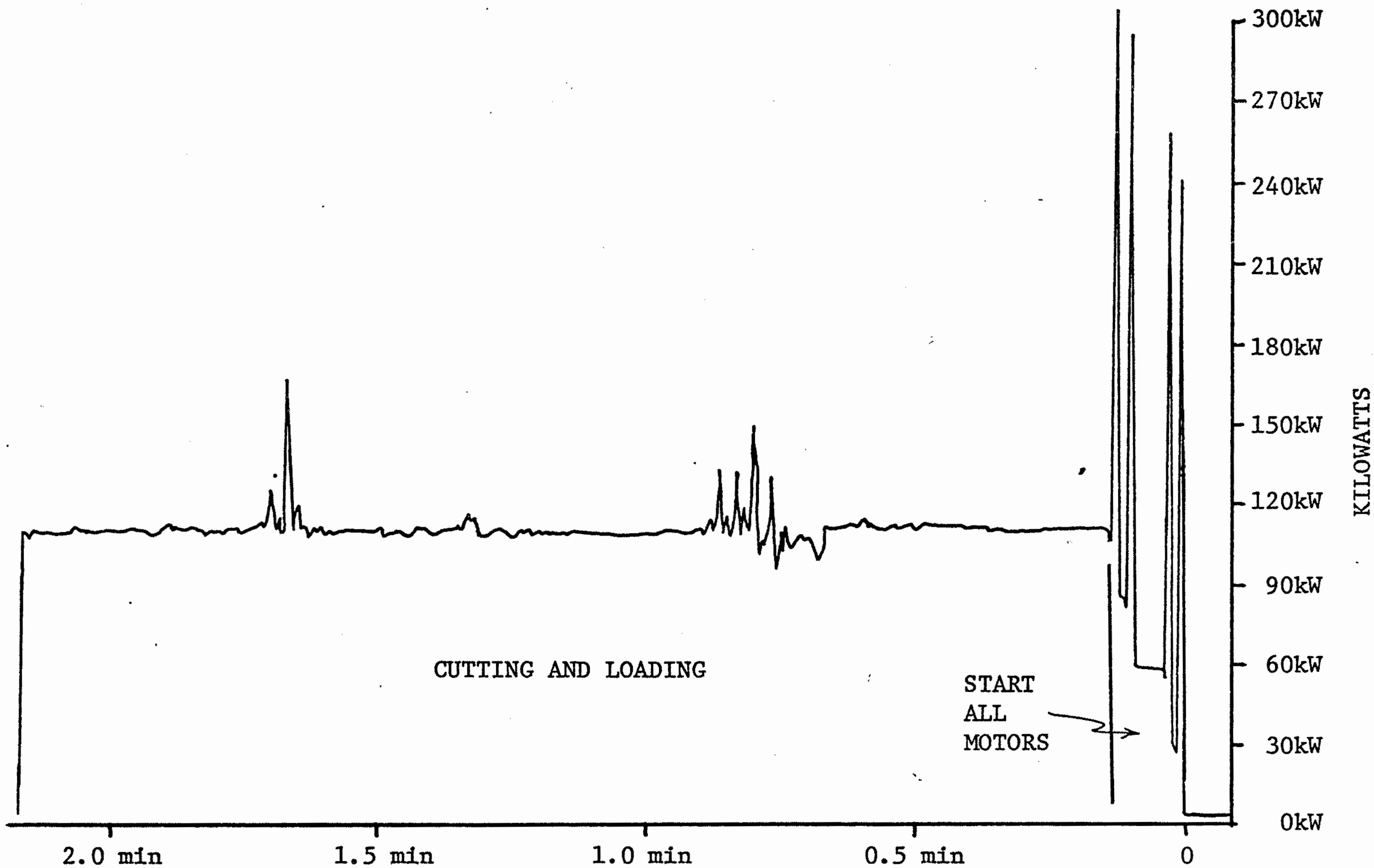

Figure 84a. Cutting and Loading Power Cycle for a Lee-Norse CM26H Continuous Miner One (550V).

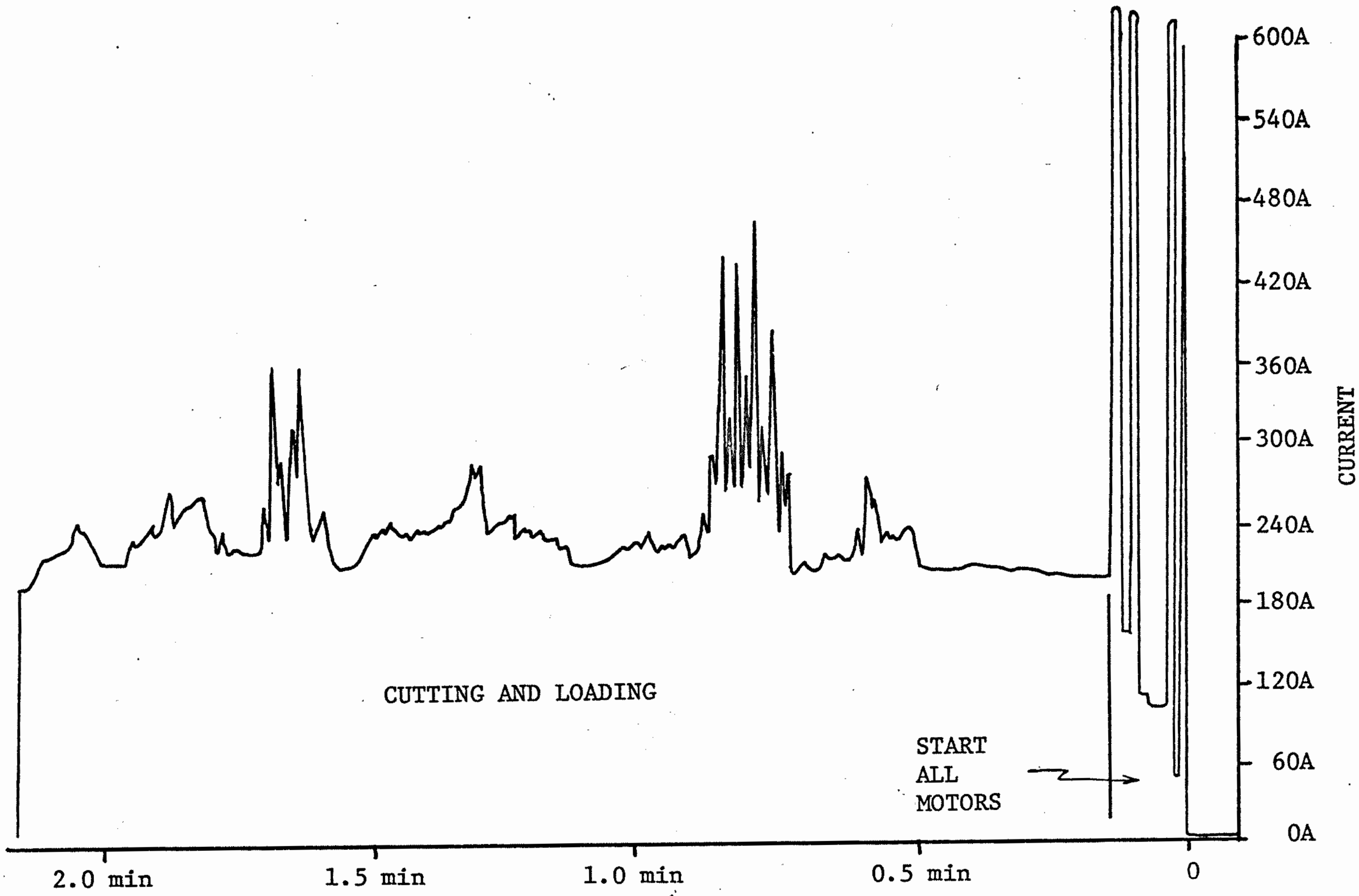

Figure 84b. Cutting and Loading Current Cycle for a Lee-Norse CM26H Continuous Miner One (550V)

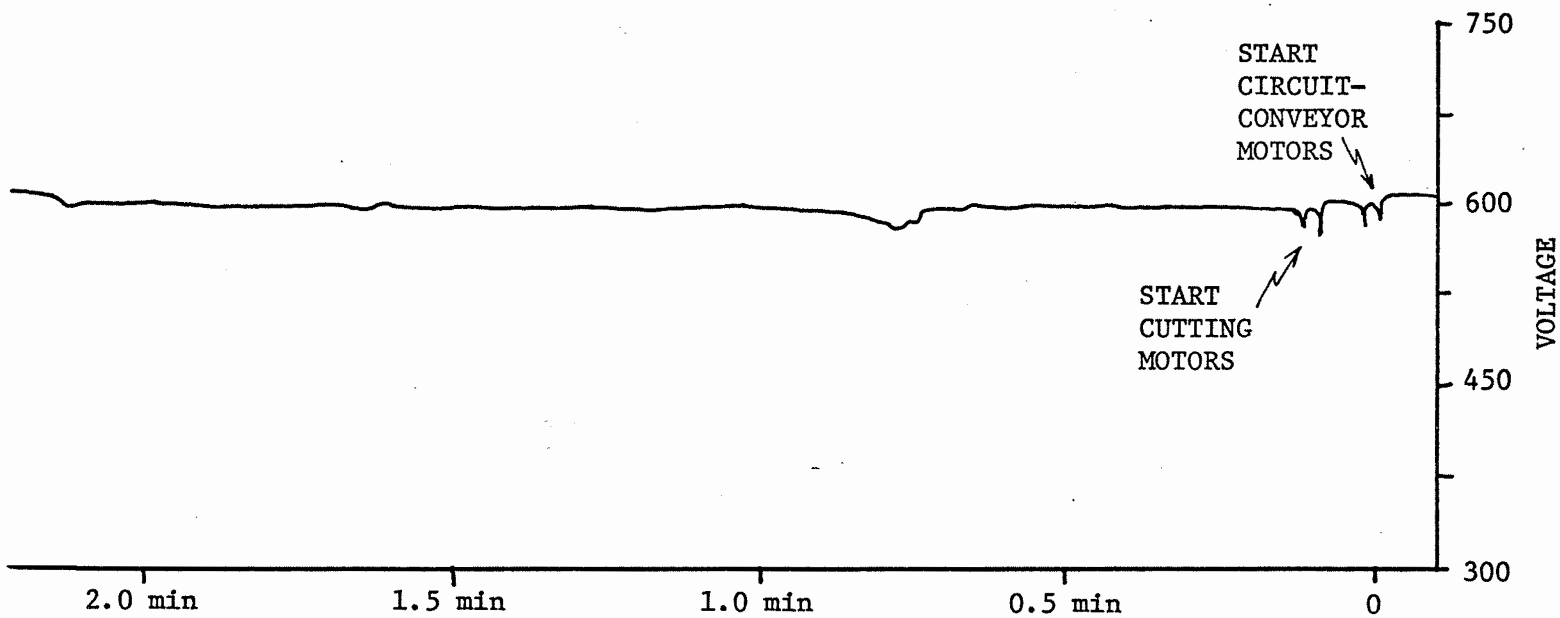

Figure 84c. Cutting and Loading Voltage Cycle for a Lee-Norse CM26H Continuous Miner (550V).

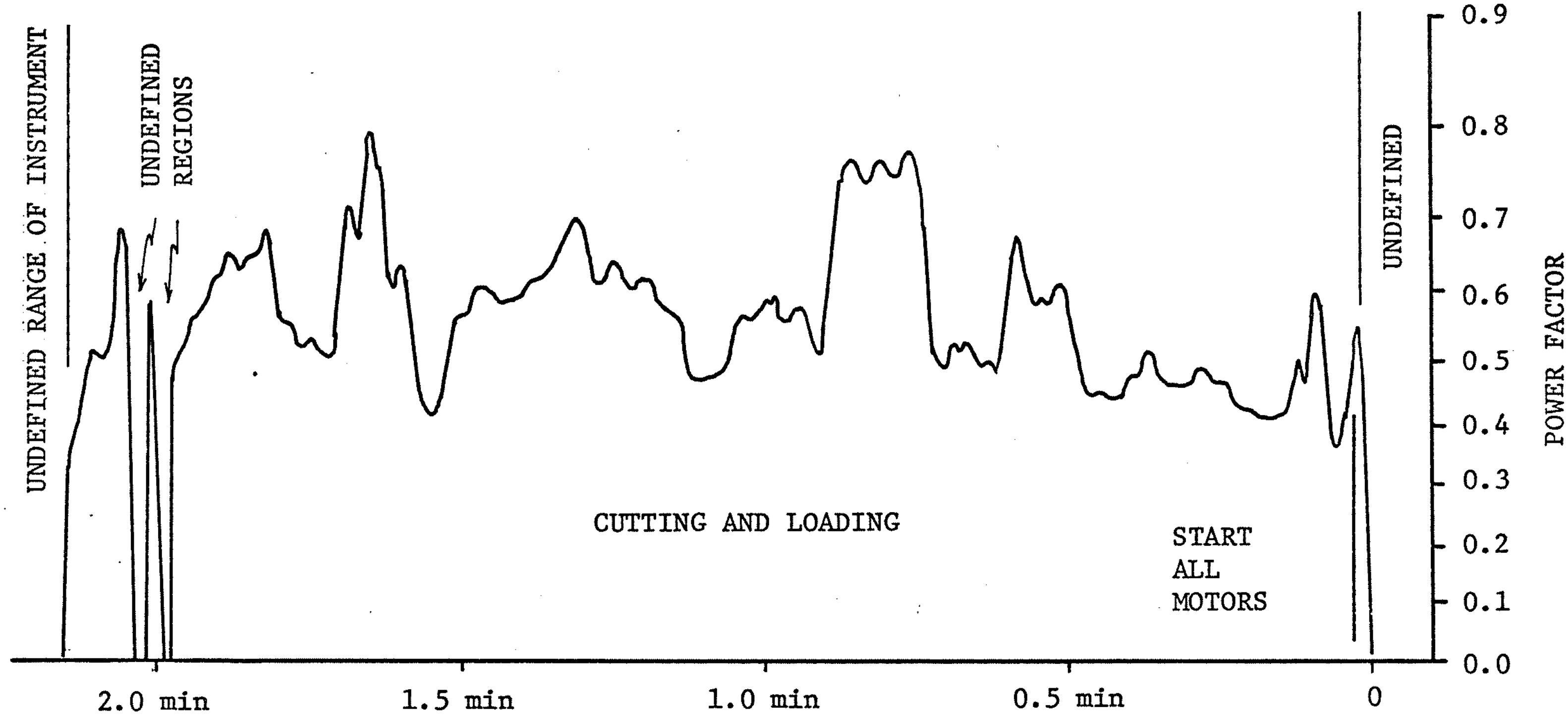

Figure 84d. Cutting and Loading Power Factor Cycle for a Lee-Norse CM26H Continuous Miner One (550V).

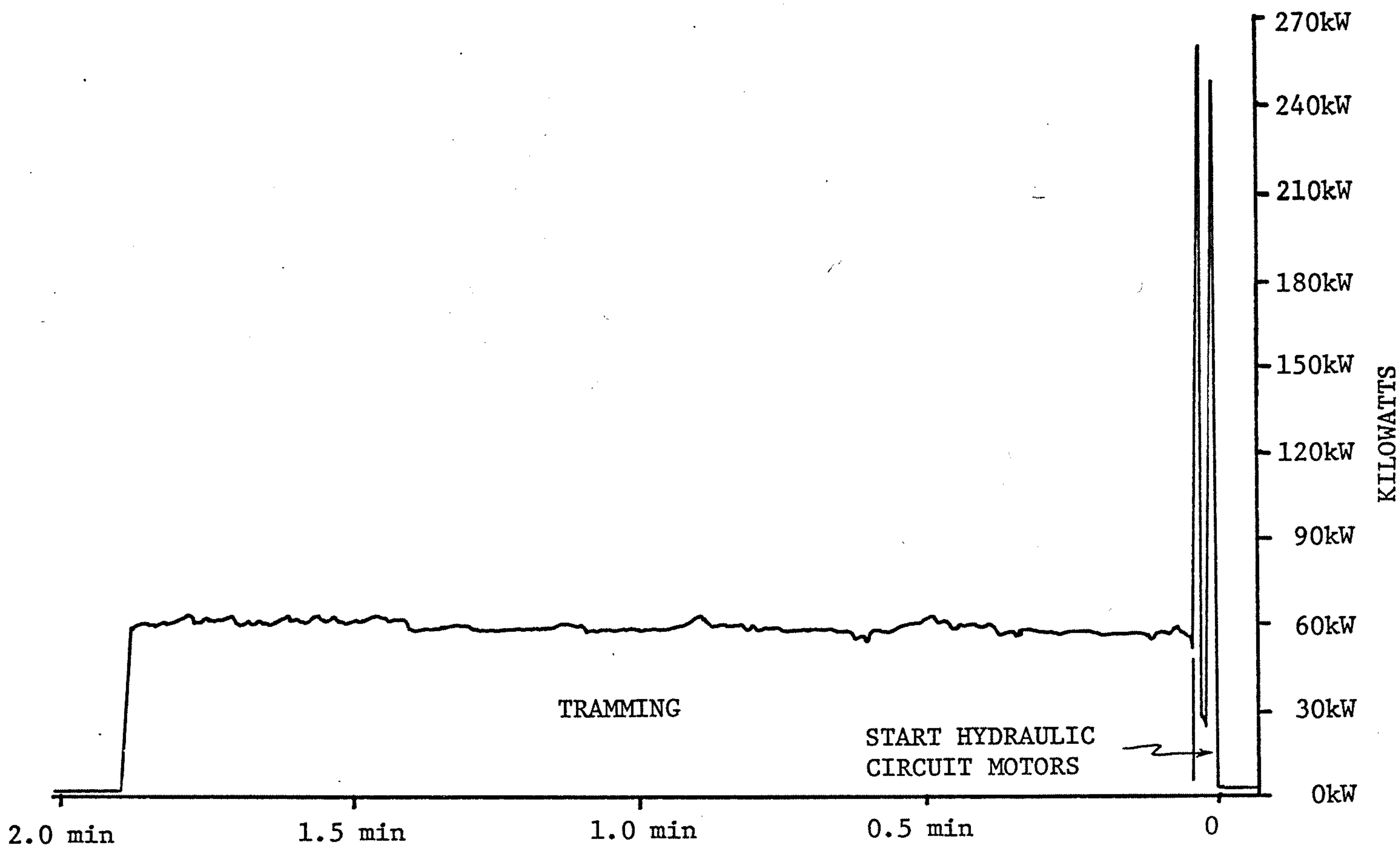

Figure 85a. Tramming Power Cycle for a Lee-Norse CM26H Continuous Miner One (550V).

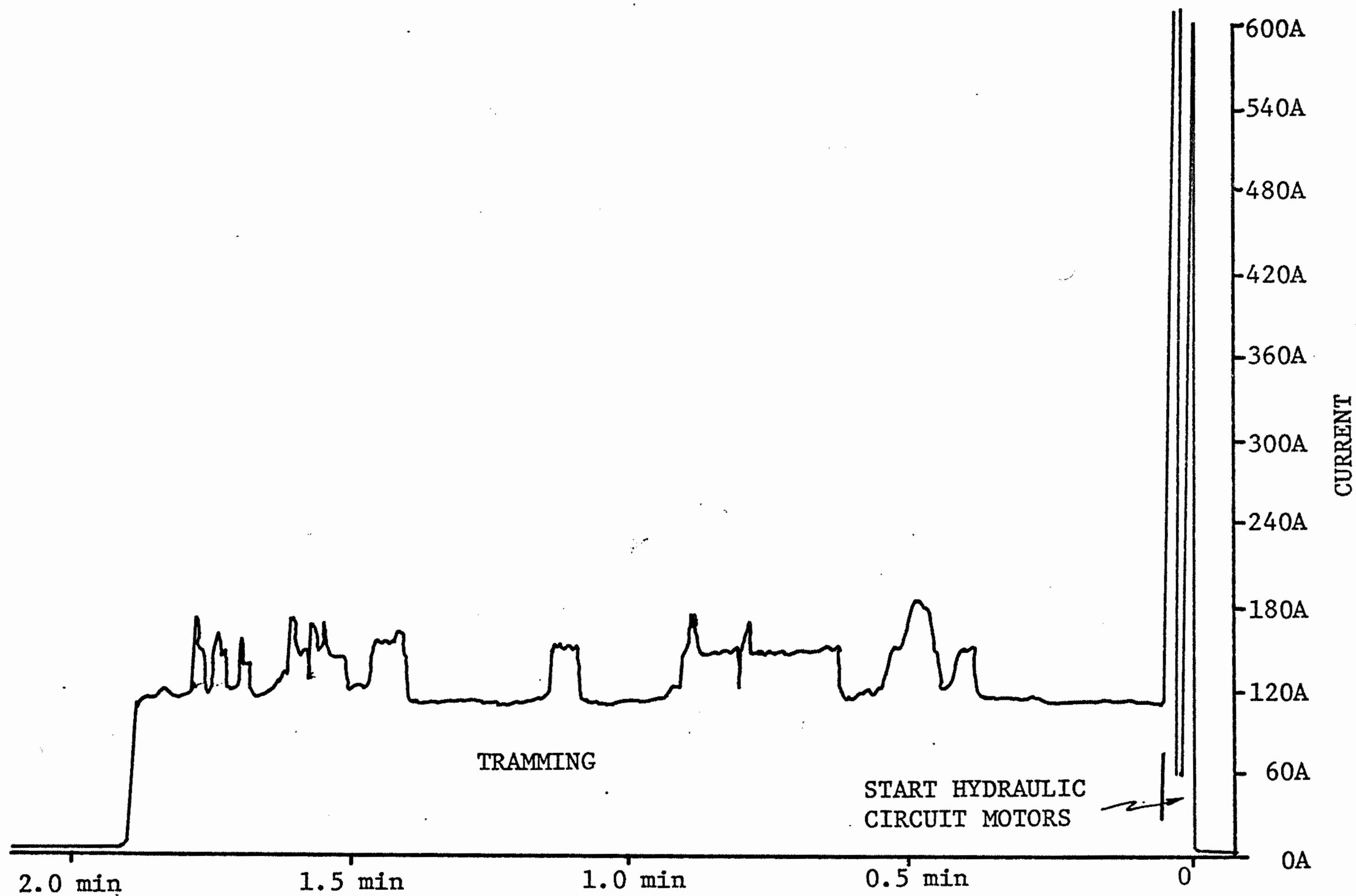

Figure 85b. Tramming Current Cycle for a Lee-Norse CM26H Continuous Miner One (550V).

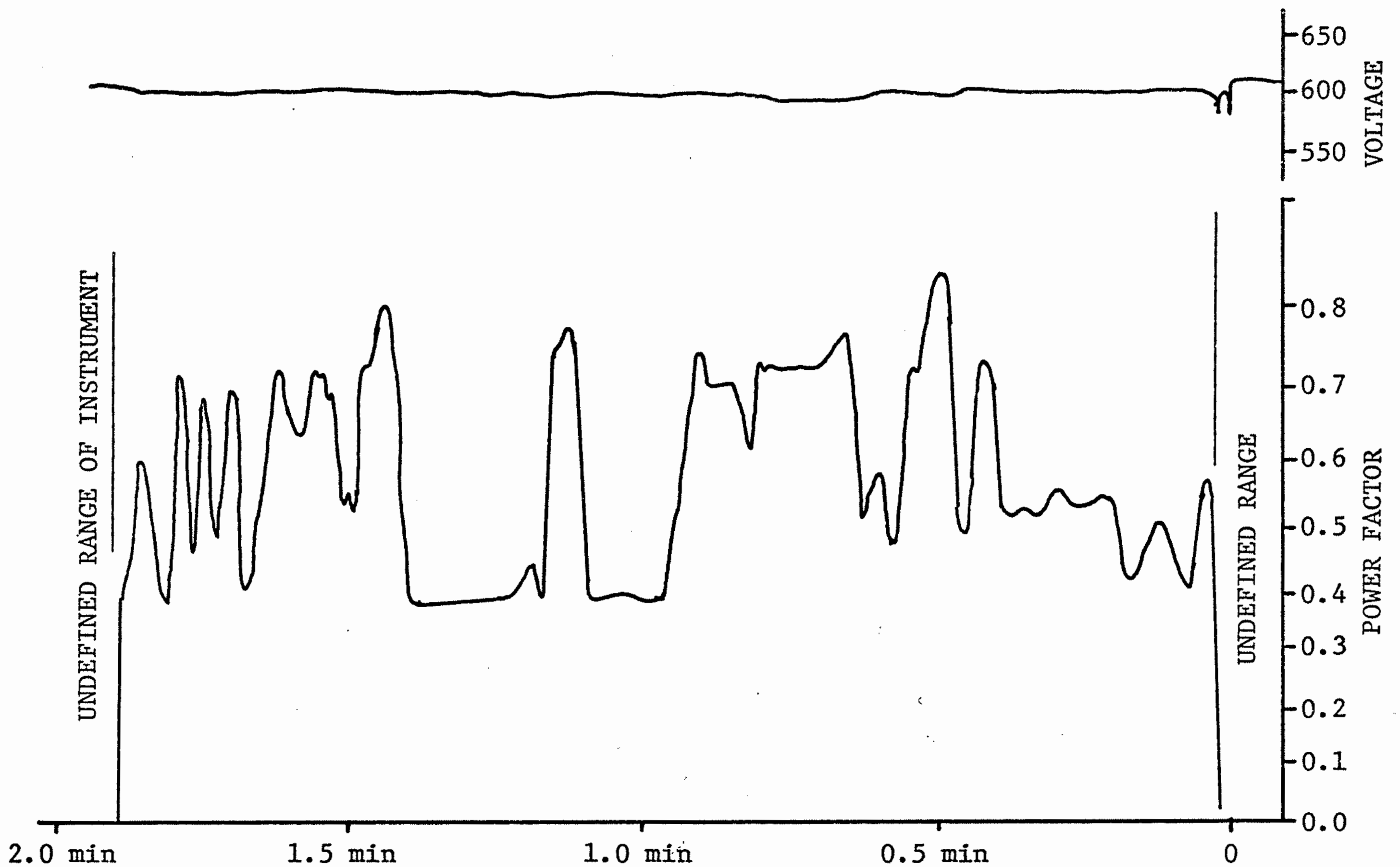

Figure 85c. Tramming Power Factor and Voltage Cycles for a Lee-Norse CM26H Continuous Miner One.

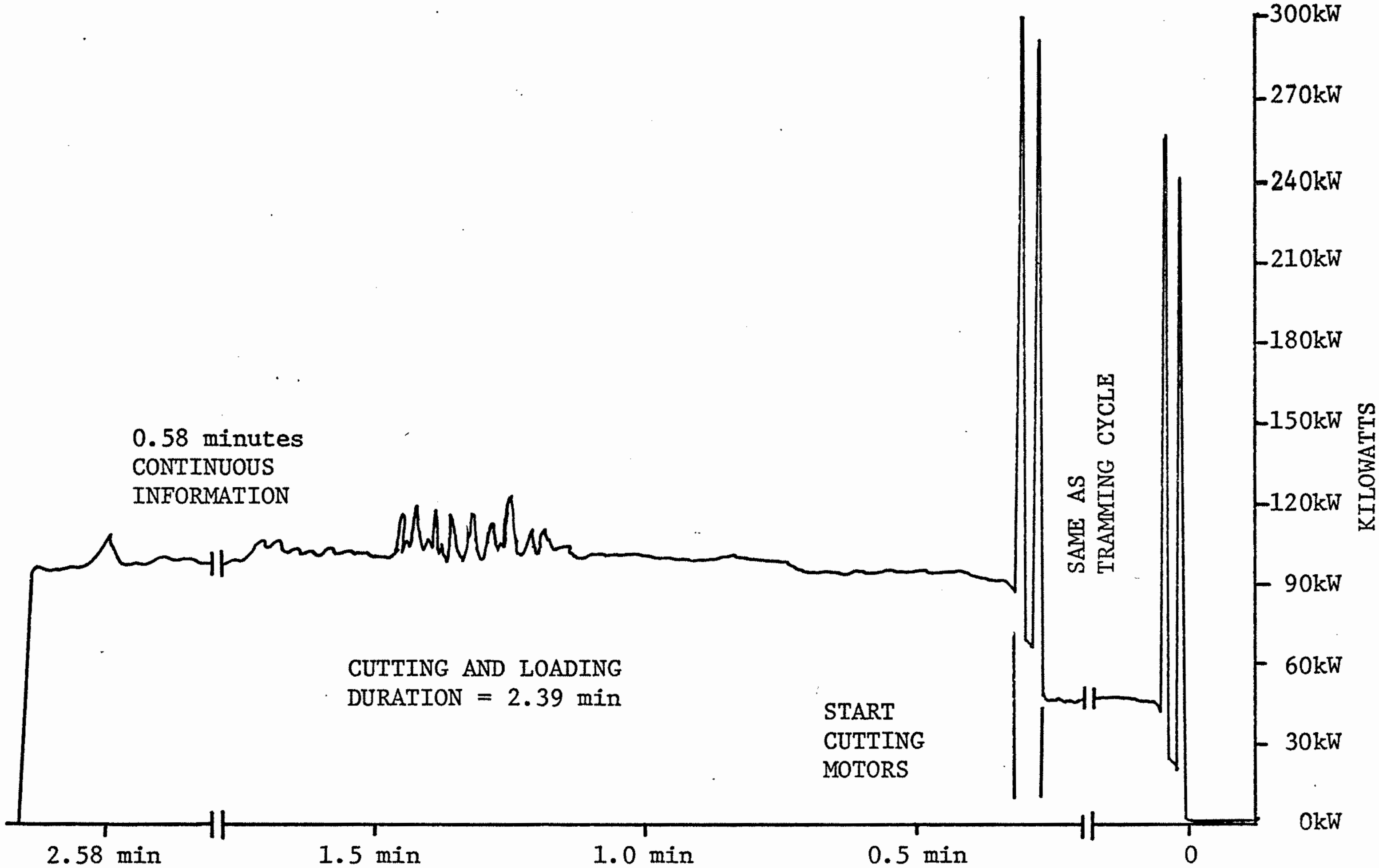

Figure 86a. Cutting and Loading Power Cycle for a Lee-Norse CM26H Continuous Miner Two (550V).

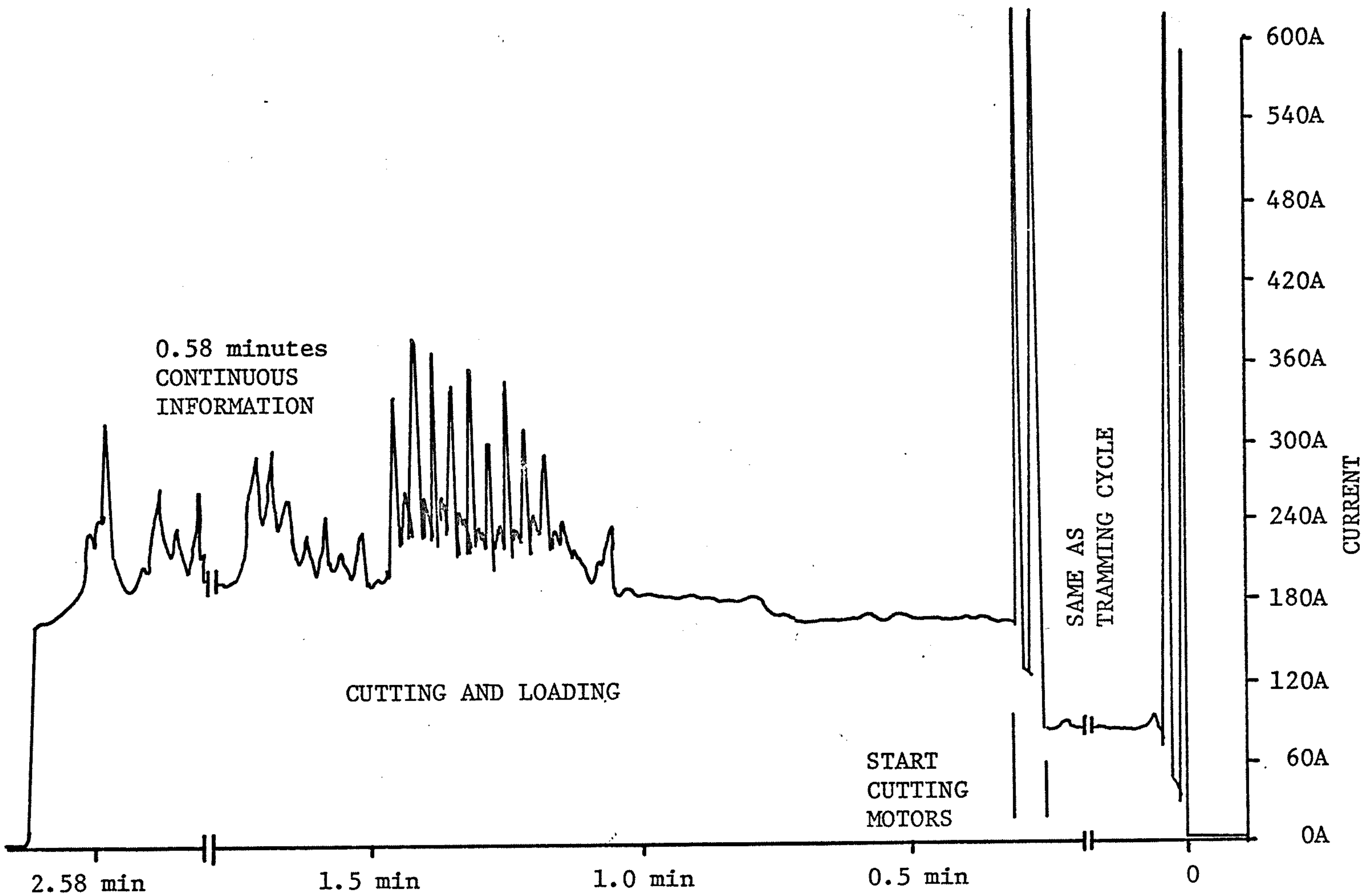

Figure 86b. Cutting and Loading Current Cycle for a Lee-Norse CM26H Continuous Miner Two (550V).

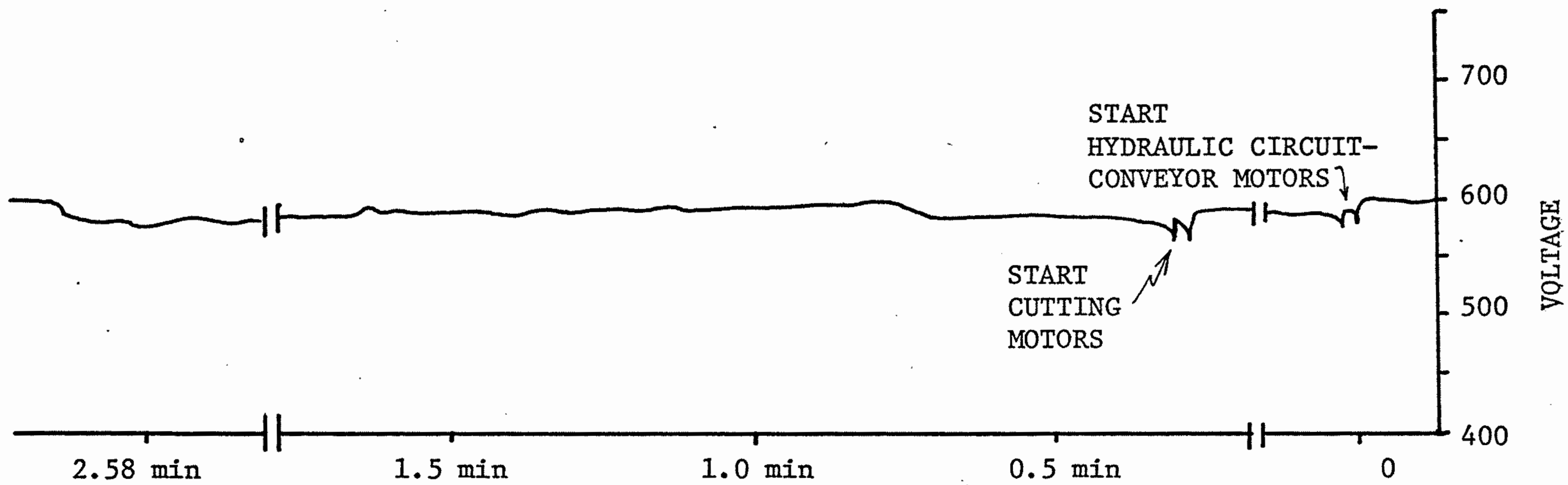

Figure 86c. Normal Cutting and Loading Voltage Cycle for a Lee-Norse CM26H Continuous Miner Two.

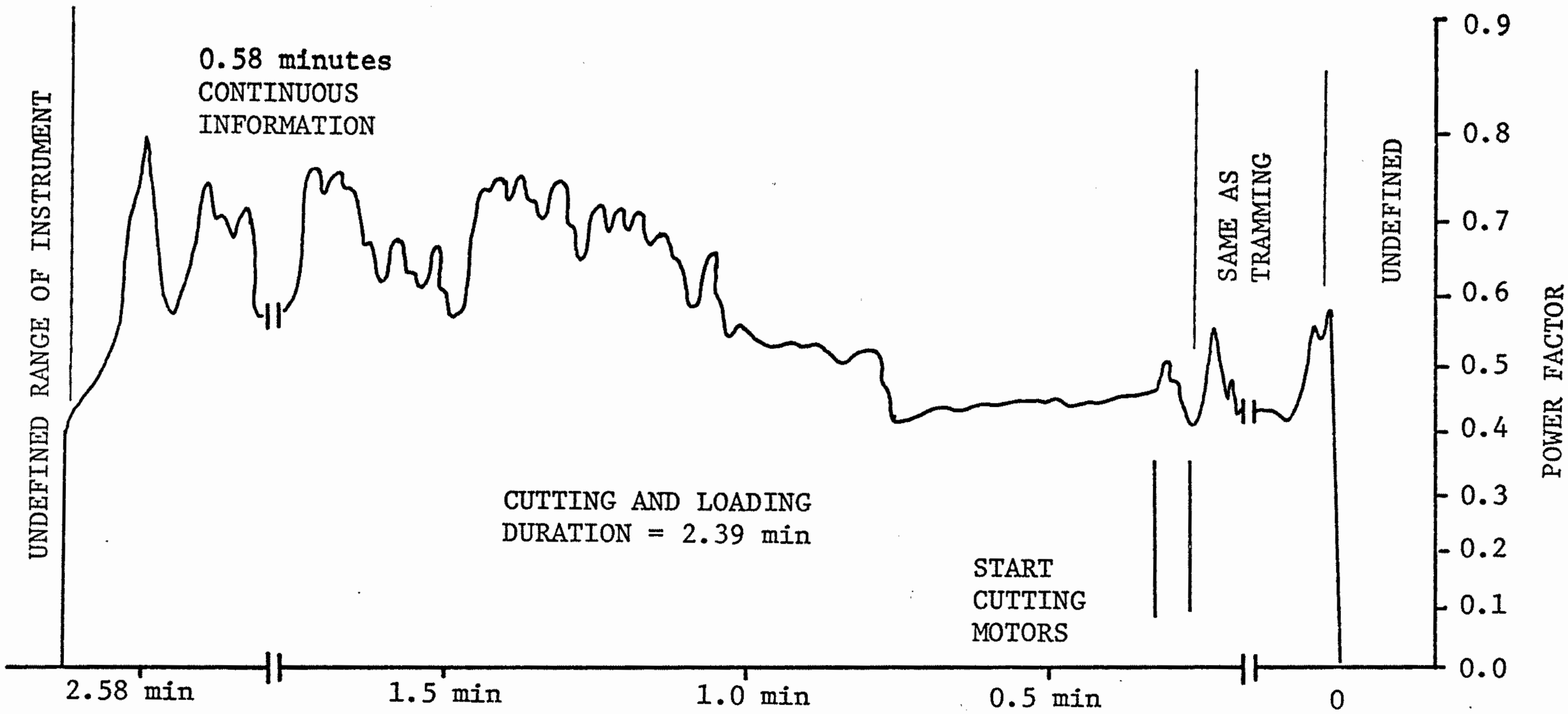

Figure 86d. Normal Cutting and Loading Power Factor Cycle for a Lee-Norse CM26H Continuous Miner Two.

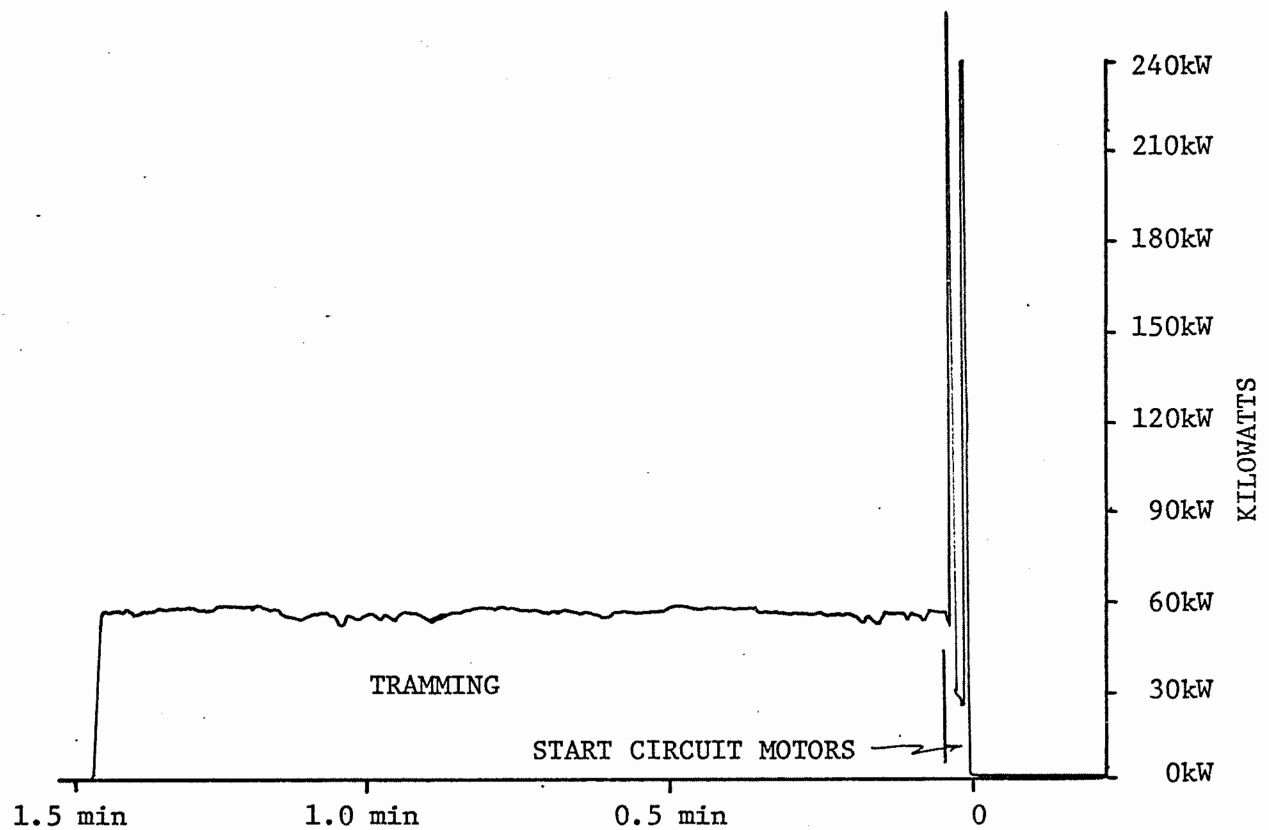

Figure 87a. Normal Tramming Power Cycle for a Lee-Norse CM26H Continuous Miner Two (550V).

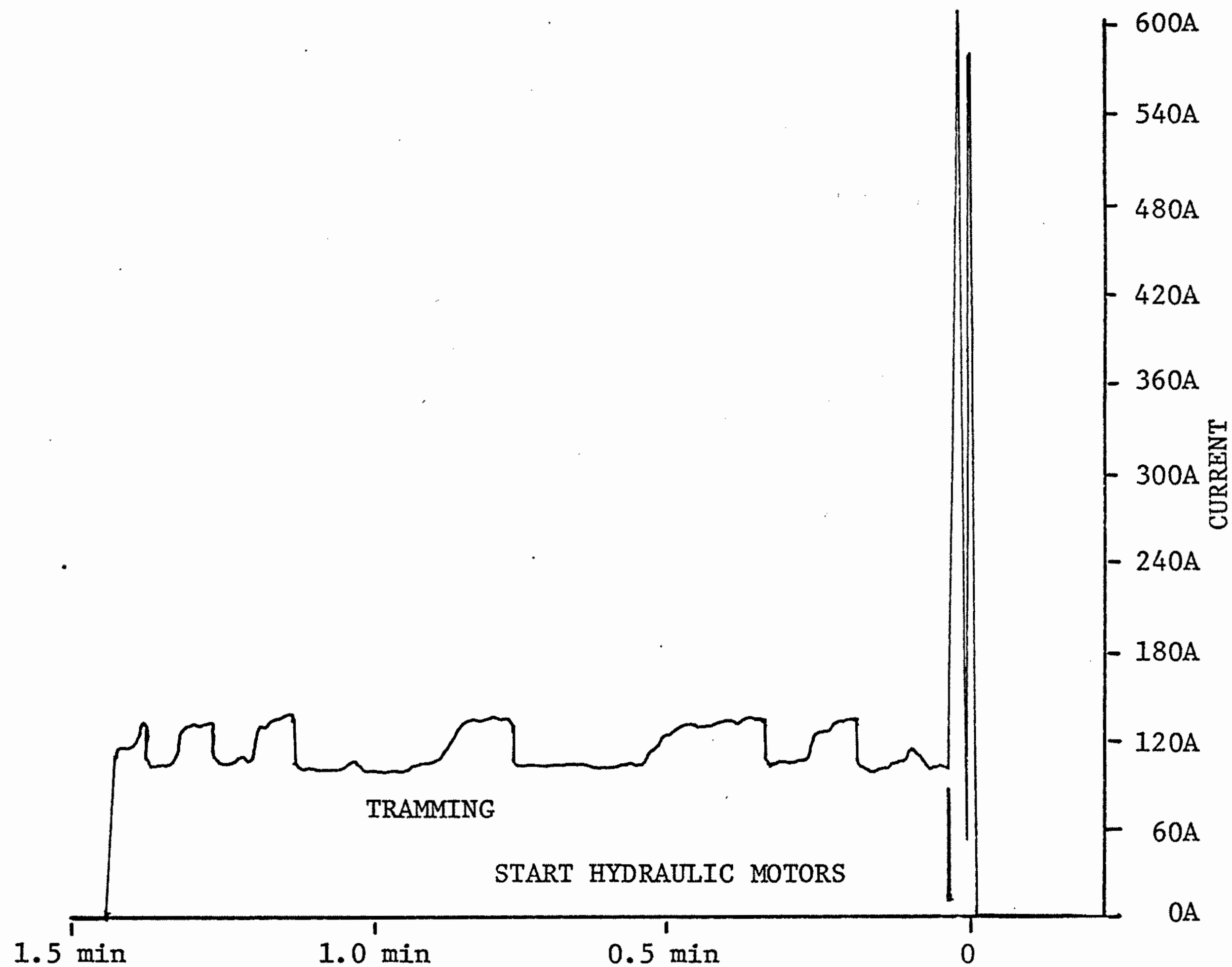

Figure 87b. Normal Tramming Current Cycle for a Lee-Norse CM26H Continuous Miner Two (550V).

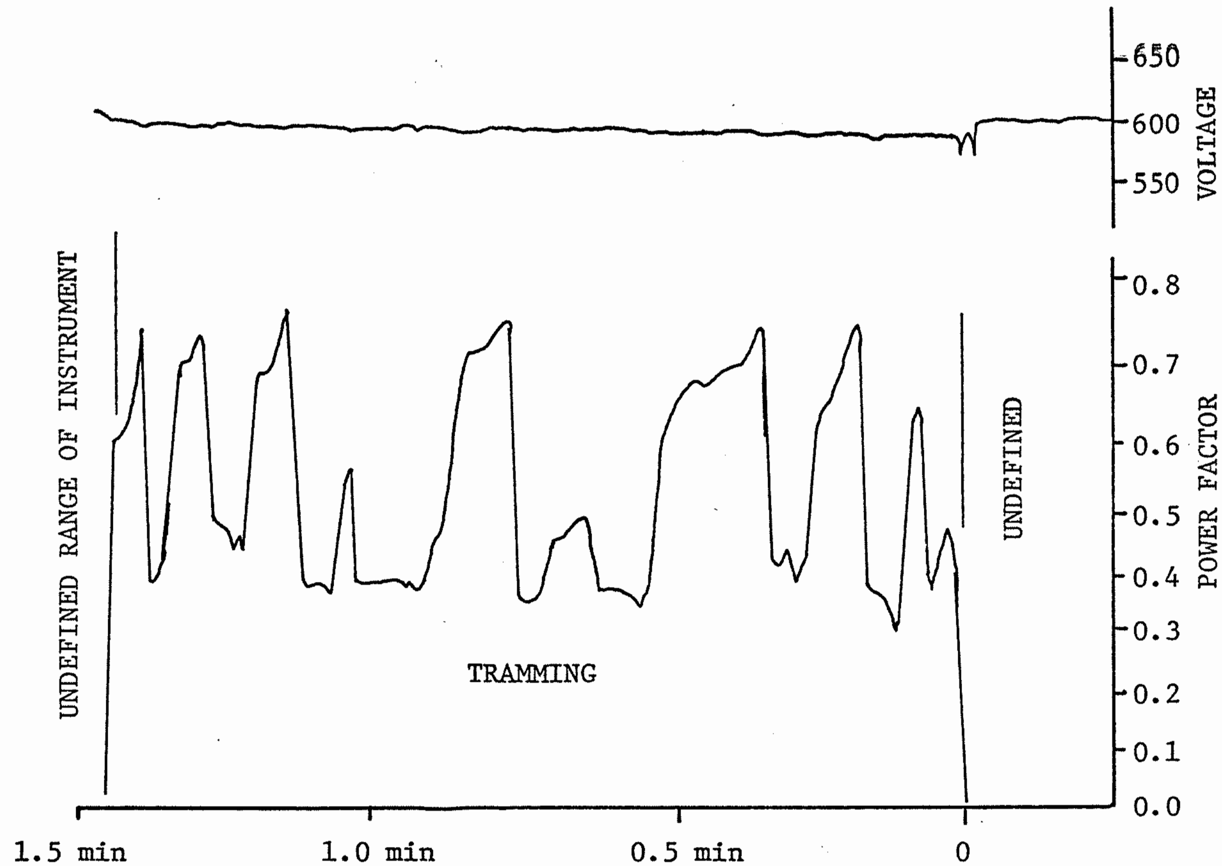

Figure 87c. Normal Tramming Voltage and Power Factor Cycle for a Lee-Norse CM26H Continuous Miner Two (550V).

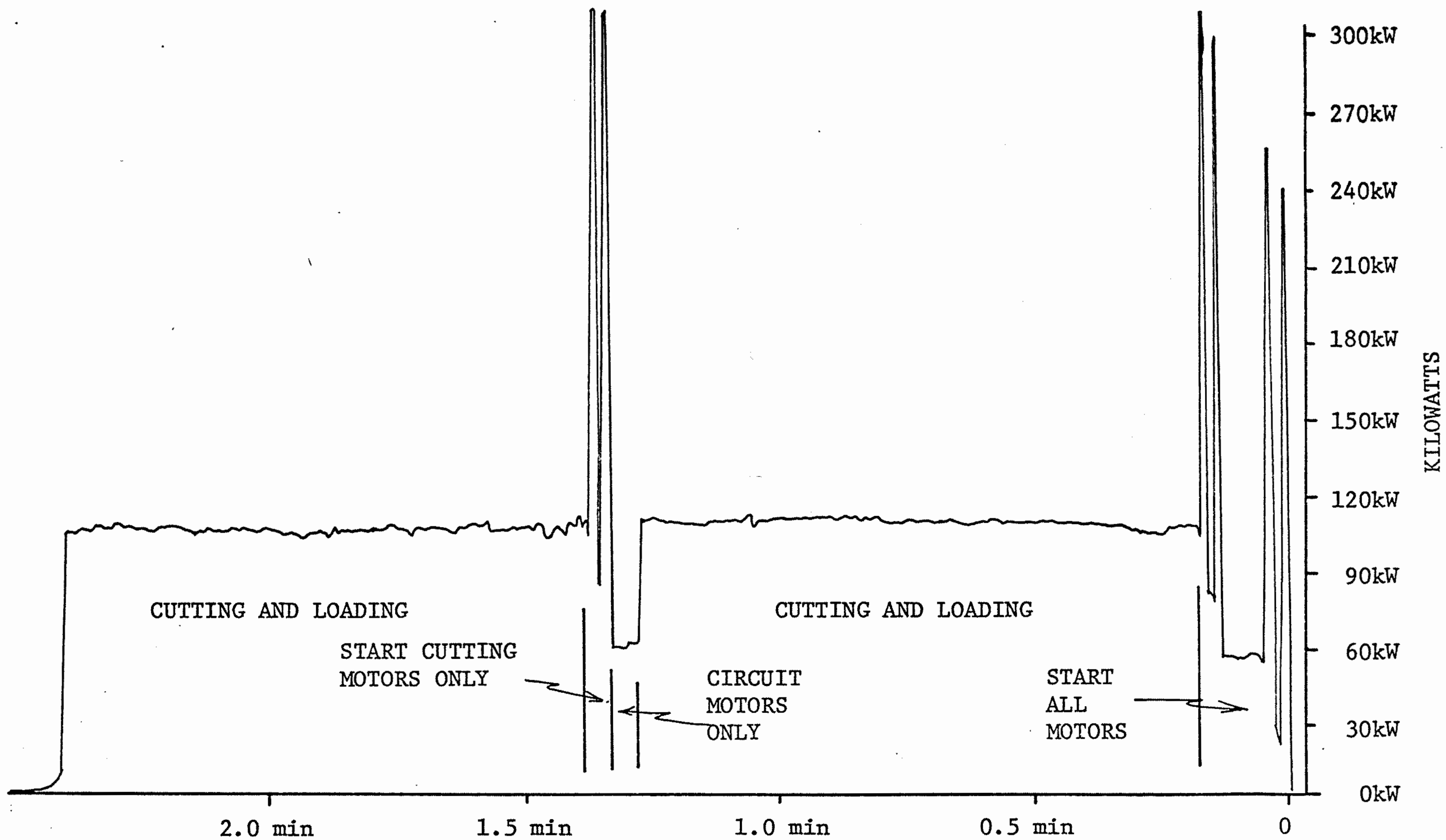

Figure 88a. Cutting and Loading Power Cycle for a Lee-Norse CM26H Continuous Miner Two (550V).

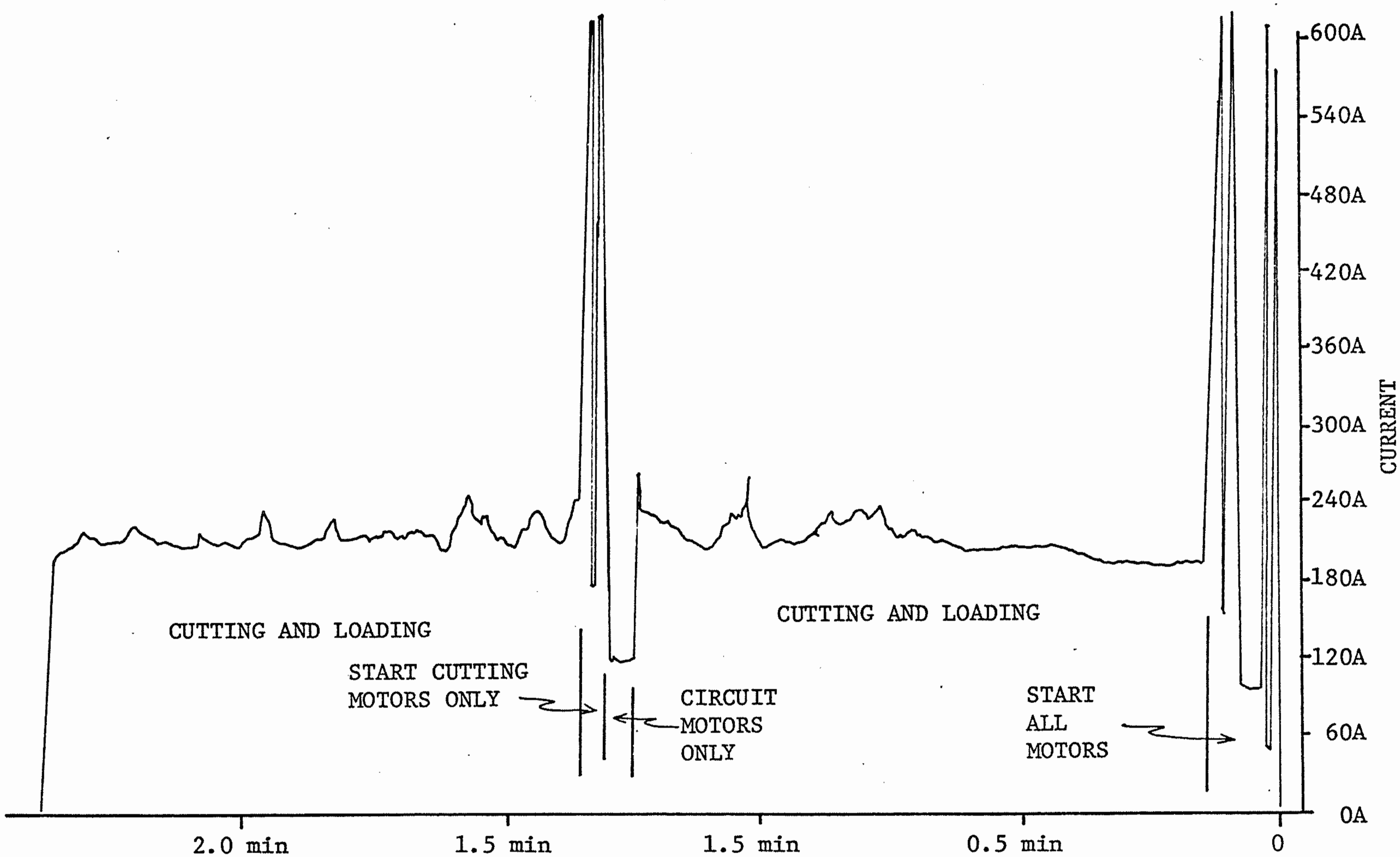

Figure 88b. Cutting and Loading Current Cycle for a Lee-Norse CM26H Continuous Miner Two (550V).

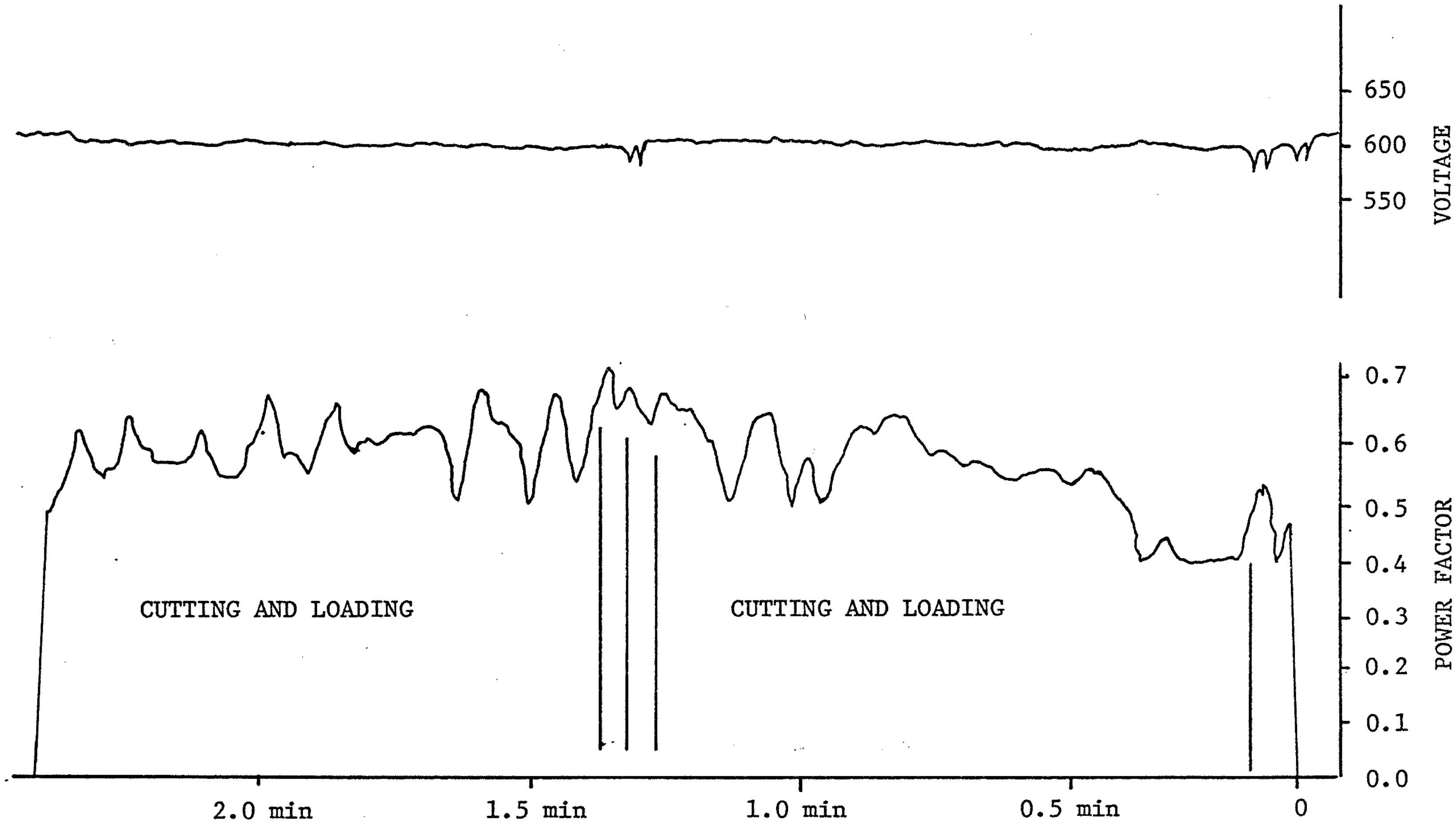

Figure 88c. Cutting and Loading Power Factor and Voltage Cycles for a Lee-Norse CM26H Continuous Miner Two.

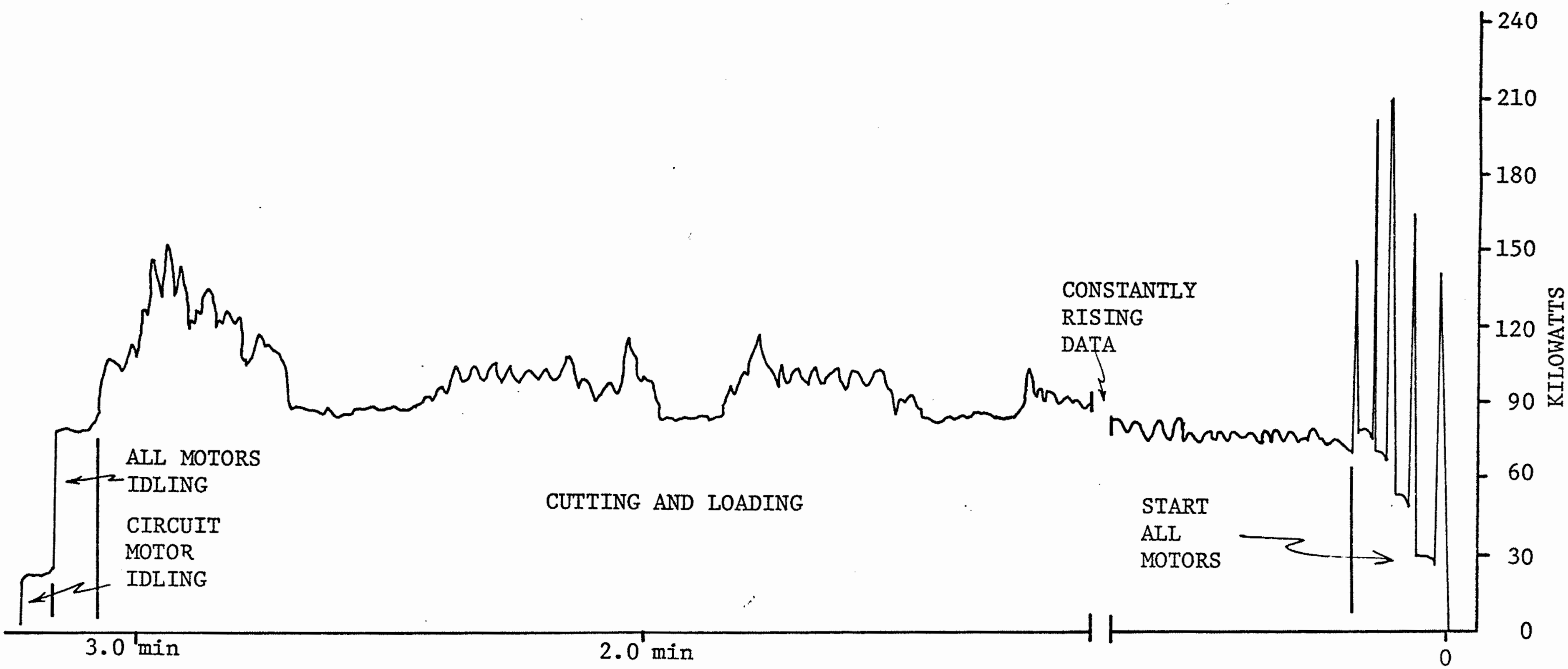

Figure 89a. Lee-Norse CM28E Continuous Miner (440V) Normal Cutting and Loading Power Cycle.

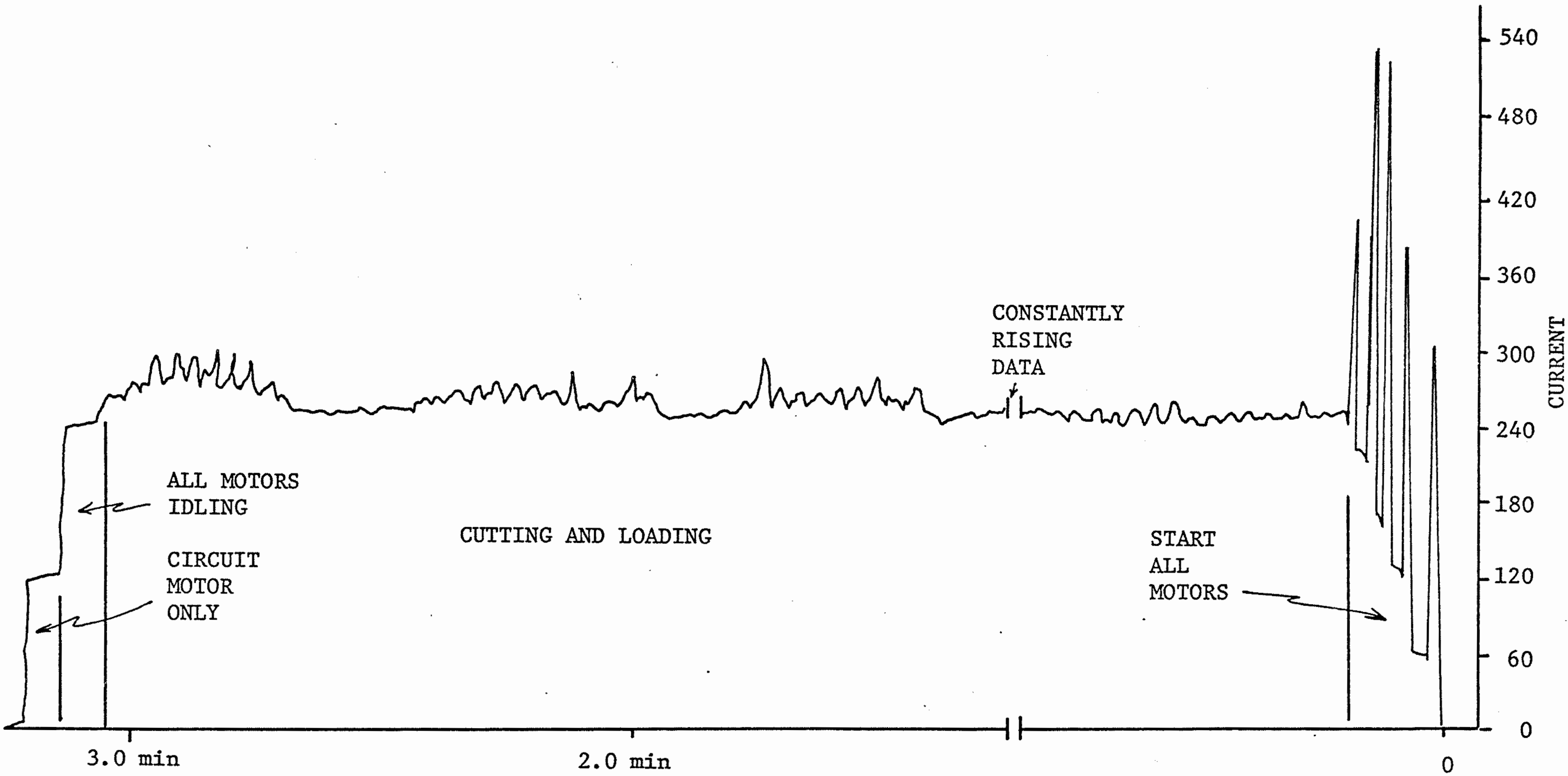

Figure 89b. Lee-Norse CM28E Continuous Miner (440V) Normal Cutting and Loading Current Curve.

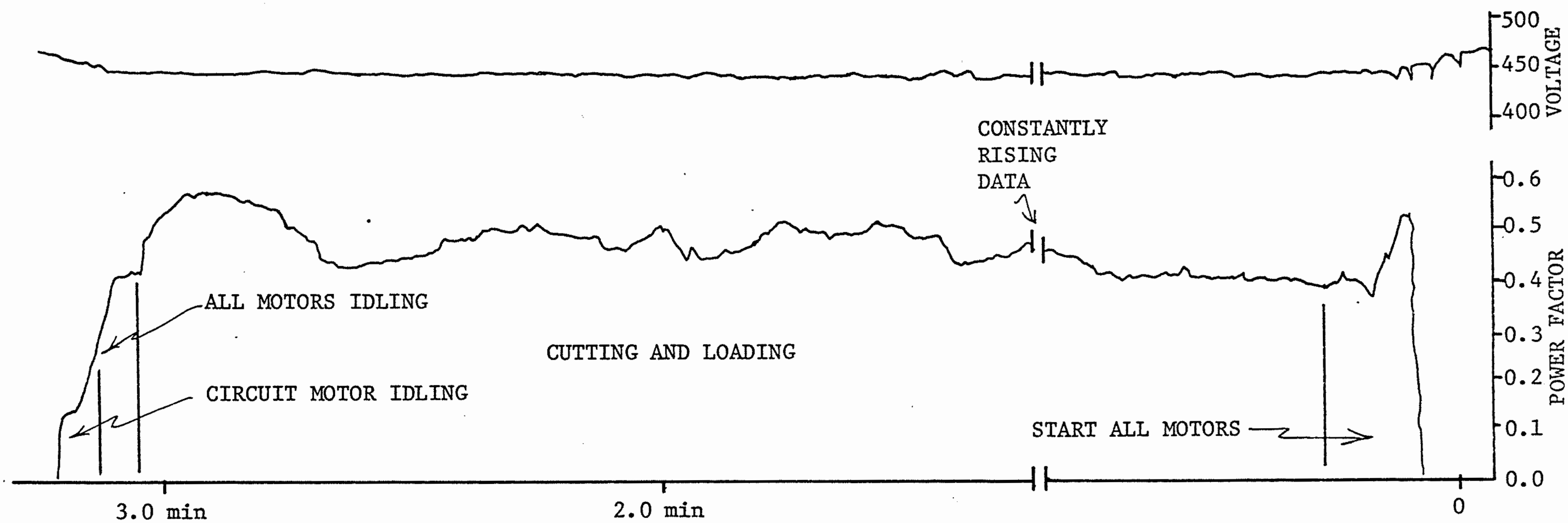

Figure 89c. Lee-Norse CM28E Continuous Miner (440V) Cutting and Loading Curve for Power Factor and Voltage.

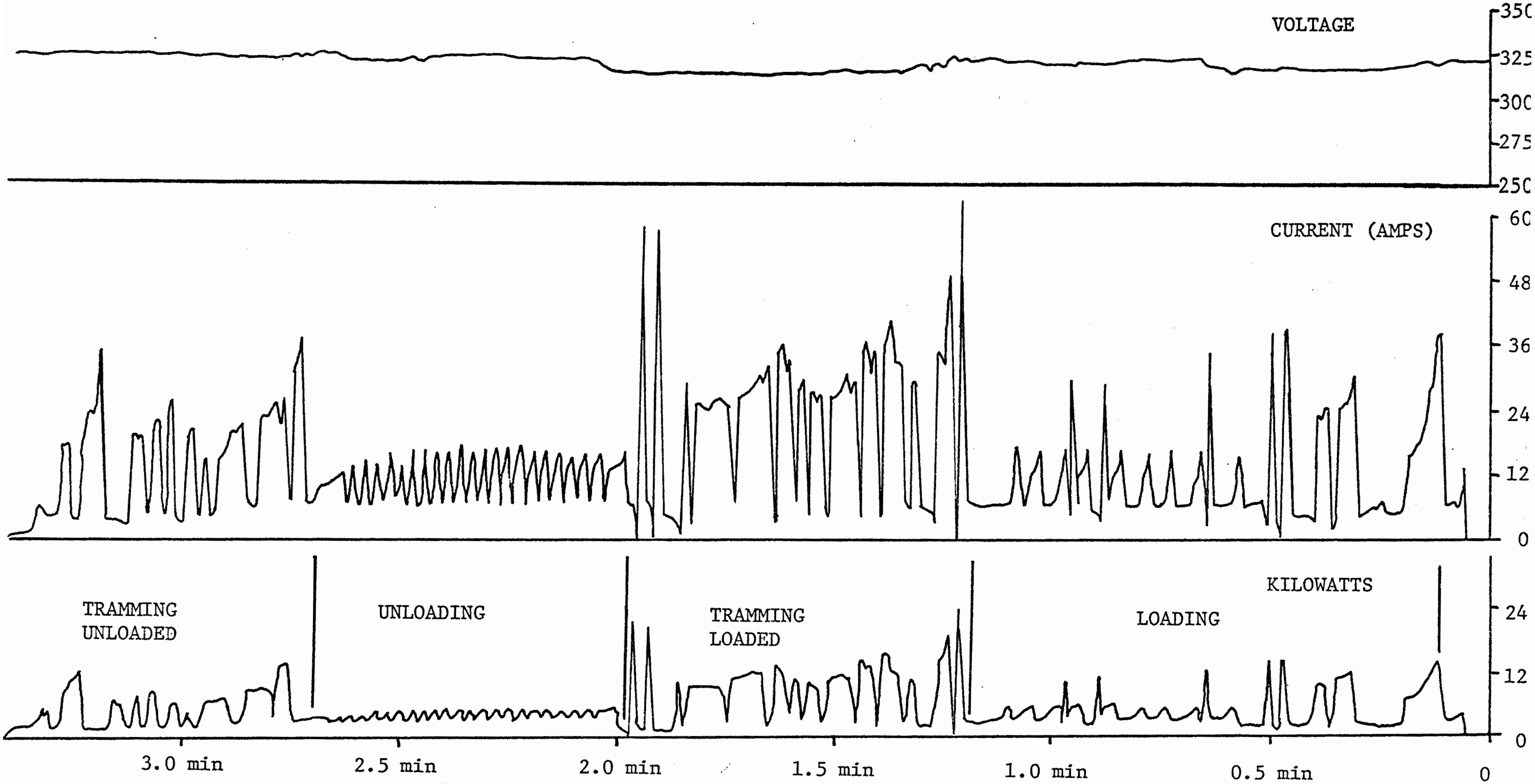

Figure 90. Normal Operational Cycle for a Joy 18SC Shuttle Car (All Tests Similar).

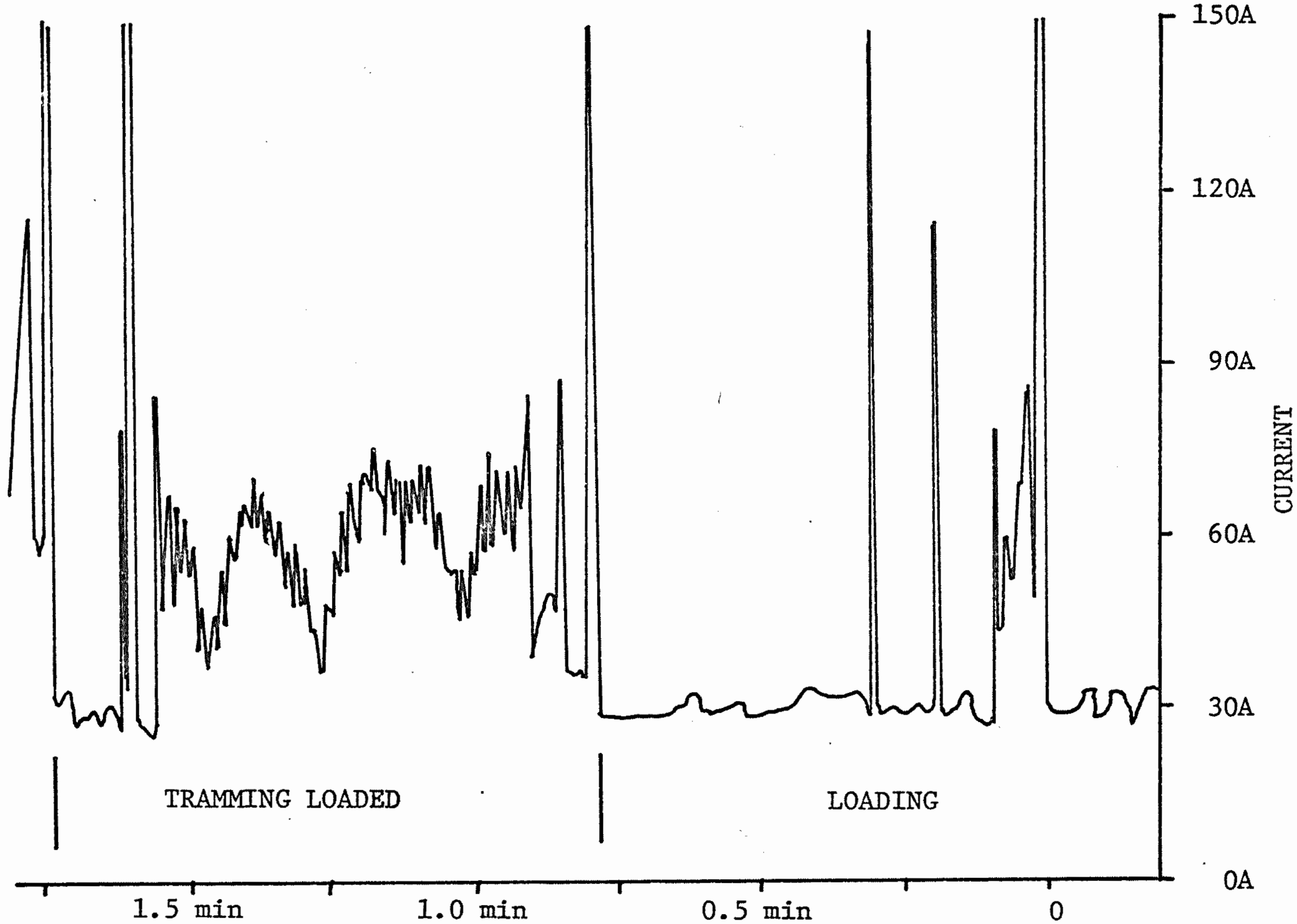

Figure 91a. Current Operational Cycle for a 48S Torkar (a-c) During Loading and Tramming Loaded.

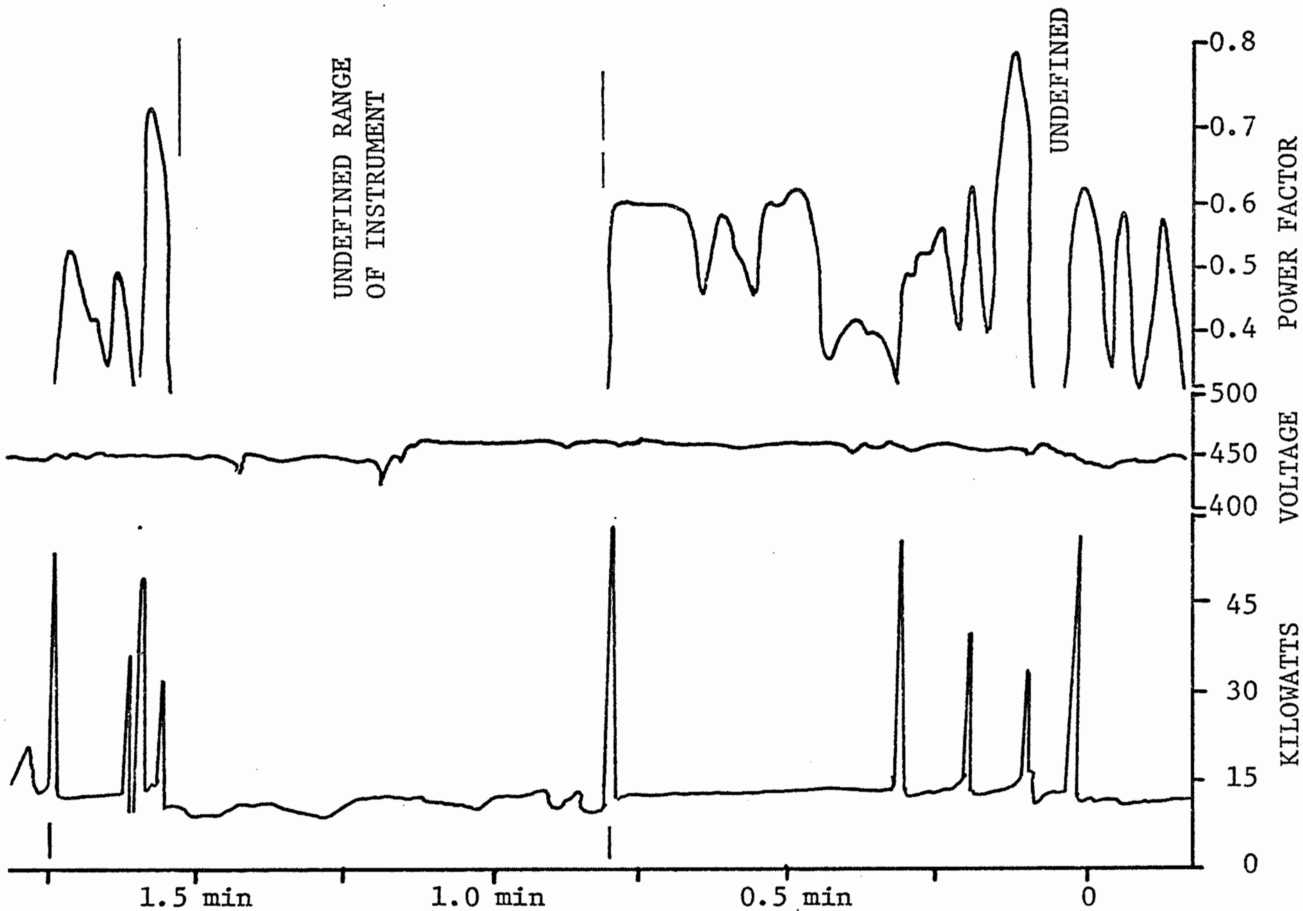

Figure 91b. Power, Voltage and Power Factor Operational Cycles for a 48S Torkar (a-c) During Loading and Tramming Loaded.

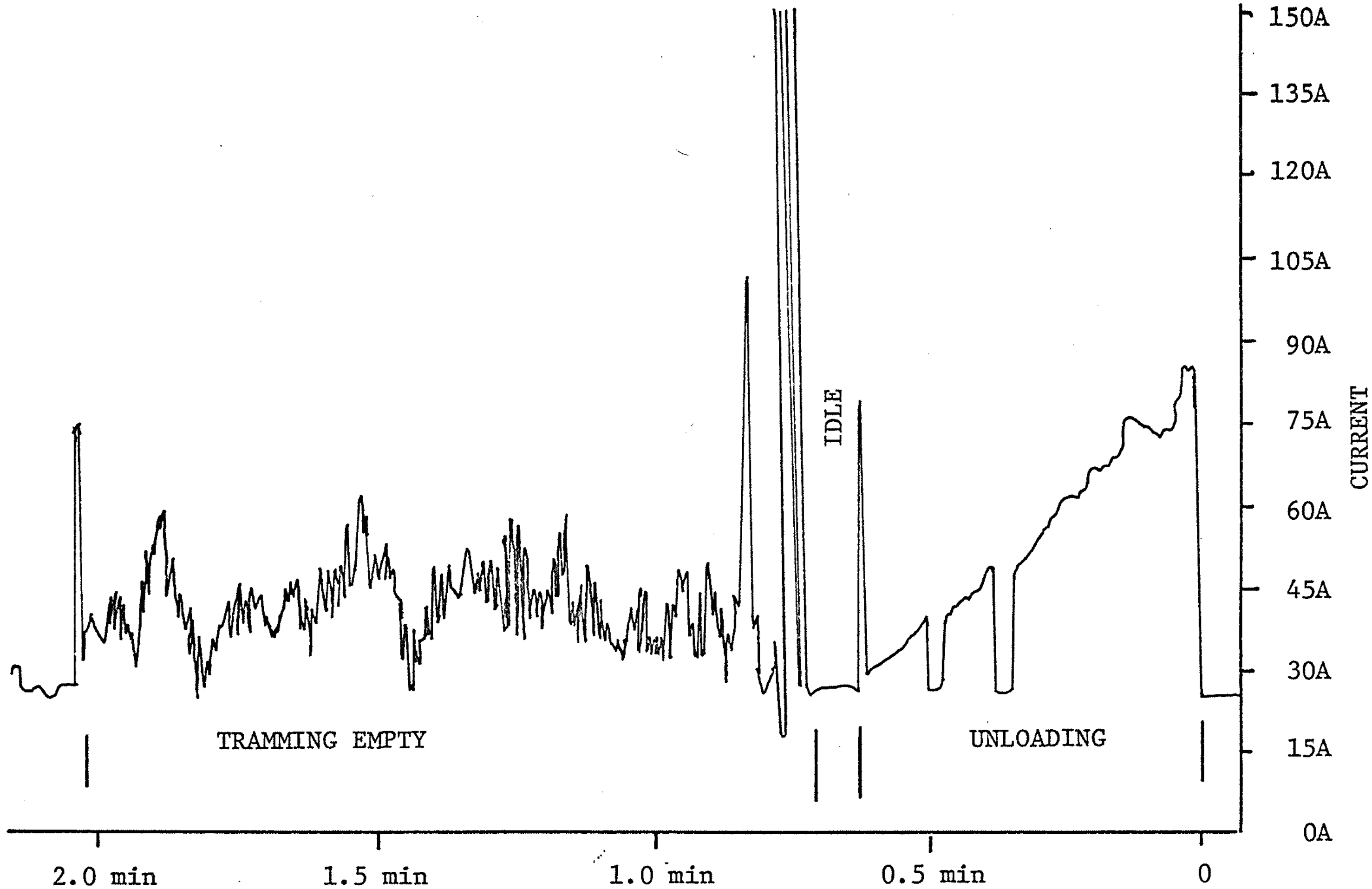

Figure 92a. Current Operational Cycle for a 48S Torkar (a-c) During Unloading and Tramming Empty.

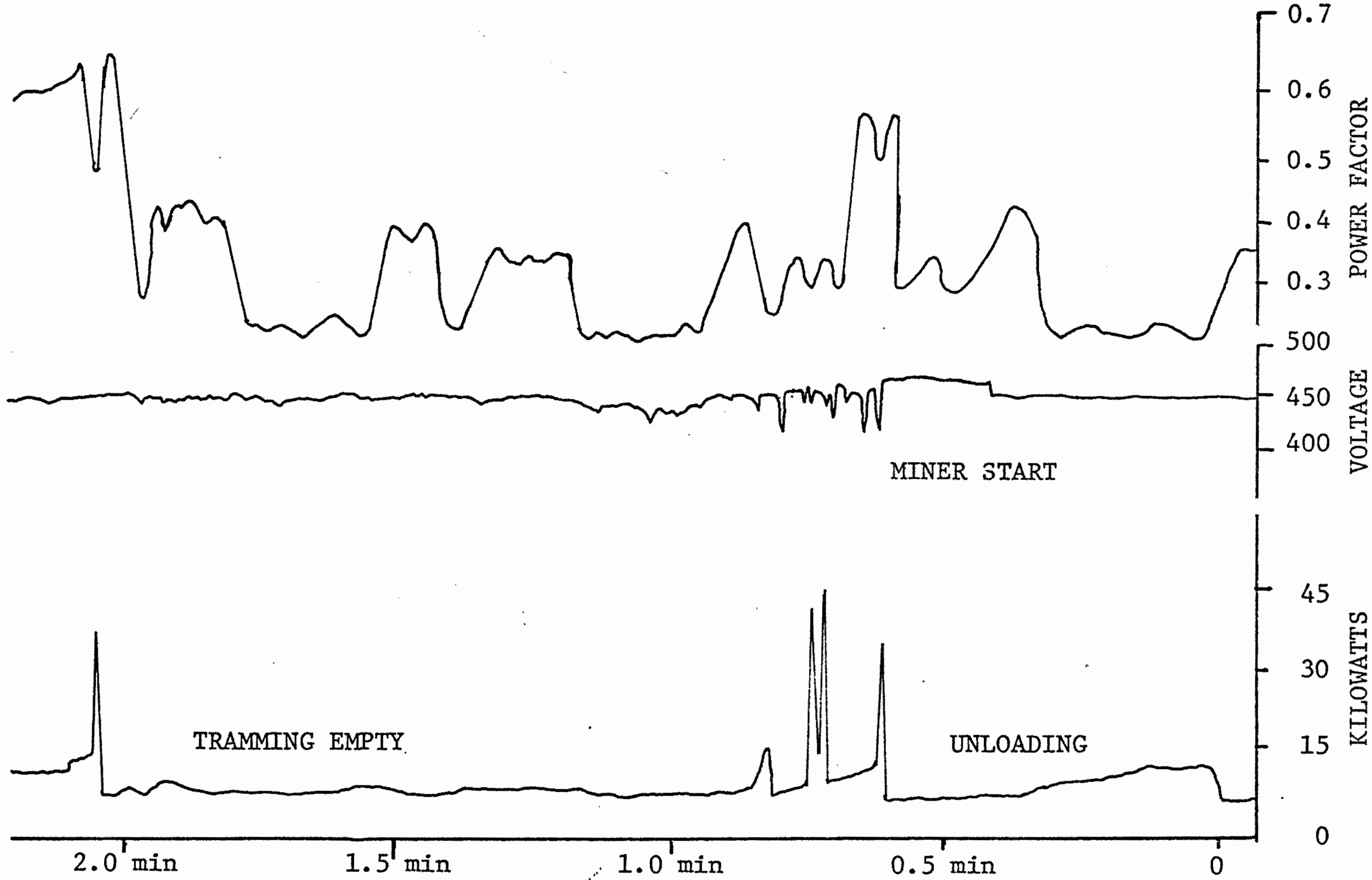

Figure 92b. Power, Voltage, and Power Factor Operational Cycles for a 48S Torkar During Unloading and Tramming Empty.

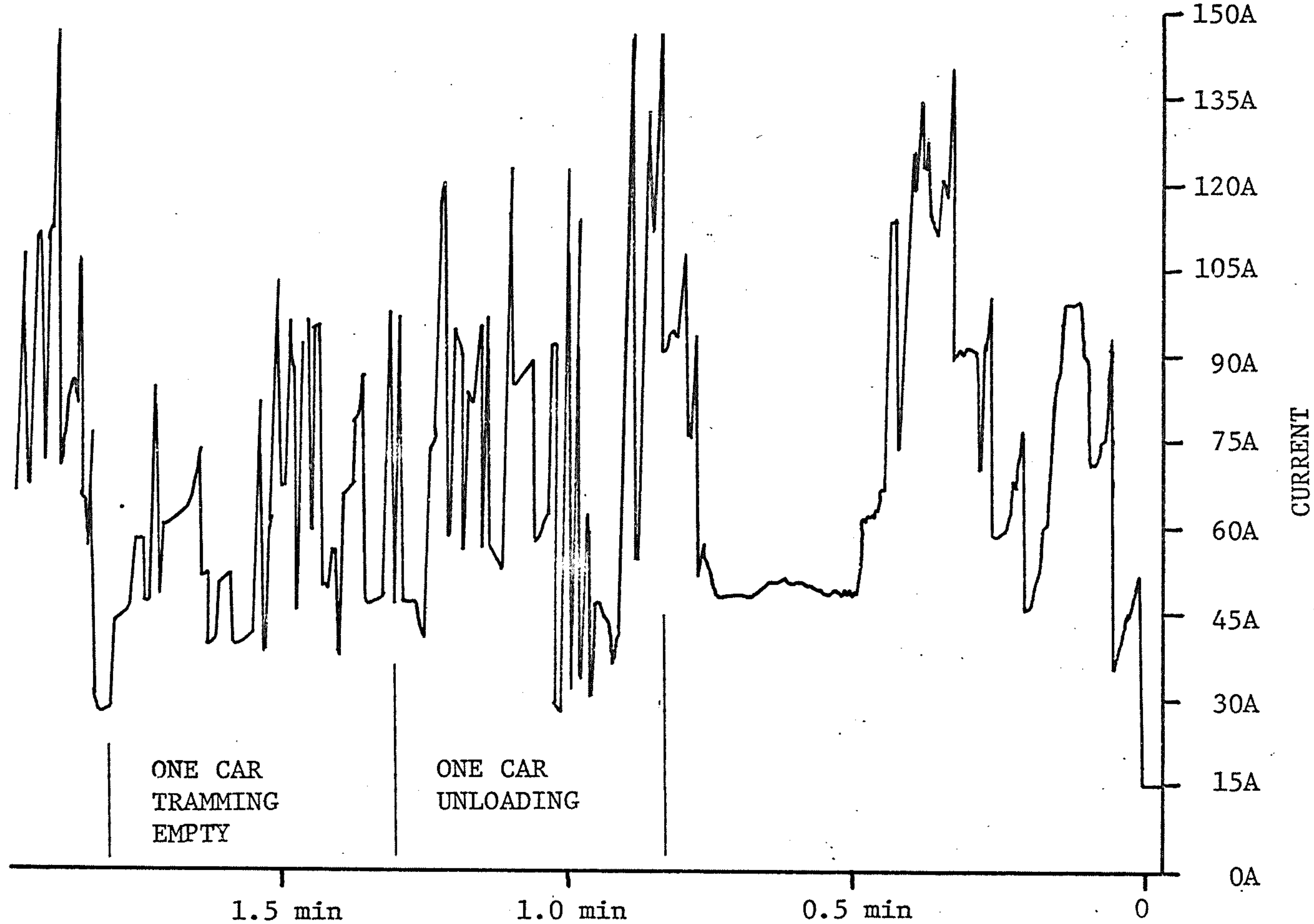

Figure 93a. Current Curve of Rectifier Input (480Vac) During Tramming and Loading Cycles for Two Joy 10SC Shuttle Cars.

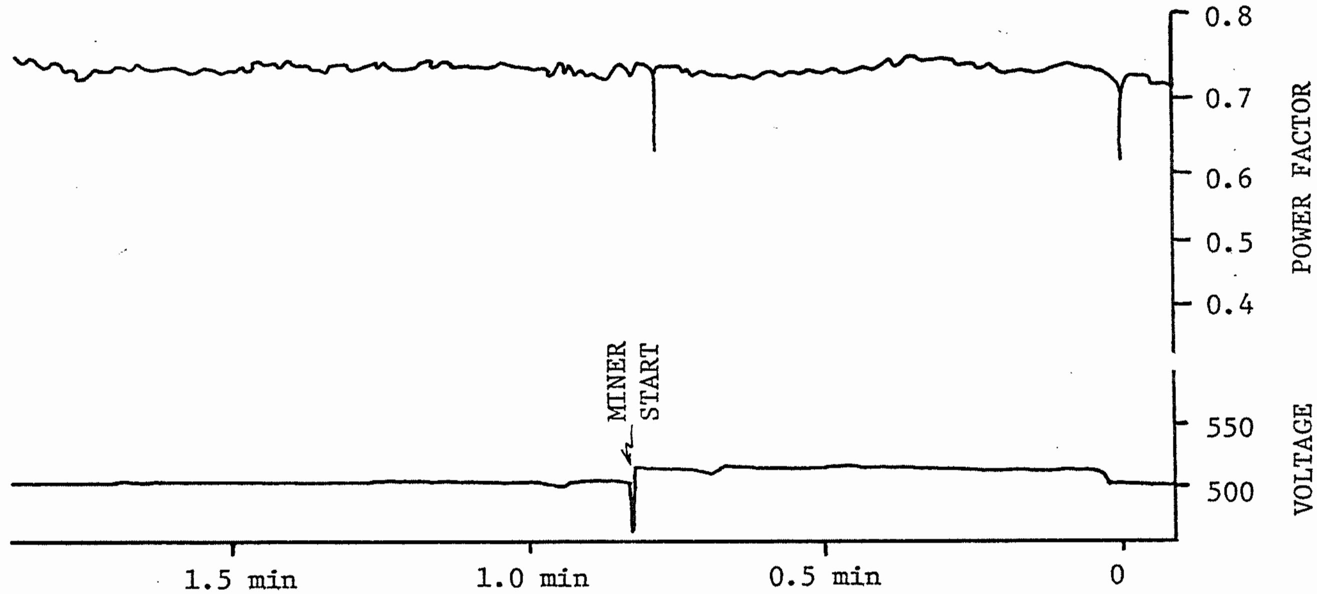

Figure 93b. Power Factor and Voltage Curves of Rectifier Input (480V) During Tramming and Loading Cycles for Two Joy 10SC Shuttle Cars.

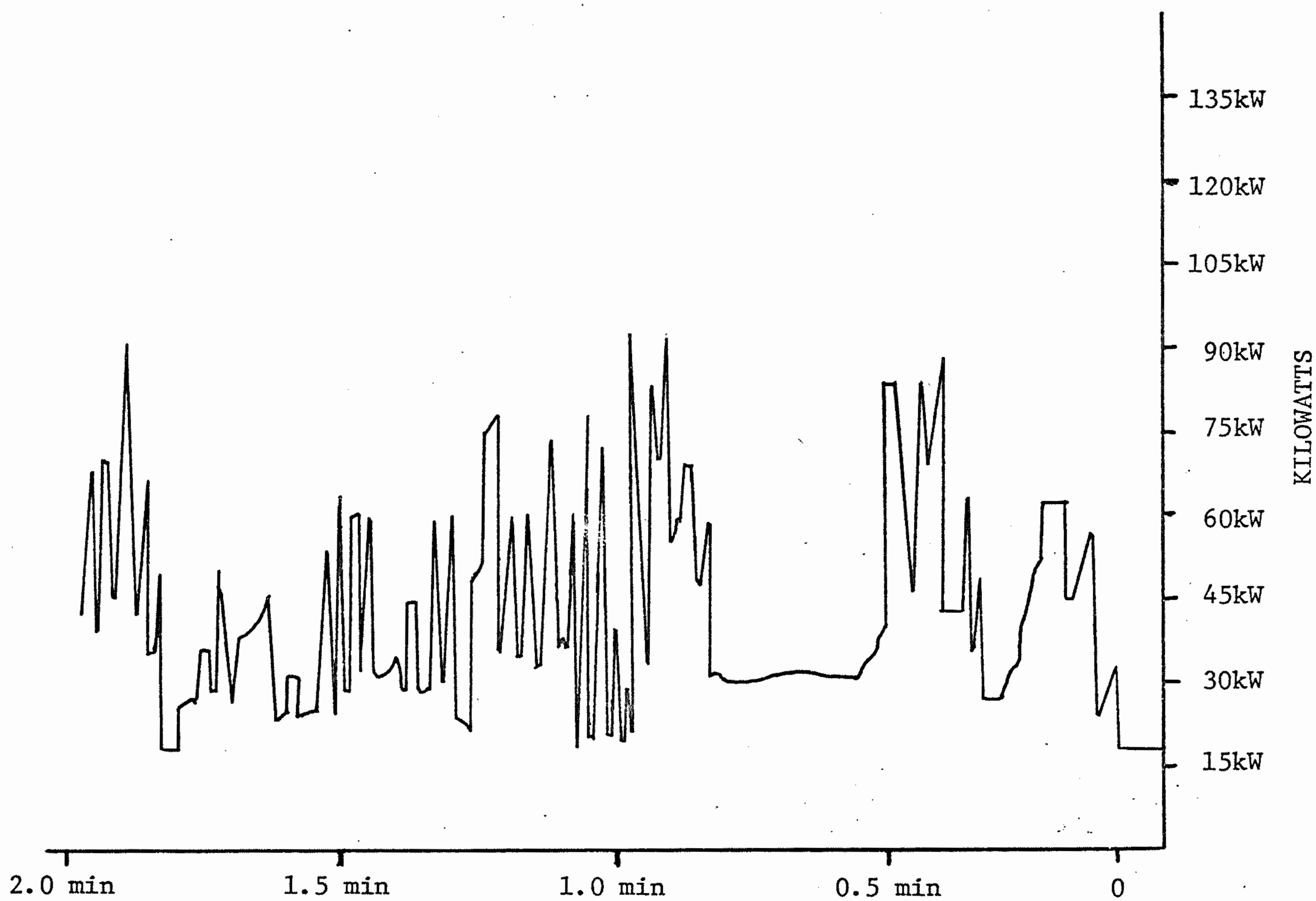

Figure 93c. Power Curve of Rectifier Input (480V) During Tramming and Loading Cycles for Two Joy 10SC Shuttle Cars.

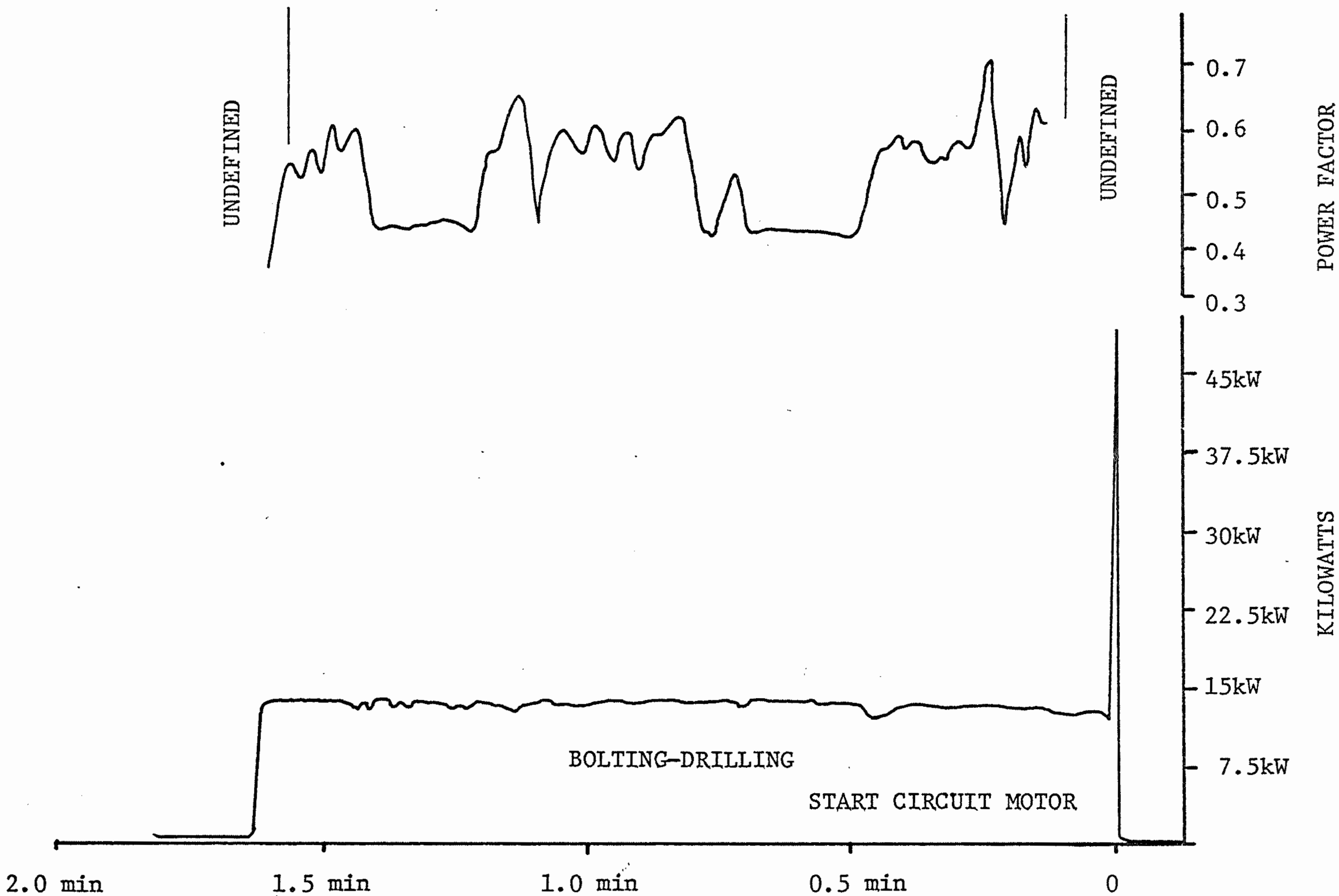

Figure 94a. Normal Drill and Bolt Power and Power Factor Curves for a Fletcher LTDO-15 Roof Bolter (550V).

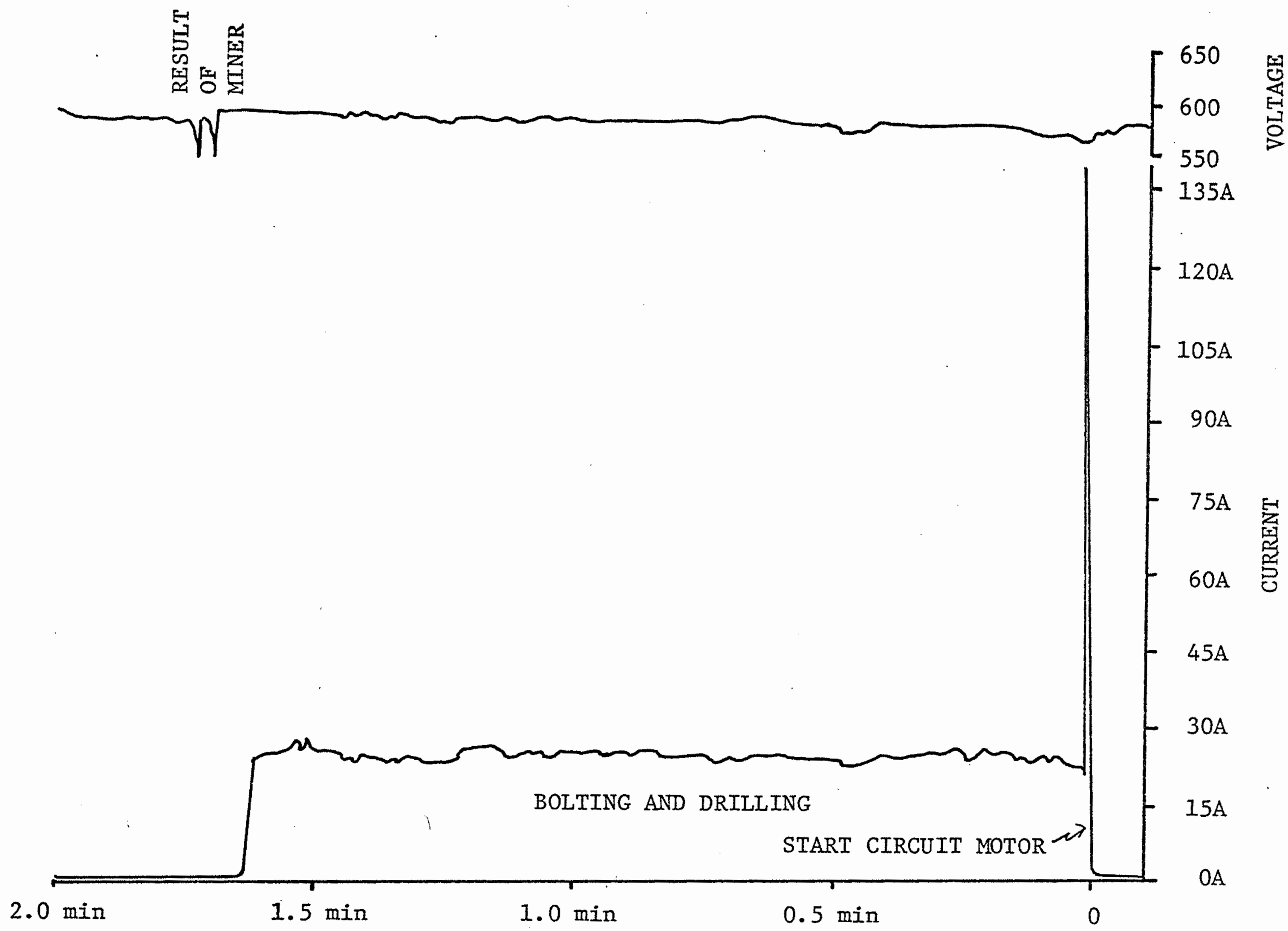

Figure 94b. Normal Drill and Bolt Curves of Voltage and Current for a Fletcher LTDO-15 Roof Bolter (550V).

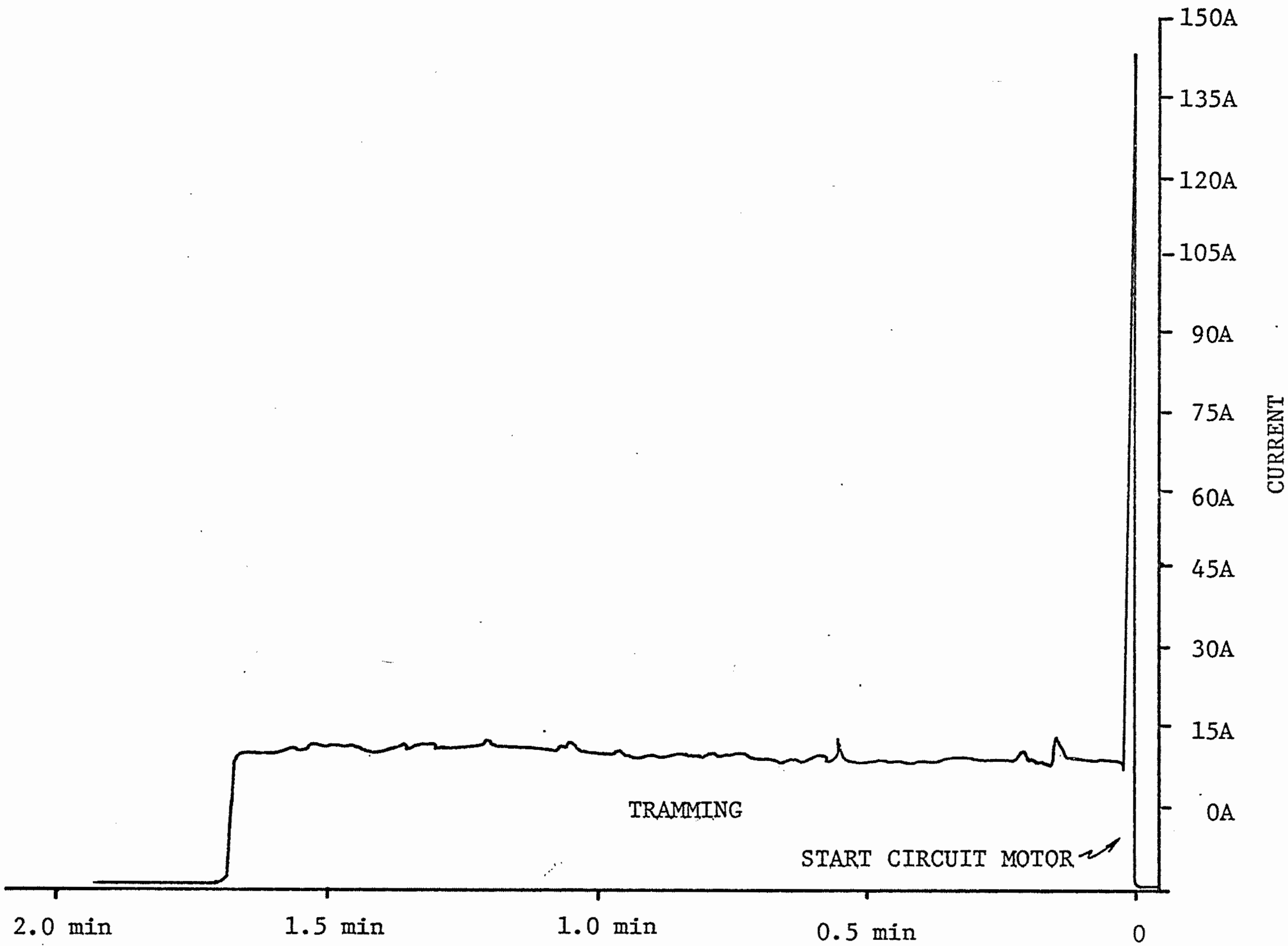

Figure 95a. Normal Tramming Current Cycle for a Fletcher LTDO-15 Roof Bolter (550V).

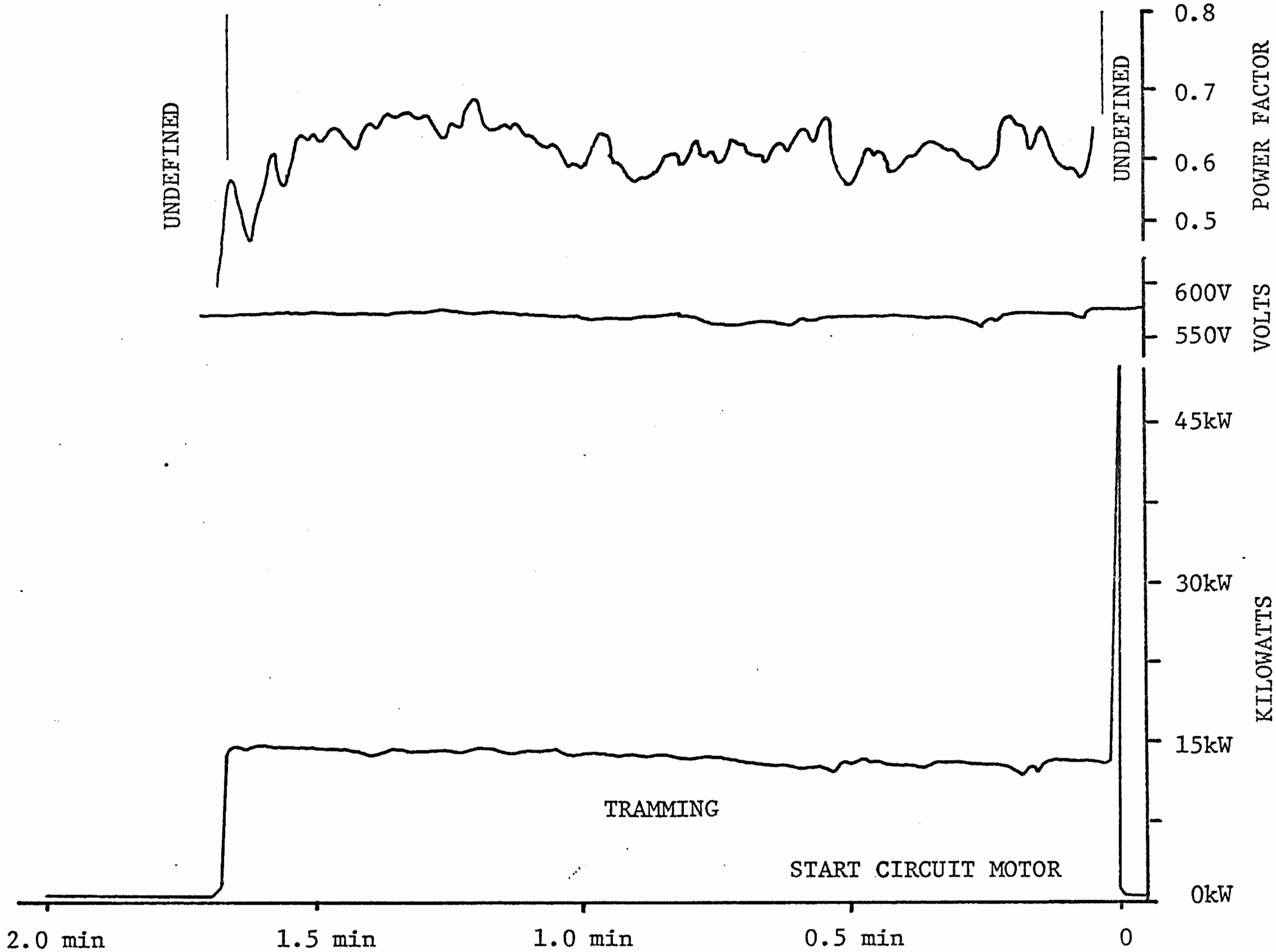

Figure 95b. Normal Tramming Power, Voltage and Power Factor Cycles for a Fletcher LTDO-15 Roof Bolter (550V).

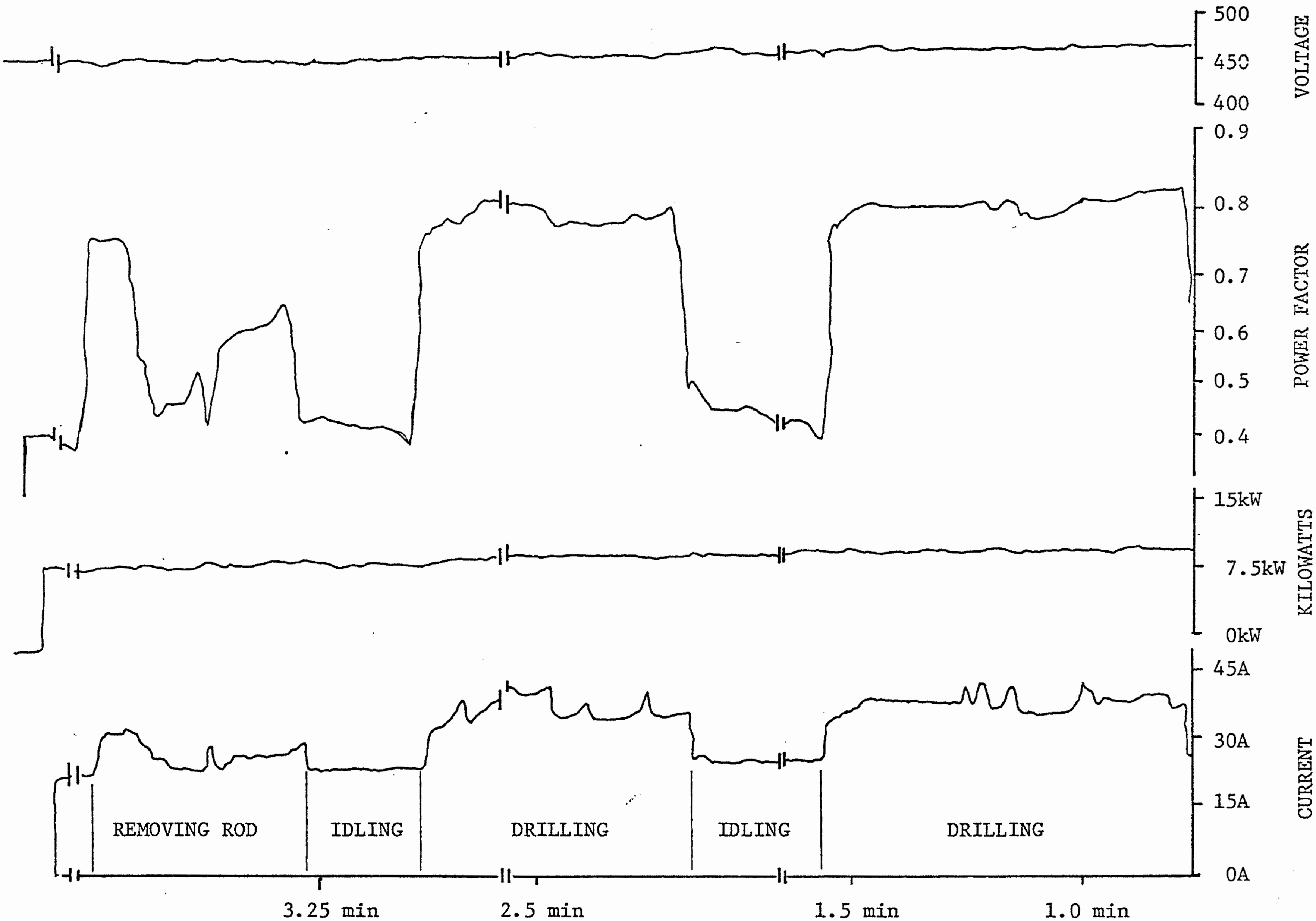

Figure 96. Normal Drilling Electrical Operational Cycle for Galis 300 Roof Bolters.

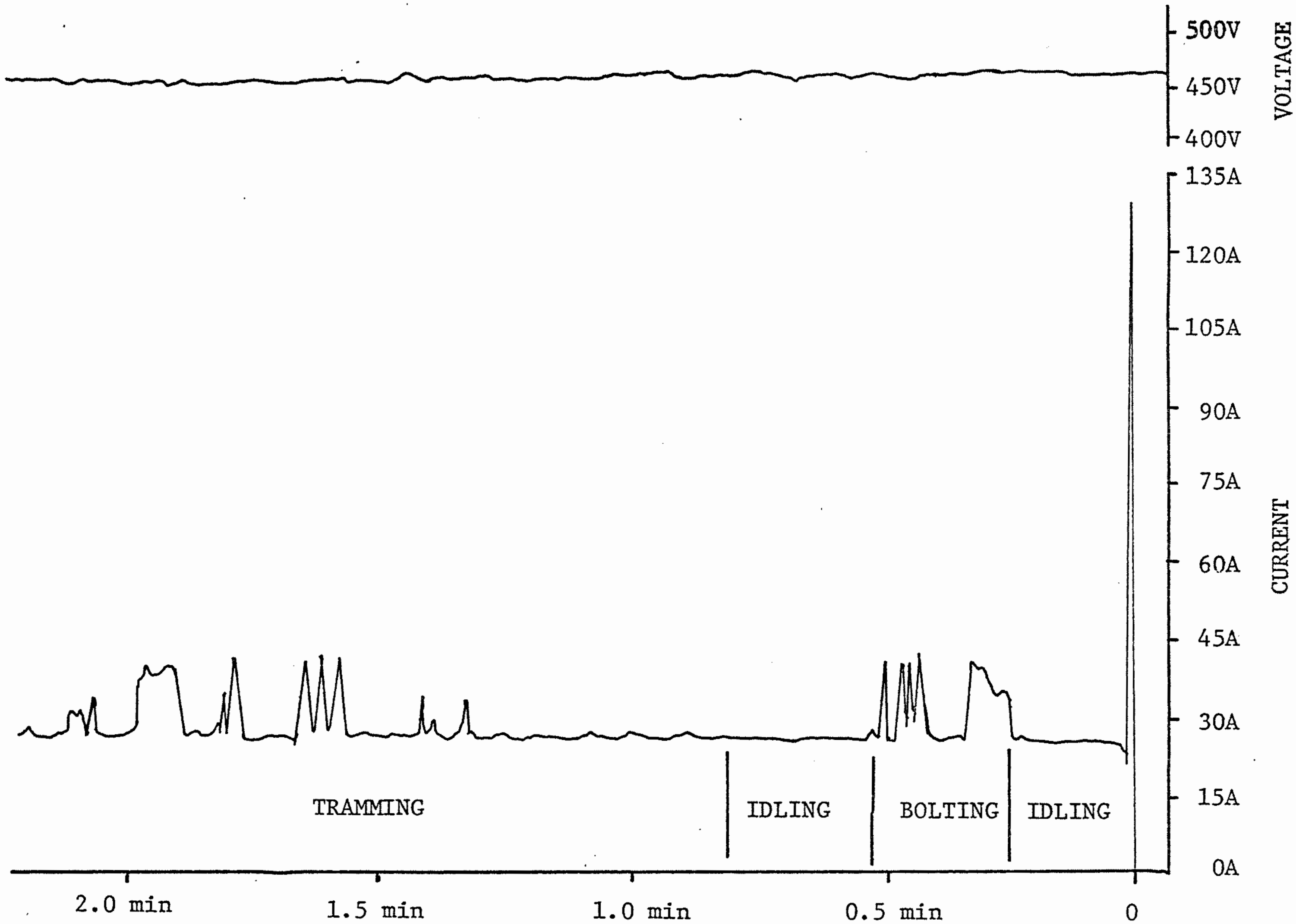

Figure 97a. Normal Tramming-Bolting Current and Voltage Cycles for Galis 300 Roof Bolters.

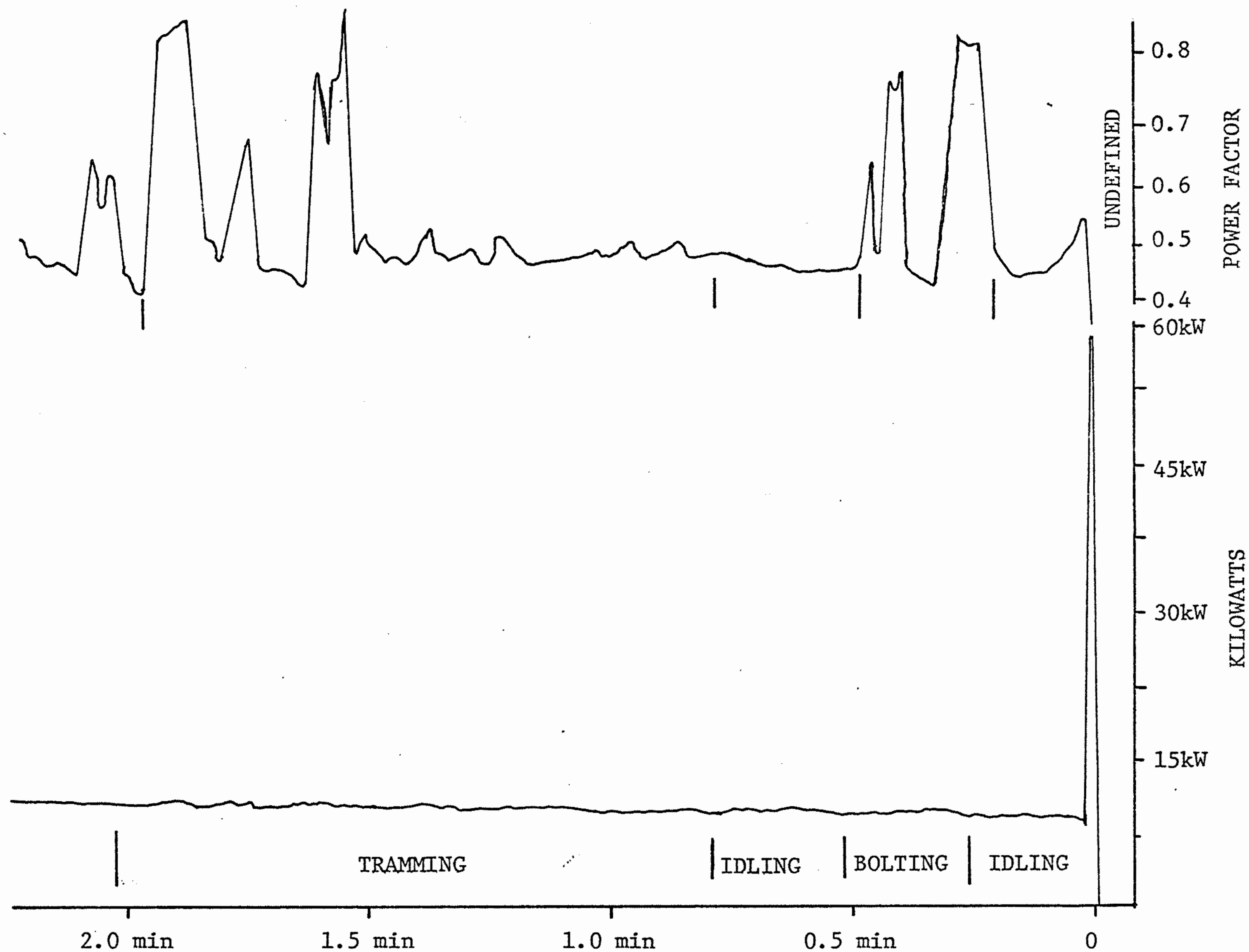

Figure 97b. Normal Tramming-Bolting Power and Power Factor Cycles for Galis 300 Roof Bolters.

APPENDIX III

CABLE SPLICE SAMPLE DESCRIPTION

Groups A and C - Sample Description

Connector: One sleeve per conductor, hydraulically crimped making two curved indentations around a half connector circumference on each end of a "butt" type joint.

Insulation: One flame resistant rubber insert covering all conductors and plastic tape.

Jacket: Pre-stretched tubular flame resistant rubber jacket.

Dimensions: 1 x 1-5/8 x 12-1/8 inches, No. 2, Type G cable; 7/8 x 1-3/8 x 11-1/2 inches, No. 4, Type G cable (maximum for splices on hand).

Groups B and D - Sample Description

Connector: One sleeve per conductor, hydraulically crimped making two curved indentations around a half connector circumference on each end of a "butt" type joint.

Insulation: One flame resistant rubber insert covering all conductors and plastic tape.

Jacket: Stretchable tubular flame resistant rubber jacket.

Dimensions: 1 x 1-5/8 x 9-7/8 inches, No. 2, Type G cable; 7/8 x 1-3/8 x 9-1/8 inches, No. 4, Type G cable (maximum for splices on hand).

Groups E and G - Sample Description

Connector: One double flared sleeve per conductor, mechanically crimped making a four-sided circular indentation on a "lap" joint.

Insulation: Fiber glass tape and filler tape.

Jacket: Flame resistant jacketing tape.

Dimensions: 1-1/8 x 2-1/8 x 12-3/4 inches, No. 2, Type G cable; 1 x 1-5/8 x 11-1/2 inches, No. 4, Type W cable (maximum for splices on hand).

Group F - Sample Description

Connector: One beat ring per conductor, crimped by hammering around a "lap" type joint (four splices).

One compression sleeve per conductor, crimped by making a rectangular indentation in a "lap" type joint (two splices).

Insulation: One heat-shrinkable sleeve per conductor.

Jacket: Flame resistant heat-shrinkable sleeve.

Dimensions: 1-3/8 x 2 x 18 inches, No. 2, Type W cable (maximum of the splices on hand).

Groups H and I - Sample Description

Connector: Two stainless steel bands per conductor mechanically tightened on a "crow's foot joint." One band is used on the ground wire "lap" joint.

Insulation: One heat-shrinkable sleeve coated internally with thermoplastic adhesive and electrical grade putty applied per conductor.

Jacket: Flame resistant, molded, heat-shrinkable sleeve coated internally with thermoplastic adhesive and coated externally with heat sensitive (thermochromic) paint.

Dimensions: 1-1/4 x 1-3/4 x 16-1/8 inches, No. 2, Type G cable (maximum of the splices on hand).

Groups J, K and L - Sample Description

Connector: One sleeve per conductor, mechanically crimped making a rectangular indentation on each end of a "butt" type joint.

Insulation: One flame resistant rubber insert covering all conductors and plastic tape.

Jacket: Pre-stretched tubular flame resistant rubber jacket.

Dimensions: 1-1/8 x 1-3/4 x 12-1/8 inches, No. 2, Type G cable; 1-1/4 x 1-1/2 x 11-1/2 inches, No. 4, Type G cable (maximum for splices on hand).

Group M - Sample Description

Connector: One sleeve per conductor, mechanically crimped making a rectangular indentation on each end of a "butt" type joint.

Insulation: One tubular rubber insert per conductor, covering bare portion only, and plastic tape.

Jacket: Pre-stretched tubular flame resistant rubber jacket.

Dimensions: 15/16 x 1-5/16 x 11-1/2 inches, No. 4, Type G cable (maximum for splices on hand).

Groups N and O - Sample Description

Connector: One sleeve per conductor, hydraulically crimped making a four-sided circular indentation on each end of a "butt" type joint.

Insulation: One flame resistant rubber insert covering all conductors and plastic tape.

Jacket: Pre-stretched tubular flame resistant rubber jacket.

Dimensions: 1-1/2 x 1-11/16 x 12-1/8 inches, No. 2, Type G cable; 1 x 1-1/2 x 11-1/2 inches, No. 4, Type G cable (maximum for splices on hand).

APPENDIX IV

CABLE SPLICE DATA

SYMBOLS

White or White Cond. = White Conductor

Black or Black Cond. = Black Conductor

Std. = Standard or Unspliced Cable

Water = Electrode in Water Bath

No. = Sample Identifying Number

Pos. Cond. = Positive Conductor

Diff. = Difference

L = Length

Three Samples - Group A - No. 2, Type G Cable, 39 Inches Long

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.
1	5	5	0	5	5	0	10	10	0
2	5	5	0	5	5	0	10	10	0
3	5	5	0	5	5	0	12	10	2

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
1	1000+	1000+	1000+	1000+	1000+	1000+
2	1000+	1000+	1000+	1000+	1000+	1000+
3	1000+	1000+	1000+	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
1	1000+	1000+	1000+	1000+	1000+	1000+
2	1000+	1000+	1000+	1000+	1000+	1000+
3	1000+	1000+	1000+	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
1	1000+	1000+	1000+	1000+	1000+	1000+
2	1000+	1000+	1000+	1000+	1000+	1000+
3	1000+	1000+	1000+	1000+	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
2	2390	4760	50

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
1	36.3 @ 15 kV	-	White
1	36.8 @ 15 kV	-	Black
3	5.0 @ 15 kV	-	White
3	5.2 @ 15 kV	-	Black

Three Samples - Group B - No. 2, Type G Cable, 39 Inches Long

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.
4	5	5	0	5	5	0	10	10	0
5	5	5	0	5	5	0	10	10	0
6	5	5	0	5	5	0	11	10	1

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
4	1000+	1000+	1000+	1000+	1000+	1000+
5	1000+	1000+	1000+	1000+	1000+	1000+
6	1000+	1000+	1000+	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
4	1000+	1000+	1000+	1000+	1000+	1000+
5	1000+	1000+	1000+	1000+	1000+	1000+
6	1000+	1000+	1000+	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
4	1000+	1000+	1000+	1000+	1000+	1000+
5	1000+	1000+	1000+	1000+	1000+	1000+
6	1000+	1000+	1000+	1000+	1000+	1000+

Tensile Strength:

Groups A and B are connected in the same manner and have similar insulation. Since there are only three samples in each group, the 2390 lb. value will have to be used for Group B also.

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
4	4.6 @ 15 kV	-	White
4	4.0 @ 15 kV	-	Black
5	4.6 @ 15 kV	-	White
5	4.0 @ 15 kV	-	Black
6	4.0 @ 15 kV	-	White
6	4.0 @ 15 kV	-	Black

Three Samples - Group C - No. 4, Type G Cable, 36 Inches Long

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.
7	11	8	3	10	8	2	20	15	7
8	11	8	3	13	8	5	22	15	7
9	11	8	3	11	8	3	22	15	7

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
7	125	55	60	1000+	1000+	1000+
8	125	60	45	1000+	1000+	1000+
9	150	70	75	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
7	125	55	60	1000+	1000+	1000+
8	125	60	45	1000+	1000+	1000+
9	150	70	75	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
7	125	55	60	1000+	1000+	1000+
8	125	60	45	1000+	1000+	1000+
9	150	75	75	1000+	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
9	1420	3000	47

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
7	385 @ 6.5 kV	7 kV*	White
7	-	7 kV	Black
8	360 @ 5.5 kV	Est. 6 kV	White
8	475 @ 5.5 kV	Est. 6 kV	Black

*Failure occurred as a result of sharp edges on connector protruding into splice kit primary insulation.

Three Samples - Group D - No. 4, Type G Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.	L
10	11	8	3	10	8	2	20	15	5	36"
11	10	8	2	11	8	3	24	15	9	36"
12	11	8	3	10	8	2	23	16	7	38.5"

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
10	1000+	1000+	1000+	1000+	1000+	1000+
11	1000+	1000+	1000+	1000+	1000+	1000+
12	1000+	1000+	1000+	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
10	1000+	1000+	1000+	1000+	1000+	1000+
11	1000+	1000+	1000+	1000+	1000+	1000+
12	1000+	1000+	1000+	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
10	1000+	1000+	1000+	1000+	1000+	1000+
11	1000+	1000+	1000+	1000+	1000+	1000+
12	1000+	1000+	1000+	1000+	1000+	1000+

Tensile Strength:

Groups C and D are connected in the same manner and have similar insulation. Since there are only three samples in each group, the 1420 lb. value will have to be used for Group D also.

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
10	6.6 @ 15 kV	-	White
10	4.8 @ 15 kV	-	Black
11	24 @ 15 kV	-	White
11	11 @ 15 kV	-	Black
12	6.2 @ 15 kV	Est. 12.25 kV	White
12	17.3 @ 15 kV	-	Black

Six Samples - Group E - No. 2, Type G Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.	L
13	7	5	2	7	5	2	11	10	1	37-3/4"
14	5	5	0	7	5	2	13	10	3	37-1/2"
15	6	5	1	5	5	0	12	10	2	37-1/2"
16	6	5	1	6	5	1	15	10	5	37-1/2"
17	7	5	2	6	5	1	10	10	0	37-1/2"
18	5	5	0	8	5	3	11	10	1	37-1/4"

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
13	1000+	1000+	1000+	1000+	1000+	1000+
14	1000+	1000+	1000+	1000+	1000+	1000+
15	1000+	1000+	1000+	1000+	1000+	1000+
16	1000+	1000+	1000+	1000+	1000+	1000+
17	1000+	1000+	1000+	1000+	1000+	1000+
18	1000+	1000+	1000+	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
13	1000+	1000+	1000+	1000+	1000+	1000+
14	1000+	1000+	1000+	1000+	1000+	1000+
15	1000+	1000+	1000+	1000+	1000+	1000+
16	1000+	1000+	1000+	1000+	1000+	1000+
17	1000+	1000+	1000+	1000+	1000+	1000+
18	1000+	1000+	1000+	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
13	1000+	1000+	1000+	1000+	1000+	1000+
14	1000+	1000+	1000+	1000+	1000+	1000+
15	1000+	1000+	1000+	1000+	1000+	1000+
16	1000+	1000+	1000+	1000+	1000+	1000+
17	1000+	1000+	1000+	1000+	1000+	1000+
18	1000+	1000+	1000+	1000+	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
14	1580	4760	33

Six Samples - Group E - No. 2, Type G Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
13	5.8 @ 15 kV	-	White
13	7.7 @ 15 kV	Est. 16 kV	Black
14	-	-	-
14	-	-	-
15	3.8 @ 12.5 kV	Est. 13 kV	White
15	4.5 @ 15 kV	-	Black
16	1.1 @ 10.5 kV	11 kV*	White
16	1.3 @ 10 kV	10.5 kV*	Black
17	2.9 @ 15 kV	-	White
17	3.8 @ 15 kV	-	Black
18	3.6 @ 15 kV	-	White
18	1.0 @ 15 kV	-	Black

*Failure resulted from primary insulation that was nicked by the splicer when the conductors were being cut to proper lengths.

Six Samples - Group F - No. 2, Type W Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.	L
19	10	8	2	10	8	2	-	-	-	68"
20	10	9	1	10	9	1	-	-	-	70"
21	9	8	1	9	8	1	-	-	-	68"
22	9	8	1	8	8	0	-	-	-	64"
23	9	9	0	9	9	0	-	-	-	70"
24	8	8	0	8	8	0	-	-	-	67"

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water
19	1000+	-	-	1000+	1000+
20	1000+	-	-	1000+	1000+
21	1000+	-	-	1000+	1000+
22	1000+	-	-	1000+	1000+
23	1000+	-	-	1000+	1000+
24	1000+	-	-	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water
19	1000+	-	-	1000+	1000+
20	1000+	-	-	1000+	1000+
21	1000+	-	-	1000+	1000+
22	1000+	-	-	1000+	1000+
23	1.0	-	-	1.2	0.1
24	1000+	-	-	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water
19	1000+	-	-	1000+	1000+
20	1000+	-	-	1000+	1000+
21	1000+	-	-	1000+	1000+
22	1000+	-	-	1000+	1000+
23	1.0	-	-	1.2	0.1
24	1000+	-	-	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
24	1610	3800	42

Six Samples - Group F - No. 2, Type W Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
19	4.6 @ 15 kV	-	White
20	1.8 @ 15 kV	-	White
21	2.8 @ 15 kV	-	White
22	3.0 @ 15 kV	-	White
23	2.9 @ 15 kV	-	White

Six Samples - Group G - No. 4, Type W Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond. -	Std. =	Diff.	Black Cond. -	Std. =	Diff.	L
25	14	14	0	14	14	0	61"
26	17	17	0	17	17	0	76"
27	13	13	0	13	13	0	58"
28	17	17	0	17	17	0	74"
29	15	15	0	15	15	0	66"
30	14	13	1	13	13	0	58-1/4"

Insulation Resistance: Megaohms

No.	White to Black	White to Water	Black to Water
25	1000+	1000+	1000+
26	1000+	1000+	1000+
27	1000+	1000+	1000+
28	1000+	1000+	1000+
29	1000+	1000+	1000+
30	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Water	Black to Water
25	1000+	1000+	1000+
26	1000+	1000+	1000+
27	1000+	10	1000+
28	1000+	1000+	1000+
29	1000+	1000+	1000+
30	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Water	Black to Water
25	1000+	1000+	1000+
26	0.1	9	9
27	0.1	4	4
28	0.1	0.4	0.3
29	0.1	0.4	0.4
30	1000+	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
26	1370	2400	57

Six Samples - Group H - No. 2, Type G Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.-	Std.=	Diff.	Black Cond.-	Std.*=	Diff.	Gnd.-	Std.=	Diff.	L
31	16	15	1	17	16	1	38	33	5	124"
32	16	15	1	17	16	1	42	32	10	121"
33	15	15	0	17	16	1	36	32	4	120-1/8"
34	16	15	1	18	16	2	37	33	4	124-1/2"
35	17	15	2	17	16	1	40	33	7	126-7/8"
36	16	15	1	18	16	2	39	33	6	126-1/8"

*Insulation Extruded into Black Conductor

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
31	1000+	1000	1000	1000+	1000+	1000+
32	1000+	1000	500	1000+	1000+	1000+
33	1000	1000	1000	1000+	1000+	1000+
34	1000+	1000	500	1000+	1000+	1000+
35	1000+	500	500	1000+	1000+	1000+
36	1000	500	500	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
31	1000+	1000	1000	1000+	1000+	1000+
32	1000+	1000	500	1000+	1000+	1000+
33	1000	1000	1000	1000+	1000+	1000+
34	1000	1000	500	1000+	1000+	1000+
35	1000	500	500	1000+	1000+	1000+
36	1000	500	500	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
31	1000+	1000	500	1000+	1000+	1000+
32	1000+	1000	500	1000+	1000+	1000+
33	1000	1000	1000	1000+	1000+	1000+
34	1000	1000	500	1000+	1000+	1000+
35	1000	500	500	1000+	1000+	1000+
36	1000	500	500	1000+	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
32	3430	4760	72

Six Samples - Group H - No. 2, Type G Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
31	27.4 @ 15 kV	-	White
31	32.6 @ 15 kV	-	Black
32	29.8 @ 15 kV	-	White
32	40 @ 15 kV	-	Black
33	29.5 @ 15 kV	-	White
33	39 @ 15 kV	-	Black
34	22 @ 15 kV	-	White
34	34 @ 15 kV	-	Black
35	37 @ 14.5 kV	15 kV**	White
35	41 @ 14 kV	14.5 kV	Black
36	23 @ 15 kV	-	White
36	37 @ 15 kV	-	Black

**Failure resulted from ground wire strand protruding into white conductor splice insulation. The ground wire strand was contained in the connector but after it passed through the connector a slight bend pointed the strand end toward the white conductor.

Six Samples - Group I - No. 2, Type G Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.-	Std.=	Diff.	Black Cond.-	Std.*=	Diff.	Gnd.-	Std.=	Diff.	L
37	16	15	1	18	16	2	39	32	7	122-1/8"
38	15	14	1	17	15	2	35	31	4	116-1/2"
39	16	15	1	17	16	1	42	32	10	120-5/8"
40	16	16	0	18	17	1	39	34	5	128-3/4"
41	16	15	1	18	16	2	42	34	8	127-1/8"
42	17	16	1	19	17	2	42	35	7	133-1/4"

*Black Cable Insulation Extruded into Conductor

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
37	1000+	1000	1000	1000+	1000+	1000+
38	1000+	1000	1000	1000+	1000+	1000+
39	1000	1000	1000	1000+	1000+	1000+
40	1000+	1000	1000	1000+	1000+	1000+
41	1000+	1000	1000	1000+	1000+	1000+
42	1000	500	500	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
37	1000+	1000	1000	1000+	1000+	1000+
38	1000+	1000	1000	1000+	1000+	1000+
39	1000	1000	1000	1000+	1000+	1000+
40	1000+	1000	1000	1000+	1000+	1000+
41	1000+	1000	1000	1000+	1000+	1000+
42	1000	500	500	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
37	1000+	1000	1000	1000+	1000+	1000+
38	1000+	1000	1000	1000+	1000+	1000+
39	1000	1000	1000	1000+	1000+	1000+
40	1000+	1000	1000	1000+	1000+	1000+
41	1000+	1000	1000	1000+	1000+	1000+
42	1000	500	500	1000+	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
38	2620*	4760	55

*Defective workmanship when applying connector.

Six Samples - Group I - No. 2, Type G Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
37	40.6 @ 15 kV	-	White
37	53.6 @ 15 kV	-	Black
38	34.2 @ 15 kV	-	White
38	39.0 @ 15 kV	-	Black
39	43 @ 15 kV	-	White
39	4.3 @ 2.5 kV	3.0 kV**	Black
40	30 @ 15 kV	-	White
40	35.2 @ 15 kV	-	Black
41	20.1 @ 15 kV	-	White
41	30.5 @ 15 kV	-	Black
42	36 @ 15 kV	-	White
42	45.0 @ 15 kV	-	Black

**Failure resulted from ground wire strand protruding into black conductor in the same manner as described in Group H.

Six Samples - Group J - No. 2, Type G Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.-	Std.=	Diff.	Black Cond.-	Std.=	Diff.	Gnd.-	Std.=	Diff.	L
43	11	10	1	11	10	1	21	21	0	81-7/8"
44	11	10	1	11	10	1	21	21	0	81-3/8"
45	10	10	0	10	10	0	20	20	0	79-3/8"
46	10	10	0	10	10	0	21	21	0	81-7/8"
47	10	10	0	10	10	0	20	20	0	80-3/4"
48	11	10	1	11	10	1	25	21	4	81-7/8"

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
43	1000+	1000+	1000+	1000+	1000+	1000+
44	1000	1000	1000	1000+	1000+	1000+
45	1000+	1000+	1000	1000+	1000+	1000+
46	1000+	1000+	1000+	1000+	1000+	1000+
47	1000+	1000+	1000+	1000+	1000+	1000+
48	1000+	1000+	1000+	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
43	1000+	1000+	1000+	1000+	1000+	1000+
44	1000	1000	1000	1000+	1000+	1000+
45	1000+	1000+	1000	1000+	1000+	1000+
46	1000+	1000+	1000+	1000+	1000+	1000+
47	1000+	1000+	1000+	1000+	1000+	1000+
48	1000+	1000+	1000+	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
43	1000+	1000+	1000+	1000+	1000+	1000+
44	1000	1000	1000	1000+	1000+	1000+
45	1000+	1000+	1000	1000+	1000+	1000+
46	1000+	1000+	1000+	1000+	1000+	1000+
47	1000+	1000+	1000+	1000+	1000+	1000+
48	1000+	1000+	1000+	1000+	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
46	2250	4760	47

Six Samples - Group J - No. 2, Type G Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
43	29.9 @ 15 kV	-	White
43	31.0 @ 15 kV	-	Black
44	42.6 @ 15 kV	-	White
44	44.0 @ 15 kV	-	Black
45	26.0 @ 15 kV	-	White
45	29.4 @ 15 kV	-	Black
46	28.5 @ 15 kV	-	White
46	29 @ 15 kV	-	Black
47	16.2 @ 15 kV	-	White
47	17.2 @ 15 kV	-	Black
48	19.8 @ 15 kV	-	White
48	18.5 @ 15 kV	-	Black

Six Samples - Group K - No. 2, Type W Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond. -	Std. =	Diff.	Black Cond. -	Std. =	Diff.	L
49	11	10	1	11	10	1	85-3/8"
50	11	10	1	11	10	1	85-3/4"
51	12	10	2	11	10	1	84-1/4"
52	12	10	2	12	10	2	85-3/4"
53	11	10	1	11	10	1	84-3/4"
54	11	10	1	11	10	1	85-5/8"

Insulation Resistance: Megaohms

No.	White to Black	White to Water	Black to Water
49	1000+	1000+	1000+
50	1000+	1000+	1000+
51	1000+	1000+	1000+
52	1000+	1000+	1000+
53	1000+	1000+	1000+
54	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Water	Black to Water
49	1000+	1000+	1000+
50	1000+	1000+	1000+
51	1000+	1000+	1000+
52	1000+	1000+	1000+
53	1000+	1000+	1000+
54	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Water	Black to Water
49	1000+	1000+	1000+
50	1000+	1000+	1000+
51	1000+	1000+	1000+
52	1000+	1000+	1000+
53	1000+	1000+	1000+
54	1000+	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
49	2060	3800	54

Six Samples - Group K - No. 2, Type W Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
49	7.8 @ 15 kV	-	White
50	12.3 @ 15 kV	-	White
51	10.3 @ 15 kV	-	White
52	11.7 @ 15 kV	-	White
53	8 @ 15 kV	-	White
54	12.8 @ 15 kV	-	White

Six Samples - Group L - No. 4, Type G Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.	L
55	17	17	0	17	17	0	32	32	0	81-1/2"
56	17	17	0	17	17	0	32	32	0	81-3/8"
57	17	17	0	17	17	0	32	32	0	81-1/4"
58	17	17	0	17	17	0	32	32	0	81-1/4"
59	17	17	0	17	17	0	32	32	0	81-1/4"
60	17	17	0	17	17	0	32	32	0	80-5/8"

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
55	1000+	1000	1000	1000	1000	1000
56	1000+	500	500	1000	1000	1000
57	1000	1000	1000	1000	1000	1000
58	1000+	1000	1000	1000+	1000+	1000
59	1000+	1000+	1000+	1000+	1000+	1000
60	1000	1000	1000	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
55	1000	1000	1000	1000	1000	1000
56	1000+	500	500	1000	1000	1000
57	1000	1000	1000	1000	1000	1000
58	1000+	1000	1000	1000+	1000	1000
59	1000+	1000+	1000+	1000+	1000+	1000
60	1000	1000	1000	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
55	1000	1000	1000	1000	1000	1000
56	1000+	500	500	1000	1000	1000
57	1000	1000	1000	1000	1000	1000
58	1000+	1000	1000	1000	1000	1000
59	1000+	1000	1000	1000+	1000	1000
60	1000	1000	1000	1000	1000	500

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
59	1900	3000	63

Six Samples - Group L - No. 4, Type G Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
55	43.5 @ 15 kV	-	White
55	52 @ 13.25 kV	Est. 13.5 kV	Black
56	67 @ 15 kV	-	White
56	68 @ 15 kV	-	Black
57	56 @ 15 kV	-	White
57	57.4 @ 15 kV	-	Black
58	39.8 @ 15 kV	-	White
58	40.5 @ 15 kV	-	Black
59	44 @ 15 kV	-	White
59	32 @ 12 kV	12.5 kV*	Black
60	52.5 @ 15 kV	-	White
60	53 @ 15 kV	-	Black

*Failure resulted from primary insulation (black conductor) cut by splicer as the cable jacket was removed. Splice insulation did not cover the area and current passed from black conductor to ground.

Six Samples - Group M - No. 4, Type W Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.	L
61	19	17	2	17	17	0	-	-	-	85-7/8"
62	19	18	1	18	18	0	-	-	-	86-5/8"
63	19	17	2	17	17	0	-	-	-	86-3/8"
64	19	18	1	18	18	0	-	-	-	86-3/4"
65	19	18	1	18	18	0	-	-	-	86-7/8"
66	19	18	1	18	18	0	-	-	-	86-1/2"

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
61	1000+	-	-	1000+	1000+	-
62	1000+	-	-	1000+	1000+	-
63	1000+	-	-	1000+	1000+	-
64	1000+	-	-	1000+	1000+	-
65	1000+	-	-	1000+	1000+	-
66	1000+	-	-	1000+	1000+	-

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
61	1000+	-	-	1000+	1000+	-
62	1000+	-	-	1000+	1000+	-
63	1000+	-	-	1000+	1000+	-
64	1000+	-	-	1000+	1000+	-
65	1000+	-	-	1000+	1000+	-
66	1000+	-	-	1000+	1000+	-

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
61	1000+	-	-	1000+	1000+	-
62	1000+	-	-	1000+	1000+	-
63	1000+	-	-	1000+	1000+	-
64	1000+	-	-	1000+	1000+	-
65	1000+	-	-	1000+	1000+	-
66	1000+	-	-	1000+	1000+	-

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
64	1480	2400	62

Six Samples - Group M - No. 4, Type W Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
61	.21 @ 4.25 kV	Est. 4.5 kV	White
62	36.5 @ 15 kV	-	White
63	27.0 @ 12.5 kV	13 kV*	White
64	30 @ 15 kV	-	White
65	34 @ 15 kV	-	White
66	23.5 @ 15 kV	-	White

*Failure resulted from severed conductor strands (white conductor) protruding into cable insulation between white and ground. Splice kit primary insulation did not cover this area.

Six Samples - Group N - No. 2, Type G Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.	L
67	11	10	1	11	10	1	21	21	0	81-1/2"
68	11	10	1	11	10	1	21	21	0	81-1/4"
69	11	10	1	11	10	1	21	21	0	81-5/8"
70	11	10	1	11	10	1	21	21	0	81-1/4"
71	11	10	1	11	10	1	21	21	0	80-7/8"
72	11	10	1	11	10	1	21	21	0	81-1/8"

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
67	1000	1000	1000	1000	1000	1000
68	1000	1000	1000	1000	1000	1000
69	1000	1000	1000	1000	1000	1000+
70	1000	1000	1000	1000	1000	1000+
71	1000	1000	1000	1000	1000	1000
72	1000+	1000+	1000+	1000	1000	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
67	1000	1000	1000	1000	1000	1000
68	1000	1000	1000	1000	1000	1000
69	1000	1000	1000	1000	1000	1000+
70	1000	1000	1000	1000	1000	1000+
71	1000	1000	1000	1000	1000	1000
72	1000+	1000+	1000+	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
67	1000	1000	1000	1000	1000	1000
68	1000	1000	1000	1000	1000	1000
69	1000	1000	1000	1000	1000	1000+
70	1000	1000	1000	1000	1000	1000+
71	15	9	17	180	180	160
72	1000+	1000+	1000+	1000	1000	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
70	1640*	4760	34

*Defective workmanship when applying connector.

Six Samples - Group N - No. 2, Type G Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
67	30 @ 15 kV	-	White
67	33.8 @ 15 kV	-	Black
68	34.8 @ 15 kV	-	White
68	34 @ 15 kV	-	Black
69	43.8 @ 15 kV	-	White
69	40.2 @ 15 kV	-	Black
70	23.8 @ 15 kV	-	White
70	25 @ 15 kV	-	Black
71	121 @ 15 kV	-	White
71	100 @ 15 kV	-	Black
72	29.2 @ 15 kV	-	White
72	27 @ 15 kV	-	Black

Six Samples - Group 0 - No. 4, Type G Cable

Conductivity: Ohms x 10^{-4}

No.	White Cond.	- Std.	= Diff.	Black Cond.	- Std.	= Diff.	Gnd.	- Std.	= Diff.	L
73	17	17	0	17	17	0	31	31	0	80-7/8"
74	18	17	1	17	17	0	32	32	0	84-1/8"
75	17	17	0	17	17	0	31	31	0	81-1/8"
76	17	16	1	16	16	0	31	31	0	80"
77	17	17	0	17	17	0	31	31	0	81"
78	17	17	0	17	17	0	31	31	0	80-7/8"

Insulation Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
73	1000+	1000+	1000+	1000+	1000+	1000+
74	1000+	1000+	1000+	1000+	1000+	1000+
75	1000+	1000+	1000+	1000+	1000+	1000+
76	1000+	1000+	1000+	1000+	1000+	1000+
77	1000+	1000+	1000+	1000+	1000+	1000+
78	1000+	1000+	1000+	1000+	1000+	1000+

Initial Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
73	1000+	1000+	1000+	1000+	1000+	1000+
74	1000+	1000+	1000+	1000+	1000+	1000+
75	1000+	1000+	1000+	1000+	1000+	1000+
76	1000+	1000+	1000+	1000+	1000+	1000+
77	1000+	1000+	1000+	1000+	1000+	1000+
78	1000+	1000+	1000+	1000+	1000+	1000+

24 Hour Moisture Resistance: Megaohms

No.	White to Black	White to Gnd.	Black to Gnd.	White to Water	Black to Water	Gnd. to Water
73	1000+	1000+	1000+	1000+	1000+	1000+
74	1000+	1000+	1000+	1000+	1000+	1000+
75	1000+	1000+	1000+	1000+	1000+	1000+
76	1000+	1000+	1000+	1000+	1000+	1000+
77	1000+	1000+	1000+	1000+	1000+	1000+
78	1000+	1000+	1000+	1000+	1000+	1000+

Tensile Strength:

No.	Lbs.	Original Cable lbs.	% Original Cable
75	1630	3000	54

Six Samples - Group O - No. 4, Type G Cable (continued)

Dielectric Breakdown Voltage:

No.	Amps x 10^{-6}	Breakdown Volts	Pos. Cond.
73	18.5 @ 15 kV	-	White
73	25.0 @ 15 kV	-	Black
74	40.0 @ 15 kV	-	White
74	45.8 @ 15 kV	-	Black
75	23.0 @ 15 kV	-	White
75	23.2 @ 15 kV	-	Black
76	19.8 @ 15 kV	-	White
76	27.6 @ 15 kV	-	Black
77	24.8 @ 15 kV	-	White
77	28.0 @ 15 kV	-	Black
78	24.8 @ 15 kV	-	White
78	27.2 @ 15 kV	-	Black

APPENDIX V

MINE ELECTRICAL SYSTEM SIMULATOR
USER'S HANDBOOK

APPENDIX V. MINE ELECTRICAL SYSTEM SIMULATOR USER'S HANDBOOK

The user is strongly urged to read thoroughly all of these instructions, plus the chapter in the text, before attempting the program.

The model has three main options:

1. Static load flow simulation of the entire mine,
2. Subsystem faulting simulation of a load,
3. Dynamic load flow simulation of the entire mine.

Each option requires a particular data card set for its successful implementation. These sets will be described in turn beginning with load flow. Appropriate job control cards (JCL) are necessary to submit the program for processing at any computer center (consult the particular computer center for the information). The program is written in Fortran IV for a "G" level compiler on an IBM 370/165 computer and needs about 65K bytes for execution.

MINE DESCRIPTOR CARD

Control of the main program options is handled by the Mine Descriptor Card which is the very first card of any card deck. In columns 1 to 72 may be written any alphanumeric information to identify the data deck output. Column 73 indicates whether the run will be a static load flow, a faulting calculation or a dynamic load flow. For static load flow, leave column 73 blank. For a fault, place an "F" in column 73 and a 1, 2, 3 or 4 in column 79 for single line-to-ground, line-to-line-ground, line-to-line, and three-phase symmetrical fault, respectively. For dynamic load flow, place a "D" in column 73 of all Mine Descriptor Cards (several of these cards can exist in the dynamic option).

As was discussed in the model formulation (see text), the fault may be placed anywhere between the distribution busbar and the correction capacitors associated with the machine. Column 80 is reserved for the fault location described by the following numbers:

0 - Fault is at machine correction components.

1 - Fault is located at ten percent of the cable length from the machine.

2 - Fault is located at 20 percent of the cable length from machine.

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8 - Fault is 80 percent of the cable length from machine.

9 - Fault is at distribution busbar.

Some actual examples of Mine Descriptor Cards are:

Load Flow for 'XYZ' Mine		
Single Line to Ground Fault	F	19
Dynamic Load Flow-Point A	D	

After the Mine Descriptor Card come the data sets for the options specified.

LOAD FLOW - STATIC

The physical order of the data supplied to the program under the static flow option is illustrated on the following page, DATA ORDER SEQUENCING.

DATA ORDER SEQUENCING

DESCRIPTION	NESTING			
Mine Descriptor Card				Static Load Option
Frequency, No. of Feeder Loads				
No. of Panels for Feeder			Feeder Load 1	
No. of a-c loads in Panel		Panel 1		
a-c load parameters power factor correction components transmission line	a-c load data 1			
	a-c load data n			
transmission line from load center to a-c distribution busbar				
No. of d-c loads in Panel				
d-c load parameters transmission line	d-c load data 1			
	d-c load data n			
transmission line from load center to d-c distribution busbar				
transformer data for Panel				
transmission line from load center to Panel connection				
		Panel n		
n transmission lines connecting Panels to form a Feeder load				
			Feeder Load n	
n transmission lines connecting Feeders to input of Main Mine Transformer				
Main Mine Transformer data				

Although it would seem logical to describe the card order (as read by the computer), it is more beneficial to show the actual method of building the data deck beginning at the first level, the Panel Data Block. The Feeder Data Block can then be constructed from a number of Panel blocks and interconnecting transmission cables. Next, the entire data deck order must be arranged as:

1. Mine Descriptor Card
2. Line frequency and the number of Feeder loads
3. Feeder Data Blocks
4. Feeder interconnecting transmission cables
5. Main Mine Transformer data block.

It can be seen that input data nesting is imperative, therefore, it is suggested the user assign his mine segments as Feeder 1, Feeder 2 and so on, then in each feeder assign Panel 1, Panel 2 and likewise. In this manner, the data required can be broken into manageable blocks corresponding to general mine described in the text. The succeeding paragraphs describe the actual process of constructing the card deck.

Panel Components Data Block. Panel 1 of the mine has in it certain a-c loads, d-c loads, power factor correction components, transmission lines and a load center (transformer and rectifier). The following number system demonstates the card order in a Panel, but Number 1 does not mean card one in the entire deck.

1. The first card in the Panel block is reserved for the number of a-c loads (in the Panel) which can range from zero to ten. If there are zero a-c loads, cards 2 through 5 are not needed.

2. The power, voltage, phase angle and power factor for each a-c load are required. Power is expressed in watts and represents the three-phase value. Voltage is line-to-line expressed in volts. Either the phase angle, or the power factor, is needed to indicate real and reactive loading. Whether the phase angle or power factor is used, care should be exercised to place the values in the proper location on the card with a blank left in the unused data space.

3. Power factor correction components may or may not be connected at the machine. If there are none, a blank card is inserted for this information to indicate that these components do not exist. Either a series or a parallel capacitor could be connected. The program is formatted to accept either capacitive ratings in Farads or capacitive reactance in Ohms. Sometimes the information is only available in terms of VARS in which case it must be converted to reactance. The conversion is:

$$X_c = \frac{V^2}{VARS} \qquad (57)$$

$$C = \frac{-1}{\omega X_c} \qquad (58)$$

where:

V = voltage across capacitor

VARS = voltampere rating

ω = radian frequency

X_c = capacitive reactance, Ω

C = capacitance, F.

Note that for a parallel capacitor V equals voltage line-to-line, and VARS is the three-phase rating and is negative in sign. For a series capacitor, V is the voltage across the capacitor, and VARS is the capacitor volt-ampere rating. The parallel capacitor situation is more common than the series, but both are included.

For data card 3, series capacitance, parallel capacitance (one phase only), series reactance, and parallel reactance (one phase only) are allowable. Blanks are inserted for data positions not used. A data position may be unused because of non-existing components. Only input either a capacitance or a reactance, not both. Capacitive reactance (Ω) is always negative while capacitor size (F) is always positive.

4. Associated with every load is a trailing cable (actually a transmission line). The information required is the length, type, unit resistance and unit reactance. Length is expected in feet so the unit resistance and unit reactance will be expressed in Ω/foot. It is desired to input the actual unit impedance for the particular cable being simulated including, if possible, any shunt reactance in that impedance. If the actual unit impedance is not known, the program will assign an impedance from the type. Assigned impedances from type specifications are assumed values taken from Jones and others work.[59] The assigned type number for each particular cable size is provided as follows:

Type Specifications for Transmission Line Input.

Type	Size
1	No cable
2	# 8
3	# 6
4	# 4
5	# 2
6	# 1
7	1/0
8	2/0
9	3/0
10	4/0
11	250 MCM
12	300 MCM
13	350 MCM
14	400 MCM
15	500 MCM

5. In some mines the load center and distribution box are separated by another transmission line (cable). For such a case, the transmission line data are read the same as in card 4 above. If there is no such cable, a zero length and type (or blanks) should be specified.
6. After all the a-c loads are read, d-c load information is next. At this stage the number of d-c loads on the panel is read as input ranging from zero to ten. If there are no d-c loads, cards 7 to 9 are omitted.
7. Power and voltage of each d-c load are required in watts and volts, respectively.
8. Data on the transmission line associated with this load are used next. In the d-c case, reactance has no meaning and only unit resistance is needed. Formatting is the same as for the a-c transmission lines (item 4).
9. From the load center to the d-c distribution busbar may be a transmission line (as was the case with a-c). Cable data entry is identical to card 4.

Every Panel is assumed to have a three-winding transformer (primary, secondary and tertiary). If there are only a-c loads, the transformer may not exist. In contrast, with any d-c load there must be a transformer and a rectifier. The following describes the information necessary for the Transformer Data Block.

Transformer Data Block. Transformers may be connected in two ways, delta or wye. For this model the primary and secondary may be either wye or delta. The d-c tertiary is permitted to be only a delta because of rectification.

1. For purposes of data card input, the primary, secondary and tertiary connections must be identified by "WYE", "DLTA" or "NONE". In the case of no transformer,"NONE" must be specified for all three windings. For a two-winding transformer the tertiary must still be specified "DLTA". Likewise, for a primary-tertiary case, the secondary winding still is specified.

In order to analyze the transformer equivalent circuit, specifications must be input for the exiter impedance and winding impedance calculations. The program permits use of three options to obtain the winding impedances:

1. short-circuit test data is option 1
2. percent kVA methods, percents read is option 2
3. percent kVA method, percents assumed is option 3.

The option to be used must be specified on the card with the tranformer connections as 1, 2 or 3 to correspond to the above listed options.

2. On the transformer may be power factor correction components connected in parallel on the secondary or primary. The sizes of these

capacitors must be read in Farads. For conversion from VAR's to Farads see data item 3 of the Panel Components Data Block.

3. The d-c rectifier has some forward resistance associated with it. Reverse direction impedance is assumed infinity. If the transformer only has two windings, read in blanks for the parameter.

4. To calculate the turns ratios needed in the program, the rated primary, secondary and tertiary voltages are input. For the two-winding transformer, it is required that the rated secondary be read also as the rated tertiary.

5. To calculate the exiter impedances the standard open circuit test data consisting of rated primary voltage, open circuit power drawn and open circuit current drawn are used. If this information is not known, zero's are input and the program assumes an exciter impedance of infinity which is a good approximation for most cases.

6. Under option 1, the standard short circuit data for the primary-secondary, primary-tertiary and secondary-tertiary windings are needed, each set of short circuit data on a separate card. If only a two-winding transformer, place blanks in the data field of the non-existent winding. In other words, for no d-c winding, blanks are inserted for primary-tertiary and secondary-tertiary data.

7. Option 2 requires the percent resistance, rated kVA and voltage be read. Percent is given in percent form, not decimal form (i.e., 1.0 percent is 1.0, not 0.01). Rated kVA is kilovolt-amperes, and voltages is volts line-to-line. Each value is needed for primary winding (A),

secondary winding (B), and tertiary winding (C). Therefore, three data cards are necessary, one for each winding.

8. Option 2 also requires percent reactance, and rated reactive kVA across the three coils, two at a time. The information is on one data card in the order: for winding AB, percent reactance and kVA; for winding BC, percent reactance and kVA; for winding AC, percent reactance and kVA.

9. For option 3, data cards 7 and 8 (of this group) are also read. However, for the percents which are unknown under option 3, blanks are inserted. The program assigns default percents.

10. To complete the data for the Panel, one more transmission line data set is read for the transmission line connecting the load center to the line connecting all the Panels on this Feeder load.

Feeder Data Block. A Feeder load is composed of a number of Panels, and each Panel in the Feeder requires the same information as specified above. Referring to the DATA ORDER SEQUENCING, a Feeder is constructed in the following manner.

1. Number of Panels in this Feeder is a key number that must be read for each Feeder load.

2. After the number of Panels is used, the data for each Panel is stacked in the order of Panel 1, Panel 2 through Panel n. For purposes of card stacking, Panel 1 is the Panel farthest from the main Feeder cable (as shown previously in Figure 6), and the number scheme progresses until Panel n is the closest to the main Feeder line.

3. The last data set to complete the Feeder load is the transmission line data for each transmission line between Panels 1 and 2, between

2 and 3, and so on, until the line between Panel n and the main Feeder line is read. Formatting is identical to other transmission line data previously described (Panel Components Data Block, item 4).

Total Mine Data Deck. The complete data deck is constructed in the succeeding order:

1. The line frequency in Hz, and the number of Feeder loads, n, are read at the very beginning of all the Feeder load data. Physically in a card deck, this card is second to the Mine Descriptor Card.

2. Data cards constituting each Feeder load are then arranged Feeder load 1, 2 ... n. Again Feeder load 1 is the one farthest from the Main Mine Transformer and Feeder n is the closest. These loads are assumed to have transmission lines separating the respective connections to the main Feeder line as shown in Figure 6. For n loads, n transmission lines are assumed. These are ordered identically to the Panel transmission lines, in other words, line between Feeders 1 and 2, between 2 and 3, and so on until the line between Feeder n and the Main Mine Transformer has been read.

3. Finally, the Main Mine Transformer data are utilized and are handled exactly as presented in the Transformer Data Block. That completes a static load flow simulation.

FAULTING OPTION

Data arrangement for a faulting simulation is very similar to that of load flow. The first card is the Mine Descriptor Card. On this card should be specified an identification (of some sort by the user to label the output), the fault option, type of fault and location. As the Mine

Descriptor Card has been described in complete detail at the beginning of the Appendix, it will not be repeated here.

As in the static load flow option, the next card would describe the line frequency and number of Feeder loads. Under normal conditions the frequency would be 60Hz, and the number of Feeder loads would be "1" for a fault simulation.

In line closely with the load flow data arrangement, the next card is the number of a-c loads on the faulted Panel. To avoid being misled, it should be pointed out that the number of Panels card is not in the fault set.

Each a-c load data are read next, including the load parameters, power factor correction components and associated transmission line. The faulted load is assumed to be a-c load n. The transmission line from the load center to distribution busbar is likewise input.

At this point, the fault routine diverges from the load flow as the next card contains the rated secondary voltage (line-to-line) and three-phase kVA rating in volts and kilovolt-amperes, respectively, of the transformer.

To finish the fault data set, the various fault impedances Z_g and Z_f are required in that order, depending on the fault type as discussed earlier. Z_g and Z_f are both complex numbers. For line-to-ground, Z_g is input; line-to-line, Z_f; line-to-line-to-ground, Z_g and Z_f; and three-phase, Z_g for one phase. For the case where Z_g or Z_f is not applicable, leave the data space blank.

LOAD FLOW - DYNAMIC

The dynamic option basically operates by looping through the load flow of the static option. However, to avoid the necessity of including the data cards for the transmission lines, correction components, transformers and so forth, the program has been arranged so that this data is stored on a disc then extracted from the disc at the proper calculation time.

For a dynamic simulation, column 73 of the Mine Descriptor Card must be set to "D". For every data set describing the electrical system that is to be run under the option, a Mine Descriptor Card with the "D" in column 73 must lead that portion of the card deck. For identification purposes, it is recommended that some description or label be assigned each data set run dynamically. The first data set is identical to the static load flow deck, including load data, transmission lines, transformers and so on.

The second data set contains only load parameters both a-c and d-c. These load parameter cards must be arranged as they were in a static load flow set (see Panel Components Data Block), but there are no transformer cards, power factor correction cards, transmission cards and so forth. Care must be taken that for every load card in the first data set, there is a corresponding card in every data set following.

The program will stop executing dynamically when it reads a Mine Descriptor Card without the "D", or runs out of cards.

It is possible to run a static load flow, several types of faulting situations and a dynamic load flow in one large deck subject only to correct data card formatting, and the time and records allowed for that job.

OUTPUT

Under either the dynamic or static load flow option, the power parameters (voltage, current, power and power factor) are printed out. These values are provided for each Panel, Feeder load and the power company connection along with identification. Both the complex and the polar versions of each parameter is printed to give complete data in a form easily understood by the user. For example, the reactive power consumed at a Panel can easily be translated into the correction capacitor needed to bring power factor close to unity. The load flow and faulting outputs are illustrated in the Appendix.

Faulting output is of a slightly different nature. The data of interest here are the line currents, line-to-line voltages, and the fault current. Again, both complex and polar values are printed for ease of analyis.

The faulting option may also be used to examine the balanced situation at the level of the load center by assigning a large fault impedance of the order of magnitude of 10^{20}. This would eliminate the need of preparing data for an entire system when only this one segment was of interest.

Included in the Appendix is a sample data deck written according to the requirements of the User's Manual. The actual information supplied does not represent a true mine·electrical system, but has been provided only to test the program options. The output generated (from the test data) is also given to aid the user in becoming familiar with program implementation.

The following abbreviations are used to identify the data cards:

MDC - Mine Descriptor Card

FDB - Feeder Data Block

PCDB - Panel Components Data Block

TDB - Transformer Data Block

TMDD - Total Mine Data Deck

FODT - Fault Option Data-Transformer

FODZ - Fault Option Data-ground impedances

and will be found to the right of the data. A blank card will be identified by "blank". The number associated with the abbreviation is the data number of that block.

Preceding the input-output example (Tables 35 and 36), is an overall flow diagram (Figure 98), a list of data card types and formats, a list of programs subroutines and a list of error messages. The messages are provided within the output to help the user debug his own data deck.

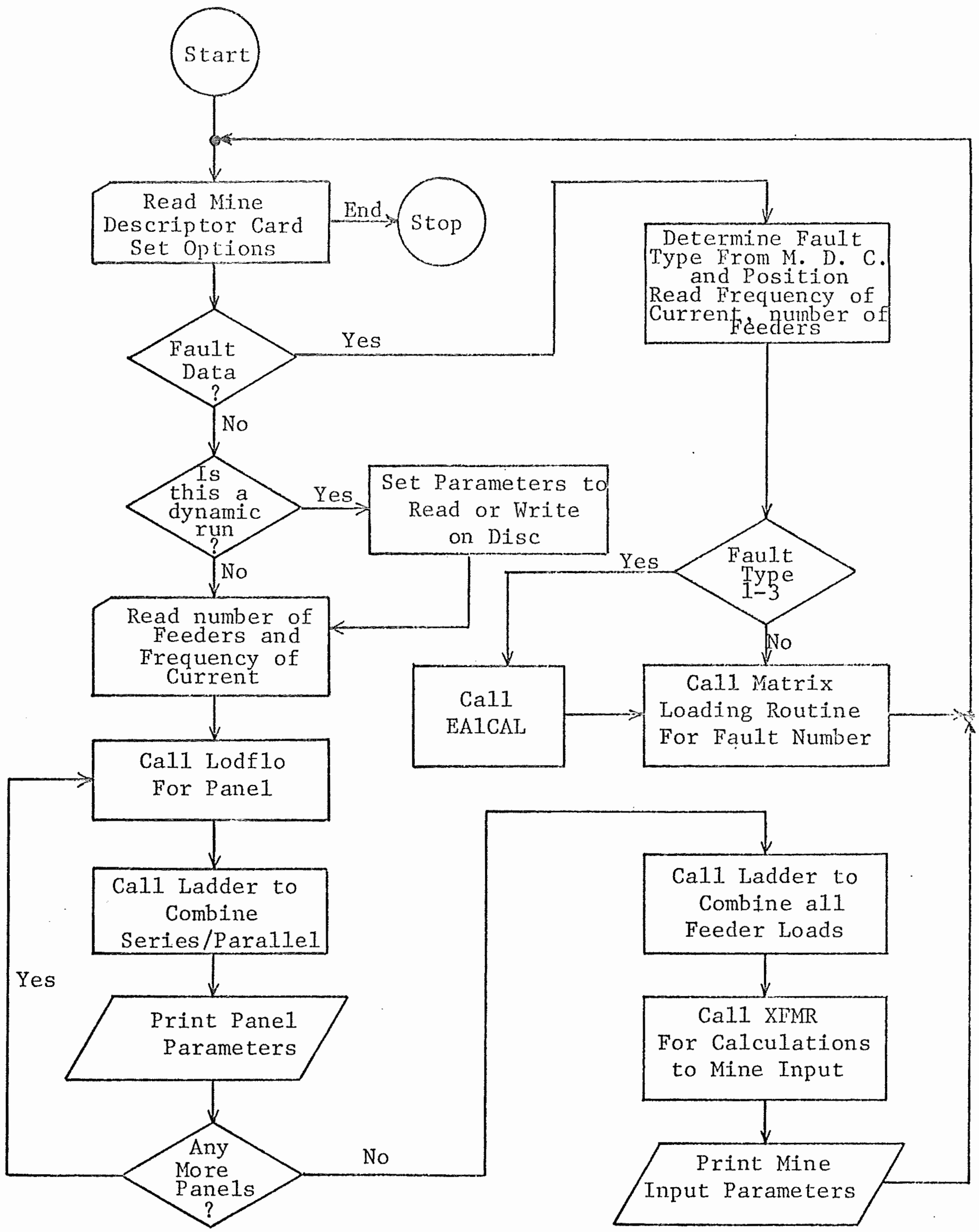

Figure 98. Overall Flow.

LIST OF DATA CARD TYPES AND FORMATS

Information	Columns	Format
Mine Descriptor Card:		
Data Set Description, character	1-72	72A1
Option letter, character	73	1A1
Fault type, integer	79	I1
Fault location, integer	80	I1
Line Frequency and Feeder Load Number:		
Line frequency, Hz, real	11-20	F10.2
Number of Feeder loads, integer	31-40	I10
Number of Panels in Feeder Load:		
Number of Panels in this Feeder load, integer	11-20	I10
Number of a-c Loads in Panel:		
Number a-c loads on the Panel, integer	11-20	I10
Alternating-Current Load Parameters:		
Power drawn by a-c load, watts, real	11-20	F10.2
Line-to-line voltage at load, volts, real	31-40	F10.2
Phase angle of load to some reference, degrees, real	51-60	F10.2
Power factor of a-c load, real	71-80	F10.2
Load Power Factor Correction Components:		
Series Correction Capacitor Rating, Farads, real	11-20	E10.5
Parallel Correction Capacitor Rating, Single Phase, Farads, real	31-40	E10.5
Series Capacitive Reactance, Ohms, real	41-60	F10.2
Parallel Capacitive Reactance, Ohms, real	71-80	F10.2
Transmission Line Data:		
Length of Line in Feet, real	11-20	F10.2

Information	Columns	Format
Transmission Line Type, real	31-40	F10.2
Unit Resistance, Ohms/ft., real	51-60	F10.9
Unit Reactance, Ohms,ft., real	71-80	F10.9
Number of d-c Loads in Panel:		
Number of d-c loads in this Panel, integer	11-20	I10
Direct-Current Load Parameters:		
Voltage of d-c Load, volts, real	11-20	F10.2
Power Drawn by d-c Load, watts, real	31-40	F10.2
Transformer Corrections and Option:		
Primary Connection on Transformer, character	11-14	A4
Secondary Connection on Transformer, character	21-24	A4
Tertiary Connection on Transformer, character	31-34	A4
Transformer Rating Data Option, integer	41	I1
NOTE: "WYE ", "DLTA", "NONE" are allowed for winding connections, left justified.		
Transformer Power Factor Correction:		
Correction Capacitor on Secondary, Farads, exponential	11-20	E10.5
Correction Capacitor on Primary, Farads, exponential	31-40	E10.5
Rectifier Resistance:		
Forward Rectifier Resistance, Ohms, real	11-20	F10.4
Transformer Voltage Ratings:		
Rated Primary Voltage Line-to-Line, Volts, real	11-20	F10.2
Rated Secondary Voltage, Line-to-Line,Volts, real	31-40	F10.2
Rated Tertiary Voltage, Line-to-Line, Volts, real	51-60	F10.2

Information	Columns	Format
Transformer Open Circuit Test Data:		
Voltage Test Data, Volts, real	11-20	F10.4
Power Test Data, Watts, real	31-40	F10.4
Current Test Data, Amperes, real	51-60	F10.4
Transformer Short Circuit Test Data:		
Voltage Test Data, Volts, real	11-20	F10.4
Power Test Data, Watts, real	31-40	F10.4
Current Test Data, Amperes, real	51-60	F10.4
Resistance Percent Transformer Data:		
Percent Resistance, percent, real	11-20	F10.2
Kilovolt-Amperes, kVA, real	31-40	F10.2
Voltage Line-to-Line, Volts, real	51-60	F10.2
Reactance Percent Transformer Data:		
Percent Reactance AB, Percent, real	6-10	F5.2
Kilovolt-Amperes AB, kVA, real	16-26	F10.0
Percent Reactance BC, Percent, real	31-35	F5.2
Kilovolt-Amperes BC, kVA, real	41-50	F10.0
Percent Reactance AC, Percent, real	56-60	F5.2
Kilovolt-Amperes AC, kVA, real	66-76	F10.0
Fault Impedances:		
Line-to-Ground Impedance, Ohms, complex	11-20 21-30	2F10.2
Line-to-Line Impedance, Ohms, complex	41-50 51-60	2F10.2
Transformer Data Under Fault:		
Rated Secondary Voltage, Line-to-Line, Volts, real	11-20	F10.2
Rated Three-Phase Volt-Amperes, VA, real	31-40	F10.2

LIST OF PROGRAM ROUTINES

MAIN MAIN reads the Mine Descriptor Card, determines the options, if any, loads those necessary global values for the particular options specified, and branches to the appropriate subroutine it calls to solve the option.

LODFLO Panel calculations are performed including a-c loads, d-c loads, transmission lines, etc. Other subroutines are called for portions of the panel calculations.

XFMR The transformer subroutine performs the calculations involving generating the impedances associated with the transformer, rectifier, and power factor correction capacitors on the transformer banks.

LADDER Iterative combination of panels and transmission lines or feeder loads and transmission lines are done with LADDER.

PRINT Three-phase power parameters are calculated from single phase values and printed in both complex form and polar forms.

FINDTL When the unit impedance is not known for a transmission line this subroutine will assign a standard impedance according to cable size, or will assign a cable of zero impedance if the specified one is invalid.

ZEQUIV Transformer winding impedances are calculated from the short circuit data and returned to XFMR.

PFCC Power factor correction capacitor impedances are calculated from the size in Farads and returned to ACLODS.

ACLODS The a-c loads in parallel in a panel are iteratively combined and returned either to LODFLO or EA1CAL (for fault situations).

EA1CAL To perform the fault calculations pre-fault conditions must be known. EA1CAL performs this function for all the unbalanced fault subroutines.

GAUSS The matrices generated in the fault subroutines are solved in GAUSS using Gauss-Jordan reduction with partial pivoting. If the matrix is not solvable (a column of all zeros), the routine returns an error code for the calling routine to abort further processing of the fault.

MXLOD1 The matrix for a single line-to-ground fault is loaded and the line currents and line-to-line voltages of interest are printed in both complex and polar modes.

MXLOD2 Line-to-line-to-ground matrix loading and output printing is accomplished in this subroutine.

MXLOD3 Similar to MXLOD1 and MXLOD2, but for the line-to-line fault.

MXLOD4 Three-phase symmetrical fault is analyzed on a balanced single phase equivalent basis.

ERROR MESSAGES

1. ERROR ----> INVALID FAULT TYPE #

   Source: MAIN

   Reason: Fault type # is not 1, 2, 3, 4

   Action: Program stopped executing

2. ERROR - NO TRANSFORMER DATA GIVEN

   Source: XFMR

   Reason: Transformer connection card not WYE, DLTA, NONE.

   Action: Program stopped executing.

3. XXX ERROR - NO TRANSFORMER-RECTIFIER FOR DC

   Source: XFMR

   Reason: Number of d-c loads not = 0, no transformer given.

   Action: Program stopped executing.

4. XXX ERROR - DC TERTIARY NOT GIVEN AS "ELTA" CONNECTION

   Source: XFMR

   Reason: Self-explanatory

   Action: Program stopped executing.

5. **** FINDTL **** INCORRECT TYPE >

   Source: FINDTL

   Reason: Transmission line type # not between 1 and 30.

   Action: Type 1 cable assumed with zero impedance.

6. ERROR ----- > NO LOADS SPECIFIED FOR FAULT

   Source: EA1CAL

   Reason: Fault mode in progress, but no loads were on faulted panel.

   Action: Entire data set associated with fault is bypassed, and an attempt is made to read another data set.

7. NO SOLUTION IN GAUSS ELIMINATION, ONE OR MORE COLUMNS ARE ALL ZERO

   Source: MXLOD1, MXLOD2, or MXLOD3

   Reason: Matrix loaded had column with only zeros, no solution possible.

   Action: All processing with this fault data set is aborted, and an attempt is made to read a new mine descriptor card.

Table 35. Sample Data Deck.

```
THIS IS A TEST OF LODFLO REGULAR AND DYNAMIC                          D          -MDC
          60.0                     2                                             -TMDD 1
                   3                                                             -FDB  1
                   1                                                             -PCDB 1
          72000.0           540.0               0.0                 0.72         -PCDB 2
          0.0               0.0                 0.0                 0.0          -PCDB 3
          1000.0            10.0                                                 -PCDB 4
                            1.0                                                  -PCDB 5
                   0                                                             -PCDB 6
          DLTA       WYE    DLTA        1                                        -TDB  1
          .00000E+00        .00000E+00                                           -TDB  2
          0.0                                                                    -TDB  3
          7200.0            550.0               550.0                            -TDB  4
          7200.0            34560.0             8.8957727                        -TDB  5
          70.5902452        2478.843            90.9                             -TDB  6
          0.0               0.0                 0.0                              -TDB  6
          0.0               0.0                 0.0                              -TDB  6
          400.0             0.0                 0.000115            0.000103     -TDB  10
                   3                                                             -PCDB 1
          72000.0           540.0               0.0                 0.72         -PCDB 2
          0.0               0.0                 0.0                 0.0          -PCDB 3
          1000.0            10.0                                                 -PCDB 4
          72000.0           540.0               .76699406           0.0          -PCDB 2
          0.0               0.0                 0.0                 0.0          -PCDB 3
          1000.0            10.0                                                 -PCDB 4
          72000.0           540.0               0.0                 0.72         -PCDB 2
          0.0               0.0                 0.0                 0.0          -PCDB 3
          1000.0            10.0                                                 -PCDB 4
                            1.0                                                  -PCDB 5
                   0                                                             -PCDB 6
```

Table 35. Continued

NONE	NONE	NONE				-TDB 1
		1.0				-TDB 10
	0					-PCDB 1
	1					-PCDB 6
200.0		100000.0				-PCDB 7
1000.0		10.0				-PCDB 8
		1.0				-PCDB 9
DLTA	WYE	DLTA	1			-TDB 1
.00000E+00		.00000E+00				-TDB 2
0.0						-TDB 3
7200.0		550.0		550.0		-TDB 4
7200.0		34560.0		8.8957727		-TDB 5
0.0		0.0		0.0		-TDB 6
70.5902452		2478.843		90.9		-TDB 6
0.0		0.0		0.0		-TDB 6
		1.0				-TDB 10
		1.0				-FDB 3
		1.0				-FDB 3
		1.0				-FDB 3
	5					-FDB 1
	1					-PCDB 1
72000.0		540.0		0.0	0.72	-PCDB 2
0.0		0.0		0.0	0.0	-PCDB 3
1000.0		10.0				-PCDB 4
		1.0				-PCDB 5
	1					-PCDB 6
200.0		100000.0				-PCDB 7
1000.0		10.0				-PCDB 8
		1.0				-PCDB 9
DLTA	WYE	DLTA	1.0			-TDB 1

Table 35. Continued

.00000E+00		.00000E+00				-TDB 2
0.0						-TDB 3
7200.0		550.0		550.0		-TDB 4
7200.0		34560.0		8.8957727		-TDB 5
70.5902452		2478.843		90.9		-TDB 6
70.5902452		2478.843		90.9		-TDB 6
70.5902452		2478.843		90.9		-TDB 6
		1.0				-TDB 10
	1					-PCDB 1
72000.0		540.0		0.0	0.72	-PCDB 2
0.0		0.0		0.0	0.0	-PCDB 3
1000.0		10.0				-PCDB 4
		1.0				-PCDB 5
	0					-PCDB 6
DLTA	WYE	DLTA	1.0			-TDB 1
.00000E+00		.43900E-04				-TDB 2
0.0						-TDB 3
7200.0		550.0		550.0		-TDB 4
7200.0		34560.0		8.8957727		-TDB 5
70.5902452		2478.843		90.9		-TDB 6
0.0		0.0		0.0		-TDB 6
0.0		0.0		0.0		-TDB 6
400.0		0.0		0.000115	0.000103	-TDB 10
	1					-PCDB 1
72000.0		540.0		0.0	0.72	-PCDB 2
0.0		0.0		0.0	0.0	-PCDB 3
1000.0		10.0				-PCDB 4
		1.0				-PCDB 5
	0					-PCDB 6
WYE	WYE	DLTA	1.0			-TDB 1

Table 35. Continued

.00000E+00		.00000E+00				-TDB 2
0.0						-TDB 3
7200.0		550.0		550.0		-TDB 4
7200.0		34560.0		8.8957727		-TDB 5
70.5902452		2478.843		90.9		-TDB 6
0.0		0.0		0.0		-TDB 6
0.0		0.0		0.0		-TDB 6
400.0		0.0		0.000115	0.000103	-TDB 10
1						-PCDB 1
72000.0		540.0		0.0	0.72	-PCDB 2
0.0		0.0		0.0	0.0	-PCDB 3
1000.0		10.0				-PCDB 4
		1.0				-PCDB 5
0						-PCDB 6
WYE	DLTA	DLTA	1.0			-TDB 1
.00000E+00		.00000E+00				-TDB 2
0.0						-TDB 3
7200.0		550.0		550.0		-TDB 4
7200.0		34560.0		8.8957727		-TDB 5
70.5902452		2478.843		90.9		-TDB 6
0.0		0.0		0.0		-TDB 6
0.0		0.0		0.0		-TDB 6
400.0		0.0		0.000115	0.000103	-TDB 10
1						-PCDB 1
72000.0		540.0		0.0	0.72	-PCDB 2
0.0		0.0		0.0	0.0	-PCDB 3
1000.0		10.0				-PCDB 4
		1.0				-PCDB 5
0						-PCDB 6
DLTA	DLTA	DLTA	1.0			-TDB 1

Table 35. Continued

.00000E+00	.00000E+00				-TDB 2
0.0					-TDB 3
7200.0		550.0	550.0		-TDB 4
7200.0		34560.0	8.8957727		-TDB 5
70.5902452		2478.843	90.9		-TDB 6
0.0		0.0	0.0		-TDB 6
0.0		0.0	0.0		-TDB 6
400.0		0.0	0.000115	0.000103	-TDB 10
		1.0			-FDB 3
		1.0			-FDB 3
		1.0			-FDB 3
		1.0			-FDB 3
		1.0			-FDB 3
		1.0			-TMDD 3
		1.0			-TMDD 3
NONE	NONE	NONE			-TDB 1
DATA SET # 2 CONSISTS ONLY OF LOADS (THE SAME AS BEFORE)				D	-MDC
72000.0		540.0	0.0	0.72	-PCDB 2
72000.0		540.0	0.0	0.72	-PCDB 2
72000.0		540.0	0.0	0.72	-PCDB 2
72000.0		540.0	0.0	0.72	-PCDB 2
200.00		100000.00			-PCDB 7
72000.0		540.0	0.0	0.72	-PCDB 2
200.00		100000.00			-PCDB 7
72000.0		540.0	0.0	0.72	-PCDB 2
72000.0		540.0	0.0	0.72	-PCDB 2
72000.0		540.0	0.0	0.72	-PCDB 2
72000.0		540.0	0.0	0.72	-PCDB 2
NOW LETS VARY THE LOADS IN THIS RUN TO SEE WHAT HAPPENS				D	-MDC
72000.0		540.0		0.72	-PCDB 2

Table 35. Continued

72000.0	540.0		0.72		-PCDB 2
36000.0	540.0		0.65		-PCDB 2
95000.0	540.0		0.70		-PCDB 2
200.0	10000.0				-PCDB 7
72000.0	540.0		0.72		-PCDB 2
200.0	15000.0				-PCDB 7
95000.0	540.0		0.70		-PCDB 2
72000.0	540.0		0.72		-PCDB 2
72000.0	540.0		0.72		-PCDB 2
72000.0	540.0		0.72		-PCDB 2
THIS IS A TEST DATA SET FOR DEBUG PURPOSES FAULTED CONDITION			F	10	-MDC
60.00	1				-TMDD 1
4					-PCDB 1
72000.00	540.00			.72	-PCDB 2
		"blank"			-PCDB 3
1000.00	10.00				-PCDB 4
72000.00	540.00			.72	-PCDB 2
		"blank"			-PCDB 3
1000.00	10.00				-PCDB 4
72000.00	540.00			.72	-PCDB 2
		"blank"			-PCDB 3
1000.00	10.00				-PCDB 4
72000.00	540.00			.72	-PCDB 2
		"blank"			-PCDB 3
1000.00	10.00				-PCDB 4
200.00	10.00				-PCDB 5
525.00	180000.00				-FODT
1.00	1.00				-FODZ
THIS IS A TEST OF TWO LINES TO GROUND ROUTINE			F	2	-MDC
60.00	1				-TMDD 1

Table 35. Continued

4						-PCDB 1
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
200.00	10.00					-PCDB 5
325.00	180000.00					-FODT
1.00	1.00		1.00		1.00	-FODZ
THIS IS A TEST OF LINE TO LINE				F	3	-MDC
60.00	1					-TMDD 1
4						-PCDB 1
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3

Table 35. Continued

1000.00	10.00					-PCDB 4
200.00	10.00					-PCDB 5
525.00	180000.00					-FODT
			1.00		1.00	-FODZ
TRY A THREE PHASE FAULT				F	4	-MDC
60.00	1					-TMDD 1
4						-PCDB 1
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
72000.00	540.00				.72	-PCDB 2
		"blank"				-PCDB 3
1000.00	10.00					-PCDB 4
200.00	10.00					-PCDB 5
1.00	1.00					-FODZ

Table 36. Computer Output.

***** MINE ELECTRICAL SYSTEM SIMULATOR *****
***** LOAD FLOW CALCULATIONS *****

NAME OF USER = ALBERT ERIC K DATE = 07/10/73

THIS IS A TEST OF LODFLO REGULAR AND DYNAMIC

NO FAULT CALCULATIONS SPECIFIED, NORMAL PROGRAM FLOW

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 1

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4193.578	-33.718	4193.711	359.54
CURRENT (AMPS)	4.256	-22.557	22.955	280.68
IMPEDANCE (OHMS)	208.206	238.285	316.432	48.86
POWER (KVA)	109.711	125.561	166.740	48.86
POWER FACTOR	0.658			

Table 36. Continued

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 2

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	481.945	272.764	553.779	29.51
CURRENT (AMPS)	230.940	-222.592	320.750	316.05
IMPEDANCE (OHMS)	2.171	2.057	2.990	43.46
POWER (KVA)	223.335	211.597	307.656	43.46
POWER FACTOR	0.726			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 3

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4625.137	2688.552	5349.785	30.17
CURRENT (AMPS)	44.400	-9.621	45.431	347.77
IMPEDANCE (OHMS)	199.208	43.780	203.962	12.40
POWER (KVA)	411.153	90.360	420.965	12.40
POWER FACTOR	0.977			

Table 36. Continued

FEEDER LOAD PARAMETERS - THREE PHASE - FEEDER LOAD 1

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	549.238	326.629	639.021	30.74
CURRENT (AMPS)	279.597	-254.770	378.262	317.66
IMPEDANCE (OHMS)	2.137	1.999	2.926	43.08
POWER (KVA)	305.795	285.957	418.667	43.08
POWER FACTOR	0.730			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 1

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4036.632	1958.509	4486.664	25.88
CURRENT (AMPS)	46.693	-22.029	51.629	334.74
IMPEDANCE (OHMS)	140.390	54.283	150.519	21.14
POWER (KVA)	374.217	144.693	401.217	21.14
POWER FACTOR	0.933			

Table 36. Continued

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 2

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4190.742	-30.507	4190.852	359.58
CURRENT (AMPS)	24.556	11.965	27.316	25.98
IMPEDANCE (OHMS)	147.076	-221.323	265.735	303.60
POWER (KVA)	109.741	-165.141	198.279	303.60
POWER)FACTOR	0.553			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 3

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6316.949	3580.085	7260.910	29.54
CURRENT (AMPS)	8.640	-10.050	13.253	310.68
IMPEDANCE (OHMS)	624.341	714.608	948.929	48.86
POWER (KVA)	109.663	125.518	166.676	48.86
POWER FACTOR	0.658			

Table 36. Continued

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 4

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6372.973	10827.316	12563.656	59.52
CURRENT (AMPS)	12.501	-5.319	13.586	336.95
IMPEDANCE (OHMS)	973.565	1271.893	1601.730	52.57
POWER)(KVA)	179.697	234.761	295.641	52.57
POWER FACTOR	0.608			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 5

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6313.641	3574.475	7255.270	29.52
CURRENT (AMPS)	14.146	-18.805	23.531	306.95
IMPEDANCE (OHMS)	324.614	424.047	534.031	52.57
POWER (KVA)	179.748	234.806	295.708	52.57
POWER FACTOR	0.608			

Table 36. Continued

FEEDER LOAD PARAMETERS - THREE PHASE - FEEDER LOAD 2

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	5912.039	1971.661	6232.145	18.44
CURRENT (AMPS)	106.536	-44.238	115.356	337.45
IMPEDANCE (OHMS)	91.858	17.845	93.575	10.99
POWER (KVA)	1222.346	237.467	1245.199	10.99
POWER FACTOR	0.982			

MINE INPUT PARAMETERS - THREE PHASE

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	663.091	454.022	803.632	34.40
CURRENT (AMPS)	386.133	-299.008	488.369	322.25
IMPEDANCE (OHMS)	2.113	1.913	2.850	42.15
POWER (KVA)	503.959	456.206	679.778	42.15
POWER FACTOR	0.741			

Table 36. Continued

***** MINE ELECTRICAL SYSTEM SIMULATOR *****
***** LOAD FLOW CALCULATIONS *****

NAME OF USER = ALBERT ERIC K DATE = 07/10/73

DATA SET # 2 CONSISTS ONLY OF LOADS (THE SAME AS BEFORE)

NO FAULT CALCULATIONS SPECIFIED, NORMAL PROGRAM FLOW

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 1

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4193.574	-33.718	4193.707	359.54
CURRENT (AMPS)	4.256	-22.557	22.955	280.68
IMPEDANCE (OHMS)	208.205	238.285	316.432	48.86
POWER (KVA)	109.711	125.561	166.740	48.86
POWER FACTOR	0.658			

Table 36. Continued

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 2

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	481.945	272.764	553.779	29.51
CURRENT (AMPS)	230.940	-222.592	320.750	316.05
IMPEDANCE (OHMS)	2.171	2.057	2.990	43.46
POWER (KVA)	223.335	211.597	307.656	43.46
POWER FACTOR	0.726			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 3

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4625.129	2688.548	5349.773	30.17
CURRENT (AMPS)	44.400	-9.621	45.431	347.77
IMPEDANCE (OHMS)	199.208	43.780	203.962	12.40
POWER (KVA)	411.152	90.360	420.964	12.40
POWER)FACTOR	0.977			

Table 36. Continued

FEEDER LOAD PARAMETERS - THREE PHASE - FEEDER LOAD 1

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	549.238	326.629	639.021	30.74
CURRENT (AMPS)	279.597	-254.770	378.262	317.66
IMPEDANCE (OHMS)	2.137	1.999	2.926	43.08
POWER (KVA)	305.795	285.957	418.667	43.08
POWER FACTOR	0.730			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 1

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4036.633	1958.510	4486.664	25.88
CURRENT (AMPS)	46.693	-22.029	51.629	334.74
IMPEDANCE (OHMS)	140.390	54.283	150.519	21.14
POWER (KVA)	374.217	144.694	401.217	21.14
POWER FACTOR	0.933			

Table 36. Continued

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 2

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4190.738	-30.505	4190.848	359.58
CURRENT (AMPS)	24.556	11.965	27.316	25.98
IMPEDANCE (OHMS)	147.076	-221.323	265.736	303.60
POWER (KVA)	109.741	-165.140	198.279	303.60
POWER FACTOR	0.553			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 3

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6316.945	3580.080	7260.906	29.54
CURRENT (AMPS)	8.640	-10.050	13.253	310.68
IMPEDANCE (OHMS)	624.339	714.607	948.927	48.86
POWER (KVA)	109.663	125.518	166.675	48.86
POWER FACTOR	0.658			

Table 36. Continued

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 4

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6372.969	10827.297	12563.641	59.52
CURRENT (AMPS)	12.501	-5.319	13.586	336.95
IMPEDANCE (OHMS)	973.561	1271.890	1601.726	52.57
POWER (KVA)	179.697	234.762	295.642	52.57
POWER FACTOR	0.608			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 5

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6313.648	3574.479	7255.277	29.52
CURRENT (AMPS)	14.146	-18.805	23.531	306.95
IMPEDANCE (OHMS)	324.613	424.046	534.030	52.57
POWER (KVA)	179.748	234.808	295.709	52.57
POWER FACTOR	0.608			

Table 36. Continued

FEEDER LOAD PARAMETERS - THREE PHASE - FEEDER LOAD 2

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	5912.039	1971.665	6232.145	18.44
CURRENT (AMPS)	106.536	-44.239	115.356	337.45
IMPEDANCE (OHMS)	91.858	17.845	93.575	10.99
POWER (KVA)	1222.345	237.469	1245.198	10.99
POWER FACTOR	0.982			

MINE INPUT PARAMETERS - THREE PHASE

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	663.092	454.022	803.633	34.40
CURRENT (AMPS)	386.133	-299.008	488.369	322.25
IMPEDANCE (OHMS)	2.113	1.913	2.850	42.15
POWER (KVA)	503.959	456.206	679.778	42.15
POWER FACTOR	0.741			

Table 36. Continued

***** MINE ELECTRICAL SYSTEM SIMULATOR *****
***** LOAD FLOW CALCULATIONS *****

NAME OF USER = ALBERT ERIC K DATE = 07/10/73

NOW LETS VARY THE LOADS IN THIS RUN TO SEE WHAT HAPPENS

NO FAULT CALCULATIONS SPECIFIED, NORMAL PROGRAM FLOW

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 1

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4193.574	-33.718	4193.707	359.54
CURRENT (AMPS)	4.256	-22.557	22.955	280.68
IMPEDANCE (OHMS)	208.205	238.285	316.432	48.86
POWER (KVA)	109.711	125.561	166.740	48.86
POWER FACTOR	0.658			

Table 36. Continued

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 2

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	483.121	272.677	554.760	29.44
CURRENT (AMPS)	217.041	-222.820	311.056	314.25
IMPEDANCE (OHMS)	2.177	2.192	3.089	45.19
POWER (KVA)	210.629	212.057	298.886	45.19
POWER FACTOR	0.705			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 3

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	3997.054	2309.509	4616.305	30.02
CURRENT (AMPS)	9.153	-8.316	12.366	317.74
IMPEDANCE (OHMS)	478.415	434.953	646.579	42.28
POWER (KVA)	73.160	66.513	98.876	42.28
POWER FACTOR	0.740			

Table 36. Continued

FEEDER LOAD PARAMETERS - THREE PHASE - FEEDER LOAD 1

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	534.600	277.896	602.514	27.47
CURRENT (AMPS)	230.450	-253.693	342.735	312.25
IMPEDANCE (OHMS)	2.145	2.161	3.045	45.22
POWER (KVA)	251.962	253.861	357.673	45.22
POWER FACTOR	0.704			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 1

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	3797.193	509.334	3831.200	7.64
CURRENT (AMPS)	11.107	-21.661	24.343	297.14
IMPEDANCE (OHMS)	207.308	177.019	272.602	40.50
POWER (KVA)	122.842	104.894	161.533	40.50
POWER FACTOR	0.760			

Table 36. Continued

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 2

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	4229.145	-46.692	4229.402	359.37
CURRENT (AMPS)	25.711	7.120	26.678	15.48
IMPEDANCE (OHMS)	190.359	-197.893	274.587	313.89
POWER (KVA)	135.486	-140.848	195.434	313.89
POWER FACTOR	0.693			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 3

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6316.945	3580.080	7260.906	29.54
CURRENT (AMPS)	8.640	-10.050	13.253	310.68
IMPEDANCE (OHMS)	624.339	714.607	948.927	48.86
POWER (KVA)	109.663	125.518	166.675	48.86
POWER FACTOR	0.658			

Table 36. Continued

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 4

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6372.969	10827.297	12563.641	59.52
CURRENT (AMPS)	12.501	-5.319	13.586	336.95
IMPEDANCE (OHMS)	973.561	1271.890	1601.726	52.57
POWER (KVA)	179.697	234.762	295.642	52.57
POWER FACTOR	0.608			

PANEL LOAD PARAMETERS - THREE PHASE - PANEL 5

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6313.648	3574.479	7255.277	29.52
CURRENT (AMPS)	14.146	-18.805	23.531	306.95
IMPEDANCE (OHMS)	324.013	424.046	534.030	52.57
POWER (KVA)	179.748	234.808	295.709	52.57
POWER FACTOR	0.608			

Table 36. Continued

FEEDER LOAD PARAMETERS - THREE PHASE - FEEDER LOAD 2

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	6123.676	1590.950	6326.965	14.56
CURRENT (AMPS)	72.104	-48.715	87.018	325.96
IMPEDANCE (OHMS)	119.352	40.184	125.935	18.61
POWER (KVA)	903.751	304.281	953.600	18.61
POWER FACTOR	0.948			

MINE INPUT PARAMETERS - THREE PHASE

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGE (VOLTS)	639.858	363.808	736.053	29.62
CURRENT (AMPS)	302.554	-302.408	427.772	315.01
IMPEDANCE (OHMS)	2.122	2.093	2.980	44.61
POWER (KVA)	388.258	382.979	545.360	44.61
POWER FACTOR	0.712			

Table 36. Continued

```
***** MINE ELECTRICAL SYSTEM SIMULATOR *****
***** LOAD FLOW CALCULATIONS *****

NAME OF USER = ALBERT ERIC K               DATE = 07/10/73

THIS IS A TEST DATA SET FOR DEBUG PURPOSES FAULTED CONDITION

FAULTED PANEL ----> WITH ONE LINE TO GROUND

FAULT IMPEDANCE =        1.00          1.00 * J
```

Table 36. Continued

FAULTED PANEL PARAMETERS

LINE TO LINE VOLTAGES AND LINE CURRENTS

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGES (VOLTS)				
E B TO C =	13.347	559.959	560.118	88.64
E C TO A =	465.544	-296.543	551.968	327.50
E A TO B =	-478.892	-263.416	546.558	208.81
CURRENT (AMPS)				
IA =	399.922	-412.892	574.819	314.08
IB =	-403.117	-148.186	429.490	200.18
IC =	138.916	419.279	441.693	71.67
FAULT CURRENT				
IF =	135.721	-141.798	196.283	313.74

Table 36. Continued

***** MINE ELECTRICAL SYSTEM SIMULATOR *****
***** LOAD FLOW CALCULATIONS *****

NAME OF USER = ALBERT ERIC K   DATE = 07/10/73

THIS IS A TEST OF TWO LINES TO GROUND ROUTINE

FAULTED PANEL ----> WITH TWO LINES TO GROUND

FAULT IMPEDANCE (LINE TO GRND) =   1.00   1.00 * J

FAULT IMPEDANCE (LINE TO LINE) =   1.00   1.00 * J

Table 36. Continued

FAULTED PANEL PARAMETERS

LINE TO LINE VOLTAGES AND LINE CURRENTS

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGES (VOLTS)				
E B TO C =	26.898	549.188	549.846	87.20
E C TO A =	463.359	-285.917	544.472	328.32
E A TO B =	-490.257	-263.270	556.474	208.24
CURRENT (AMPS)				
IA =	346.179	-410.814	537.223	310.12
IB =	-575.555	-199.398	609.117	199.11
IC =	170.404	669.808	691.144	75.73
FAULT CURRENT				
IF =	58.972	-59.596	83.841	314.70

Table 36. Continued

***** MINE ELECTRICAL SYSTEM SIMULATOR *****
***** LOAD FLOW CALCULATIONS *****

NAME OF USER = ALBERT ERIC K DATE = 07/10/73

THIS IS A TEST OF LINE TO LINE

FAULTED PANEL ----> WITH LINE TO LINE FAULT

FAULT IMPEDANCE = 1.00 1.00 * J

Table 36. Continued

FAULTED PANEL PARAMETERS

LINE TO LINE VOLTAGES AND LINE CURRENTS

	REAL	REACTIVE	MAGNITUDE	ANGLE
VOLTAGES (VOLTS)				
E B TO C =	37.665	510.986	512.372	85.79
E C TO A =	458.782	-274.344	534.552	329.12
E A TO B =	-496.448	-236.642	549.963	205.49
CURRENT (AMPS)				
IA =	362.216	-341.373	497.731	316.70
IB =	-602.594	-207.498	637.318	199.00
IC =	240.378	548.871	599.200	66.35
FAULT CURRENT				
IF =	124.625	-130.424	180.393	313.70

Table 36. Continued

***** MINE ELECTRICAL SYSTEM SIMULATOR *****
***** LOAD FLOW CALCULATIONS *****

NAME OF USER = ALBERT ERIC K DATE = 07/10/73

TRY A THREE PHASE FAULT

FAULTED PANEL ----> WITH THREE LINES TO GROUND

FAULT IMPEDANCE = 1.00 1.00 * J

Table 36. Continued

FAULTED PANEL PARAMETERS

LINE TO LINE VOLTAGES AND LINE CURRENTS

	REAL	REACTIVE	MAGNITUDE
VOLTAGE (VOLTS)			
E B TO C =	529.327	281.101	599.337
NOTE: BALANCED SYSTEM, E A TO B AND E C TO A EQUAL TO ABOVE VALUE			
CURRENT (AMPS)			
IA =	471.548	-468.239	664.534
NOTE: BALANCED SYSTEM, IB AND IC EQUAL TO ABOVE VALUE			
FAULT CURRENT			
IF =	155.884	-155.885	220.454

APPENDIX VI

MINE ELECTRICAL SYSTEM SIMULATOR SOFTWARE

```
C       ****************************************************************************
C       **                                                                        **
C       **                    MINE ELECTRICAL SYSTEM SIMULATOR                    **
C       **                                                                        **
C       **                        LCAD FLOW CALCULATICNS                          **
C       **                                                                        **
C       **                             MAIN PRCGRAM                               **
C       **                                                                        **
C       ****************************************************************************
        REAL F,W,IDC
        INTEGER NSECTN,I,NBE,NDCJ
        LOGICAL CHEQ,IFLG
        LOGICAL*1 ID(33),MNAME(73),NME(20),DAY(8),FLT/'F'/,DYN/'D'/,BNK/'
       -'/
        COMPLEX ZBE(10),IBE(10),ZSECTN(10),ISECTN(10),ZMINE,IMINE,Z1PHS,
       1I1PHS,RPWR(10)
        COMMON /LOD002/ W
        COMMON /LOD004/ IPCS
        COMMON /LOD006/ IDEV,IFLG
        EQUIVALENCE (ID(14),NME(1))
C **
C **    GET SYSTEM JOB PARAMETERS FCR HEADING
C **
        CALL NAME(ID)
        CALL DATE(DAY)
        NDYN=0
C **
C **    READ THE MINE DESCRIPTCR CARD FOR NAME AND CPTIONS
C **
690     READ(5,499,END=701) MNAME,ITYPE,IPCS
        IFLG=.FALSE.
        IDEV=5
C **
C **    DETERMINE IF DYNAMIC CPTICN SPECIFIEC AND SET UP VALUES IF SO
C **
        IF(CHEQ(MNAME(73),FLT).CR.CHEQ(MNAME(73),BNK)) NDYN=0
        IF(CHEQ(MNAME(73),DYN)) NDYN=NDYN+1
        IF(NDYN.GT.1.AND.CHEQ(MNAME(73),DYN)) IDEV=90
        IF(CHEQ(MNAME(73),DYN).AND.NDYN.EQ.1) IFLG=.TRUE.
C **
C **    READ THE FREQENCY OF THE CURRENT AND THE NUMBER OF FEEDER LOADS
C **
        READ(IDEV,1000) F,NSECTN
        IF(IFLG)  WRITE (90,1000) F,NSECTN
1000    FORMAT (10X,F10.2,10X,I10)
        W = F*6.283185
        PRINT 501
        PRINT 500,NME,DAY
        PRINT 502,(MNAME(I),I=1,72)
C.**
C **    DO WE HAVE A SET OF FAULT DATA ?
C **
        IF(CHEQ(FLT,MNAME(73))) GO TC 511
```

```
      PRINT 503
      DO 10 I = 1,NSECTN
C **
C **  PERFORM THE LOAD FLOW CALCULATICNS ON THE PANELS -- NONFAULTED SYS
C **
      CALL LODFLO (ZBE,IBE,NBE,W)
C **
C **  ITERATIVELY COMBINE THE PANELS FOR AN EQUIVALENT FEEDER LOAD
C **
      CALL LADDER (ZBE,IBE,NBE,ZSECTN(I),ISECTN(I))
C **
C **  PRINT THE THREE PHASE PARAMETERS FOR THE PANEL LOAD
C **
      WRITE (6,4000) I
4000  FORMAT ('1',T43,'FEEDER LCAD PARAMETERS - THREE PHASE - FEEDER LOA
     1D ',I3)
      CALL PRINT (ISECTN(I),ZSECTN(I))
10    CONTINUE
C **
C **
C **  ITERATIVELY COMBINE THE FEEDER LOADS FOR A SINGLE INPUT TO THE
C **  MAIN MINE TRANSFCRMER
C **
      CALL LADDER (ZSECTN,ISECTN,NSECTN,ZMINE,IMINE)
      NDCJ = 0
C **
C **  PERFORM THE CALCULATICNS THROUGH THE MAIN MINE TRANSFORMER
C **
      CALL XFMR (ZMINE,IMINE,W,NSECTN,NDCJ,RPWR,IDC,Z1PHS,I1PHS)
C **
C **  PRINT THE MAIN MINE INPUT PARAMETERS
C **
      WRITE (6,2000)
2000  FORMAT ('1',T48,'MINE INPUT PARAMETERS - THREE PHASE')
      CALL PRINT (I1PHS,Z1PHS)
      IF(IFLG) ENDFILE 90
      REWIND 90
      GO TO 690
C **
C **  THIS PART OF THE PROGRAM DOES THE FAULT CALCULATIONS
C **  TEST THE TYPE NUMBER TO SEE IF IT IS VALID
C **
511   IF(ITYPE.LE.0.OR.ITYPE.GT.4) GO TO 512
      PRINT 504
      GO TO (601,602,603,604),ITYPE
601   PRINT 801
C **
C **  PRINT THE TYPE OF FAULT
C **
801   FORMAT('+',25X,'CNE LINE TC GROUND')
      GO TO 900
602   PRINT 802
802   FORMAT('+',25X,'TWC LINES TC GROUND')
```

```
      GO TO 900
603   PRINT 803
803   FORMAT('+',25X,'LINE TO LINE FAULT')
      GO TO 900
604   PRINT 804
804   FORMAT('+',25X,'THREE LINES TO GROUND')
C **
C **  CALL EA1CAL TO CALCULATE THE NONFAULTED PARAMETERS
C **
900   IF(ITYPE.NE.4) CALL EA1CAL(&480)
C **
C **  ACCORDING TO THE TYPE NUMBER CALL THE SOLUTION ROUTINE
C **
      IF(ITYPE.EQ.1) CALL MXLCD1
      IF(ITYPE.EQ.2) CALL MXLCD2
      IF(ITYPE.EQ.3) CALL MXLCD3
      IF(ITYPE.EQ.4) CALL MXLCD4
480   GO TO 690
701   STOP
512   PRINT 505
      STOP
499   FORMAT(73A1,T79,2I1)
500   FORMAT(///,' NAME OF USER = ',20A1,5X,' DATE = ',8A1)
501   FORMAT('1',T44,'***** MINE ELECTRICAL SYSTEM SIMULATOR *****',/
     -,' ',T49,'***** LOAD FLOW CALCULATIONS *****')
502   FORMAT(///,' ',72A1)
503   FORMAT(/,' NO FAULT CALCULATIONS SPECIFIED, NORMAL PROGRAM FLOW')
504   FORMAT(///,' FAULTED PANEL ----> WITH ')
505   FORMAT(' ERROR ----> INVALID FAULT TYPE NUMBER')
      END
```

```
      SUBROUTINE LODFLO (ZBE,IBE,NBE,W)
C     ************************************************************************
C     **                                                                   **
C     **                         SUBROUTINE LODFLO                         **
C     **                                                                   **
C     **                    PANEL LOAD FLOW CALCULATIONS                   **
C     **                                                                   **
C     ************************************************************************
      REAL W,THETA,CX2,ACV1,ACP1,L,TYPE,RTL,XTL,IDC(10),DCI,DCV,DCP,
     -DCC,DCR
      COMPLEX ZBE(10),IBE(10),ZPWR(10),IPWR(10),RPWR(10),IP,ZL1,
     -YPWR
      COMMON /LOD001/ YPWR,IP,NACJ
      COMMON /LOD006/ IDEV,IFLG
      LOGICAL IFLG
      INTEGER NBE,NACJ,NDCJ,K,I
C **
C **  READ NUMBER OF PANELS
C **
      READ (IDEV,1000) NBE
      IF(IFLG) WRITE (90,1000) NBE
1000  FORMAT (10X,I10)
C **
C **  DO LOOP FOR CALCULATION OF AC CONVERSION ( 1 TO NBE )
C **
      DO 100 I = 1,NBE
      IPWR(I) = (0.0,0.0)
C **
C **  CALL ACLODS TO GET THE PARALLEL LOADS FOR THIS CONNECTION
C **  IF NONE ON THIS CONNECTION THEN GO TO 211 ON RETURN
C **
      CALL ACLODS(&211,0)
C **
C **  CALCULATE ZPWR AND IPWR FOR THAT ENTRY
C **
      ZPWR(I) = 1.0/YPWR
      IPWR(I) = IP
C **
C **  READ TRANSMISSION LINE TO AC BUS BAR
C **
      READ (IDEV,4000) L,TYPE,RTL,XTL
      IF(IFLG) WRITE (90,4000) L,TYPE,RTL,XTL
C **
C **  IS TRANSMISSION LINE COMPONENT SELECTION REQUIRED ?
C **  IF YES THEN CALL FINDTL
C **  IF NO THEN CALCULATE ZPWR
C **
      IF(RTL.NE.0.0.AND.XTL.NE.0.0) GO TO 21
      CALL FINDTL(L,TYPE,RTL,XTL)
21    ZPWR (I) = ZPWR(I) + CMPLX(L*RTL,L*XTL)
C **
C **  READ NUMBER OF DC LOADS ON THIS CONNECTION
C **
```

```
211   READ (IDEV,2000) NDCJ
      IF(IFLG) WRITE (90,2000) NDCJ
      IDC(I) = 0.0
      IF(NDCJ.EQ.0) GO TO 24
C **
C **  SET INITIAL CONDITICNS
C **
      DCI=0.0
      DCC=0.0
C **
C **  DO LOOP TO CONVERT EACH PARALLEL DC CONNECTION
C **
      DO 300 K=1,NDCJ
C **
C **  READ DC POWER PARAMETERS
C **
      READ (5,5000) DCV,DCP
      DCI = DCI + DCP/DCV
      DCR = DCP/(DCI**2.0)
C **
C **  READ DC EQUIPMENT LINE PARAMETERS
C **
      READ (IDEV,4000) L,TYPE,RDC,RXC
      IF( IFLG) WRITE (90,4000) L,TYPE,RDC,RXC
C **
C **  IS TRANSMISSION LINE COMPCNENT REQUIRED ?
C **  IF YES CALL FINDTL
C **  IF NO THEN PROCEED WITH CALCULATICN
C **
      IF(RDC.NE.0.0) GO TO 22
      CALL FINDTL(L,TYPE,RDC,RXC)
22    DCC = DCC + 1.0/(DCR + L*RDC)
C **
C **  LOOP ENDS CALCULATE IDC
C **
300   CONTINUE
      IDC(I) = DCI
      RPWR(I) = 1.0/DCC
C **
C **  READ TRANSMISSION LINE TC DC BUS BAR
C **
      READ (IDEV,4000) L,TYPE,RDC,RXC
      IF(IFLG) WRITE (90,4000) L,TYPE,RDC,RXC
C **
C **  IS TRANSMISSION LINE COMPCNENT SELECTICN REQUIRED ?
C **  IF NO THEN CALCULATE RPWR IMMEDIATELY
C **
      IF(RDC.NE.0.0)GO TO 23
      CALL FINDTL(L,TYPE,RDC,RXC)
23    RPWR(I) = RPWR(I) + L*RDC
24    CALL XFMR (ZPWR(I),IPWR(I),W,NACJ,NDCJ,RPWR(I), IDC(I), ZBE(I),
     1IBE(I))
      READ (IDEV,4000) L,TYPE,RTL,XTL
```

```
      IF(IFLG) WRITE (90,4000) L,TYPE,RTL,XTL
C **
C **  IS TRANSMISSION LINE COMPONENT REQUIRED
C **  IF YES CALL FINDTL
C **
      IF(RTL.NE.0.0.AND.XTL.NE.0.0) GO TO 25
      CALL FINDTL(L,TYPE,RTL,XTL)
25    ZBE(I) = ZBE(I) + CMPLX(L*RTL,L*XTL)
C **
C **  PRINT THREE PHASE PARAMETERS FOR THE PANEL LOAD
C **
      WRITE (6,6000) I
6000  FORMAT ('3',T43,'PANEL LOAD PARAMETERS - THREE PHASE - PANEL ',I3)
      CALL PRINT(IBE(I),ZBE(I))
2000  FORMAT(10X,I10)
4000  FORMAT(2(10X,F10.2),2(10X,F10.9))
5000  FORMAT (2(10X,F10.2))
100   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE XFMR (ZPWR,IPWR,W,NACJ,NDCJ,RPWR,IDC,ZBUTT,IBUTT)
C     ******************************************************************
C     **                                                              **
C     **                     SUBROUTINE XFMR                          **
C     **                                                              **
C     **                 TRANSFORMER CALCULATIONS                     **
C     **                                                              **
C     ******************************************************************
      COMMON /LOD006/ IDEV,IFLG
      LOGICAL IFLG
      REAL IDC,PCR(3),RKVA(3),VOLTLL(3),R(3),ISCAC,ISCDC,IACDC,KVARF,
     1W,RFW,CC3,CC4,      A1,A2,RATEP,RATEAC,RATEDC,RPVOC,PEOC,IEOC,
     2VPSCDC,VPSCAC,VPACDC,PSCAC,PSCDC,PACDC,PCX12,XKVA12,PCX23,XKVA23,
     3PCX13,XKVA13,PV,PC,XAB,XBC,XCA,WLE,RE
      COMPLEX ZPWR,IPWR,RPWR,          ZAB,ZCA,ZBC,ZA,ZB,ZC,ZCC3,AZACEQ,
     2IACEQ,IDCEQ,IIN,Z,ZE,ZINT,IPRMRY,ZBUTT,IBUTT,ZEQUIV
      INTEGER NDCJ,PRMRY,SCNDRY,TRTARY,J,WYE/'WYE '/,DLTA/'DLTA'/,
     1NONE/'NONE'/,NACJ
      READ (IDEV,8000) PRMRY,SCNDRY,TRTARY,METH
      IF(IFLG) WRITE (90,8000) PRMRY,SCNDRY,TRTARY,METH
      METH=METH-2
8000  FORMAT (10X,A4,T21,A4,T31,A4,T41,I1)
C **
C **  IF TRANSFORMER IS NOT WYE OR DELTA PRINT ERROR MESSAGE
C **
      IF(PRMRY.EQ.WYE .OR.PRMRY.EQ.DLTA) GO TO 25
      IF(PRMRY.EQ.NONE) GO TO 26
      WRITE (6,80001)
80001 FORMAT (1X,'XXX ERROR - NO TRANSFORMER DATA GIVEN')
      STOP
26    IF(NDCJ.EQ.0) GO TO 27
      WRITE (6,80002)
80002 FORMAT (1X,'XXX ERROR - NO TRANSFORMER-RECTIFIER FOR DC')
      STOP
27    ZBUTT = ZPWR
      IBUTT = IPWR
      GO TO 106
C **
C **  READ PRIMARY AND SECONDARY CORRECTION COMPONENTS
C **
25    READ (IDEV,9000) CC3,CC4
      IF(IFLG) WRITE (90,9000) CC3,CC4
9000  FORMAT(2(10X,E10.5))
C **
C **  READ FORWARD RECTIFIER RESISTANCE
C **
      READ (IDEV,2001) RFW
      IF(IFLG) WRITE (90,2001) RFW
2001  FORMAT(10X,F10.4)
C **
C **  CONVERT CORRECTION COMPONENTS TO IMPEDANCE VALUES
C **
      IF(CC3) 503,503,501
```

```
501    CX3 = -1.0/(W*CC3)
       GO TO 5C4
503    CX3 = -0.723700E+74
504    IF(CC4) 5C7,5C7,505
505    CX4 = -1.0/(W*CC4)
       GO TO 5C8
507    CX4 = -0.723700E+74
C **
C **   READ THE PRIMARY, SECCNDARY AND TERTIARY VOLTAGES
C **
508    READ (IDEV,9001) RATEP,RATEAC,RATEDC
       IF(IFLG) WRITE (90,9001) RATEP,RATEAC,RATEDC
9001   FORMAT (3(10X,F10.2))
C **
C **   CALCULATE TURNS RATIOS
C **
       A1 = RATEP/RATEAC
       A2 = RATEP/RATEDC
C **
C **   READ OPEN CIRCUIT TEST DATA
C **
       READ (IDEV,9010) RPVOC,PEOC,IEOC
       IF(IFLG) WRITE (90,9010) RPVOC,PEOC,IEOC
9010   FORMAT (3(10X,F10.4))
C **
C **   CALCULATE TRANSFORMER EXCITER CCMPONENTS
C **
       IF(RPVOC.NE.0.0) GO TO 9011
       WLE = 0.723700E+74
       RE = 0.723700E+74
       GO TO 9012
9011   RE = (RPVOC ** 2.0)/PEOC
       WLE = 1.0/SQRT(((IEOC/RPVOC)**2.0)-(1.0/(RE**2.0)))
C **
C **
 9012  IF(METH) 9013,9015,9015
C **
C **   READ TRANSFORMER SHCRT CIRCUIT DATA
C **
9013   PEAD (IDEV,9010) VPSCAC,PSCAC,ISCAC
       IF(IFLG) WRITE(90,9010) VPSCAC,PSCAC,ISCAC
C **
C **   IF SHORT CIRCUIT DATA IS NCT AVAILABLE READ PERCENTS OF KVA
C **   TYPE DATA.  IF PERCENTS NCT GIVEN, ASSUME PERCENTS AND PROCEED.
C **   UTILIZING ONE OF THREE SETS OF DATA, CALCULATE THREE WINDINGS
C **   IMPEDANCES.
C **
       READ (IDEV,9010) VPSCDC,PSCDC,ISCDC
       IF(IFLG) WRITE (90,9010) VPSCDC,PSCDC,ISCDC
       READ (IDEV,9010) VPACDC,PACDC,IACDC
       IF(IFLG) WRITE (90,9010) VPACDC,PACDC,IACDC
       ZAB = ZEQUIV(VPSCAC,PSCAC,ISCAC)
       ZCA = ZEQUIV(VPSCDC,PSCDC,ISCDC)
```

```
      ZBC = ZEQUIV(VPACDC,PACDC,IACDC)
      GO TO 9400
C **
C **
9015  READ (IDEV,9200) (PCR(J),RKVA(J),VCLTLL(J),J=1,3)
      IF(IFLG) WRITE (90,9200) (PCR(J),RKVA(J),VCLTLL(J),J=1,3)
9200  FORMAT(3(10X,F10.2))
      READ (IDEV,9300) PCX12,XKVA12,PCX23,XKVA23,PCX13,XKVA13
      IF(IFLG) WRITE (90,9300) PCX12,XKVA12,PCX23,XKVA23,PCX13,XKVA13
9300  FORMAT (3(5X,F5.2,5X,F10.0))
      IF(METH) 9013,102,100
100   DO 101  J = 1,3
      PCR(J) = 0.42
101   CONTINUE
      PCX12 = 3.0
      PCX23 = 3.0
      PCX13 = 3.0
C **
C **
102   CONTINUE
      KVARF = RKVA(2)
      PV = VOLTLL(2)/1.732051
      PC = (KVARF*1000.0)/(3*PV)
      DO 103  J = 1,3
      R(J) = PCR(J)/100.0*(KVARF/RKVA(J))*PV/PC
103   CONTINUE
      XAB = PCX12/100.0*(KVARF/XKVA12)*PV/PC
      XBC = PCX23/100.0*(KVARF/XKVA23)*PV/PC
      XCA = PCX13/100.0*(KVARF/XKVA13)*PV/PC
      ZAB = CMPLX(R(1) + R(2),XAB)
      ZBC = CMPLX(R(2)+R(3),XBC)
      ZCA = CMPLX(R(1)+R(3),XCA)
C **
C **
9400  ZA = (ZAB + ZCA - ZBC)/2.0
      ZB = (ZAB + ZBC - ZCA)/2.0
      ZC = (ZCA + ZBC - ZAB)/2.0
      ZCC3 = CMPLX(0.0,CX3)
      IF(NACJ.GT.0) GO TO 997
      AZACEQ =(.7237005E+70,.7237005E+70)
      IACEQ =(0.0,0.0)
      GO TO 998
C **
C **  CONVERT THE IMPEDANCES AND CURRENTS INTO THE TRANSFORMER EQUIVALEN
C **  VALUES BY APPROPRIATE USE OF TURNS RATIOS
C **  COMBINE IMPEDANCES AND CURRENTS THROUGH TRANSFORMER BY SERIES PARA
C **  COMBINATIONS BEING CAREFUL TO TAKE INTO ACCOUNT THE POSSIBLE DELTA
C **  WYE CONNECTION COMBINATIONS.
C **
  997 AZACEQ = A1**2./(1.0/ZCC3+1.0/ZPWR)
      IACEQ = (IPWR+IPWR*ZPWR/ZCC3)/A1
      IF(SCNDRY.EQ.WYE ) GO TO 998
      IACEQ = IACEQ*CMPLX(0.5,0.28867513E+00)
```

```
      AZACEQ = AZACEQ*3.0
998   AZACEQ = AZACEQ + ZB
      IF(TRTARY.EQ.DLTA) GO TC 996
      WRITE (6,1001)
1001  FORMAT (1X,'XXX ERROR - DC TERTIARY IS NOT GIVEN AS DELTA CONNECTI
     1ON')
      STOP
996   IF(NDCJ.GT.0) GO TC 999
      RPWR = (.7237005E+70,.7237005E+70)
      IDCEQ =(C.0,0.0)
      GO TO 104
999   IDCEQ = (IDC/A2)*CMPLX(0.5,0.28867513E+00)
      RPWR = ((RPWR + RFW)*(A2**2.0)*3.0) + ZC
104   Z = ZA + 1.0/(1.0/RPWR+1.0/AZACEQ)
      ZE = 1.0/(1.0/CMPLX(RE,0.0)+1.0/CMPLX(0.0,WLE))
      ZINT = 1.0/(1.0/Z + 1.0/ZE)
      IIN = IACEQ + IDCEQ
      IIN = IIN + (IIN*Z)/ZE
      IF(PRMRY.EQ.WYE ) GO TO 107
      IIN = IIN*CMPLX(1.5,-0.866025)
      ZINT = ZINT/3.0
1C7   IPRMRY = IIN
      ZBUTT     = 1.0/(1.0/ZINT + 1.0/CMPLX(0.0,CX4))
      IBUTT     = IPRMRY + (ZINT*IPRMRY)/CMPLX(0.0,CX4)
106   RETURN
      END
```

```
      SUBROUTINE ACLODS(*,IMODE)
C     ******************************************************************
C     **                                                              **
C     **                     SUBRCUTINE ACLCCS                        **
C     **                                                              **
C     **               CALCULATE PARALLEL AC LCADS                    **
C     **                                                              **
C     ******************************************************************
      REAL ACP,ACV,THETA,ACPF,CC1,CC2,CX1,CX2,ACV1,ACP1,L,TYPE,RTL,
     *XTL
      COMMON /LOD001/ YPWR,IP,NACJ
      COMMON /LOD006/ IDEV,IFLG
      LOGICAL IFLG
C **
C **  ACLODS IS A TWO MODE PRCGRAM -- IF CALLED IN MODE 0 IT WILL
C **  CALCULATE 1 TO NACJ LCADS AND THEIR PARAMETERS
C **  IF CALLED IN MODE 1 THEN IT DOES THE CALCULATICNS FOR NACJ-1
C **  AND SETTING THE PARAMETERS CCRRECTLY IF NACJ = 1
C **  IF NACJ = 0 THEN IN EITHER MODE IT RETURNS IMMEDIATELY
C **
      COMPLEX IP,ZL1,YL1,ZL2,YPWR
      INTEGER NBE,NACJ,NDCJ,K,I,J
      READ (IDEV,2000) NACJ
      IF(IFLG) WRITE (90,2000) NACJ
      IF(NACJ.EQ.0) RETURN 1
C **
C **  DO LOOP FOR CONVERSICN CF EACH PARALLEL AC CCNNECTION
C **  SET INITIAL CCNDITICNS
C **
      IP = 0.
      YPWR = (0.0,0.0)
      IF(IMODE.EQ.1) NACJ=NACJ-1
      IF(IMODE.EQ.1.AND.NACJ.LT.1) GO TC 50
      DO 200 J = 1,NACJ
C **
C **  READ AC POWER PARAMETERS
C **
      READ (5,4001) ACP,ACV,THETA,ACPF
C **
C **  GET POWER FACTOR CORRECTICNAL CCMPCNENTS
C **
      IF(ACPF) 10,11,10
10    THETA=ARCOS(ACPF)
11    CALL PFCC(CX1,CX2)
      ACV1=ACV/1.732051
      ACP1 = ACP/3.0
      ZL1 = CMPLX((ACV1**2.)*(CCS(THETA)**2.)/ ACP1,(ACV1**2.)*COS
     1(THETA)*SIN(THETA)/ACP1)
      YL1 = 1.0/ZL1 + CMPLX(0.0,-1.0/CX2)
      ZL1 = 1.0/YL1
      IP = IP + ACV1/ZL1
C **
C **  GET TRANSMISSION LINE
```

```
C **
      READ (IDEV,4000) L,TYPE,RTL,XTL
      IF(IFLG) WRITE (90,4000) L,TYPE,RTL,XTL
C **
C **  IF TRANSMISSION LINE SELECTION REQUIRED CALL FINDTL
C **
      IF(RTL.NE.0.0.AND.XTL.NE.0.0) GO TO 20
      CALL FINDTL(L,TYPE,RTL,XTL)
20    ZL2 = ZL1 + CMPLX(L*RTL,L*XTL + CX1)
200   YPWR = YPWR + 1.0/ZL2
C **
C **  END OF LOOP
C **
      RETURN
50    YPWR=(.2E-20,.2E-20)
      RETURN
2000  FORMAT(10X,I10)
4000  FORMAT(2(10X,F10.2),2(10X,F10.9))
4001  FORMAT(4(10X,F10.2))
      END
```

```
      SUBROUTINE LADDER (ZBE,IBE,NBE,ZSECTN,ISECTN)
C     **********************************************************************
C     **                                                                  **
C     **                        SUBROUTINE LADDER                         **
C     **                                                                  **
C     **        ITERATIVE COMBINATION OF SERIES - PARALLEL LOADS          **
C     **                                                                  **
C     **********************************************************************
      COMMON /LOD006/ IDEV,IFLG
      COMPLEX ZBE(10),IBE(10),ZSECTN,ISECTN
      REAL RTL,XTL,L,TYPE
      INTEGER NBE,I
      LOGICAL IFLG
      DO 100 I = 1,NBE
C **
C **  READ TRANSMISSION LINE IN SERIES WITH LOAD
C **
      READ (IDEV,4000) L,TYPE,RTL,XTL
      IF(IFLG) WRITE (90,4000) L,TYPE,RTL,XTL
4000  FORMAT(2(10X,F10.2),2(10X,F10.9))
      IF(RTL.NE.0.0.AND.XTL.NE.0.0) GO TO 10
      CALL FINDTL (L,TYPE,RTL,XTL)
C **
C **  COMBINE TRANSMISSION LINE AND SERIES LOAD
C **
10    ZBE(I) = ZBE(I) + CMPLX (L*RTL,L*XTL)
      IF(I.EQ.NBE) GO TO 100
C **
C **  NOW COMBINE PARALLEL LOADS
C **
      ZBE(I+1) = (ZBE(I+1)*ZBE(I))/(ZBE(I) + ZBE(I+1))
      IBE(I+1) = (IBE(I) + IBE(I+1))
100   CONTINUE
      ZSECTN = ZBE(NBE)
      ISECTN = IBE(NBE)
      RETURN
      END
```

```
      SUBROUTINE FINDTL (L,TYPE,RTL,XTL)
C     ************************************************************************
C     **                                                                    **
C     **                         SUBRCUTINE FINDTL                          **
C     **                                                                    **
C     **    FIND TRANSMISSICN LINE UNIT RESISTANCE & UNIT REACTANCE         **
C     **                                                                    **
C     ************************************************************************
      REAL L,TYPE,RTL,XTL
      REAL REACT(30)/0.0,.0000488,.0000454,.0000421,.0000392,.0000376,
     1 .0000363,.0000353,.0000341,.0000331,.0000333,.0000324,.0000318,
     2 .0000314,.0C00307,15*0.0/
      REAL RES(30)/0.0,.000878,.000541,.000339,.000216,.000173,
     1 .000139,.000111,.0000891,.0000713,.0000610,.0000513,.0000443,
     2 .0000395,.0000323,15*0.0/
C **
C **  CHECK TYPE AGAINST MAXIMUM AND MINIMUM  IF ERROR THEN TYPE 1
C **  IS ASSIGNED
C **
      I=ABS(TYPE)
      IF(I.GT.0.AND.I.LE.30) GO TO 5
      I=1
      WRITE(6,100) L,TYPE,RTL,XTL,I
  100 FORMAT('0','**** FINDTL **** INCORRECT TYPE'/
     1' >',2(1CX,F10.2),2(10X,F10.7),'< ',I2,' ASSUMED')
    5 RTL= RES(I)
      XTL= REACT(I)
      RETURN
      END
```

```
      SUBROUTINE PFCC (CX1,CX2)
C     ******************************************************************
C     **                                                              **
C     **    SUBROUTINE PFCC    CALCULATE POWER FACTCR CORRECTIONS     **
C     **                                                              **
C     ******************************************************************
      COMMON /LOD002/ W
      COMMON /LODC06/ IDEV,IFLG
      LOGICAL IFLG
      READ (IDEV,201) CC1,CC2,CX1,CX2
      IF(IFLG) WRITE (90,201) CC1,CC2,CX1,CX2
C **
C **  THIS ROUTINE READS IN THE PCWER FACTCR CCRRECTICN
C **  COMPONENTS
C **
      IF(CC1) 13,13,12
C **
C **  IF CC1 EXISTS THEN CALCULATE CX1, CTHERWISE SET CX1 TO ZERO
C **
12    CX1=-1.0/(W*CC1)
13    IF(CX1) 15,14,14
14    CX1=0.0
15    IF(CC2) 17,17,16
C **
C **  IF CC2 EXISTS THEN CALCULATE CX2, OTHERWISE SET CX2 TO INFINITY
C **
16    CX2=-1.0/(W*CC2)
17    IF(CX2) 19,18,18
18    CX2=-.72370C5E+76
19    RETURN
201   FORMAT(2(10X,E10.5),2(10X,F10.2))
      END
```

```
      COMPLEX FUNCTION ZEQUIV (VPSC,PSC,ISC)
C     ***********************************************************************
C     **                                                                   **
C     **                    CCMPLEX FUNCTICN ZEQUIV                        **
C     **                                                                   **
C     **                 SHORT-CIRCUIT DATA CALCULATION                    **
C     **                                                                   **
C     ***********************************************************************
      REAL VPSC,PSC,ISC
      IF(VPSC.GT.0.000001) GO TO 10
      REQ = 0.0
      WLFQ = 0.0
      GO TO 20
10    REQ = (PSC/(ISC**2.0))
      WLEQ = SQRT((VPSC/ISC)**2.-REQ**2.)
20    ZFQUIV = CMPLX(REQ,WLEQ)
      RETURN
      END
```

```
      SUBROUTINE PRINT(I1PHS,Z1PHS)
C     ******************************************************************
C     **                                                              **
C     **                      SUBROUTINE PRINT                        **
C     **                                                              **
C     **          CALCULATE THREE PHASE PARAMETERS & PRINT            **
C     **                                                              **
C     ******************************************************************
      COMPLEX I1PHS,Z1PHS,V1PHS,LIST(4),Z3PHS
      REAL VMAG,PF,CMAG,IMAG,PMAG,ANGL(4)
      V1PHS = I1PHS*Z1PHS
C **
C **  CALCULATE POWER FACTOR
C **
      PF = COS(ATAN(AIMAG(Z1PHS)/REAL(Z1PHS)))
C **
C **  CONVERT SINGLE PHASE VALUES TO THREE PHASE VALUES
C **
200   LIST(1)=I1PHS
      LIST(2)=V1PHS * (1.5,0.86602)
      LIST(4)=3.0*Z1PHS
      LIST(3) = 3.0*CMPLX((CABS(I1PHS)**2.0)*REAL(Z1PHS),(CABS(I1PHS)**2
     -.0)*AIMAG(Z1PHS))
      LIST(3)=LIST(3)/1000.
C **
C **  CALCULATE THE PARAMETERS FOR PRINTING
C **
      CMAG=CABS(LIST(1))
      VMAG=CABS(LIST(2))
      PMAG=CABS(LIST(3))
      ZMAG=CABS(LIST(4))
C **
C **  CONVERT ANGLES TO PROPER QUADRANT
C **
      CNST=180./3.1415
      DO 5 I=1,4
      ANGL(I)=ATAN(AIMAG(LIST(I))/REAL(LIST(I)))*CNST
      IF(REAL(LIST(I)).GE.0.AND.AIMAG(LIST(I)).GE.0.) GO TO 5
      IF(REAL(LIST(I)).GE.0..AND.AIMAG(LIST(I)).LT.0.) ANGL(I)=ANGL(I)+3
     -60.
      IF(REAL(LIST(I)).LT.0.) ANGL(I)=ANGL(I)+180.
5     CONTINUE
      PRINT 3000,LIST(2),VMAG,ANGL(2),LIST(1),CMAG,ANGL(1),LIST(4),ZMAG,
     -ANGL(4),LIST(3),PMAG,ANGL(3),PF
3000  FORMAT('0',T24,'REAL',9X,'REACTIVE',6X,'MAGNITUDE',7X,'ANGLE',/,'0
     1VOLTAGE (VOLTS) ',2X,3(F10.3,5X),2X,F6.2,/,'OCURRENT (AMPS) ',2X,3(
     1F10.3,5X),2X,F6.2,/,'OIMPEDANCE (OHMS) ',3(F10.3,5X),2X,F6.2,/,'OP
     1OWER (KVA) ',5X,3(F10.3,5X),2X,F6.2,/,'OPOWER FACTOR',5X,3(F10.3,5
     1X))
      RETURN
      END
```

```
      SUBROUTINE EA1CAL(*)
C     ************************************************************************
C     **                                                                    **
C     **                       SUBRCUTINE EA1CAL                            **
C     **                                                                    **
C     **              CALCULATE THE NON-FAULTED SYSTEM                      **
C     **                                                                    **
C     **          PARAMETERS NEEDED FOR FAULT CALCULATIONS                  **
C     **                                                                    **
C     ************************************************************************
      COMMON /LOD001/ YPWR,IP,NACJ
      COMMON /LOD004/ IPOS
      COMMON /LOD005/ ZNACJ,ZL2,ZL1,EA1,ZT
      COMPLEX YPWR,YNACJ,ZNACJ,IP,ZLINE,EA1,ZL1,ZL2,IPNACJ,ZTOT,ZT
      REAL L,TYPE,RTL,XTL,ACP,ACV,THETA,ACPF
C **
C **  CALL ACLODS FOR NACJ - 1 PARALLEL LOADS
C **
      CALL ACLODS(&200,1)
      READ (5,4001) ACP,ACV,THETA,ACPF
C **
C **  CALCULATE THETA AND GET POWER FACTOR CORRECTICNAL COMPONENTS
C **
      IF(ACPF) 10,11,10
10    THETA=ARCOS(ACPF)
11    CALL PFCC(CX1,CX2)
      ACV=ACV/1.732051
      ACP=ACP/3.0
      ZNACJ=CMPLX((ACV**2.)*(COS(THETA)**2.)/ACP,(ACV**2.)*COS(THETA)*SI
     -N(THETA)/ACP)
      YNACJ=1.0/ZNACJ+CMPLX(0.0,-1.0/CX2)
      ZNACJ=1.0/YNACJ
      IPNACJ=ACV/ZNACJ
C **
C **  GET TRANSMISSICN LINE
C **
      READ 4000,L,TYPE,RTL,XTL
      IF(RTL.NE.0.0.AND.XTL.NE.0.0) GO TO 20
      CALL FINDTL(L,TYPE,RTL,XTL)
20    ZLINE=CMPLX(L*RTL,L*XTL)
      ZL2=ZLINE
C **
C **  SET UP ZL2 TO REFLECT POSITICN OF FAULT
C **
      IF(IPOS.GT.0) GO TO 35
      ZLINE=CMPLX(0.0,CX1)
      GO TO 25
35    IF(IPOS.EQ.9) IPOS=IPOS+1
      RLEN=FLOAT(IPOS)/10.
      ZLINE=RLEN*ZLINE
      ZL2=ZL2-ZLINE
      ZLINE=ZLINE+CMPLX(0.0,CX1)
C **
```

```
C **  ADD THE FAULTED COMPONENT OF ZL2 TO THE LOAD IN SERIES
C **
25    ZNACJ=ZLINE+ZNACJ
      ZTOT=1.0/(YPWR+1.0/(ZNACJ+ZL2))
C **
C **  GET ZL1  TRANSMISSION LINE
C **
      READ 4000,L,TYPE,RTL,XTL
      IF(RTL.NE.0.0.AND.XTL.NE.0.0) GO TO 30
      CALL FINDTL(L,TYPE,RTL,XTL)
30    ZTOT=ZTOT+CMPLX(L*RTL,L*XTL)
      ZL1=CMPLX(L*RTL,L*XTL)
C **
C **  READ TRANSFORMER DATA
C **
      READ 4000,VLL,VA
      ZT=((VLL*VLL)/VA)*CMPLX(.01,.1)
      ZL1=ZL1+ZT
      IP=IP+IPNACJ
      ZTOT=ZTOT+ZT
C **
C **  CALCULATE EA1
C **
      EA1=IP*ZTOT
      RETURN
200   PRINT 425
425   FORMAT(' ERROR ----> NO LOADS SPECIFIED FOR FAULT ')
      RETURN 1
4000  FORMAT(2(10X,F10.2),2(10X,F10.9))
4001  FORMAT(4(10X,F10.2))
      END
```

```
      SUBROUTINE GAUSS(A,N,K,ISOL)
C     ******************************************************************
C     **                                                              **
C     **                    SUBROUTINE GAUSS                          **
C     **                                                              **
C     **              SOLUTION OF COMPLEX MATRICES                    **
C     **                                                              **
C     **               BY GAUSS JORDAN REDUCTION                      **
C     **                                                              **
C     ******************************************************************
      DIMENSION A(N,K),IS(8)
      COMPLEX A,T
      ISOL=1
      N1=N+1
C **
C **  INITIALIZE THE ARRAY 'IS' WHICH RECORDS THE PIVOTING ROWS
      DO 10 K=1,N
10    IS(K)=K
C **
C **  THE VALUE OF K STANDS FOR THE CURRENT VARIABLE THAT IS BEING
C **  ELIMINATED
      DO 1 K=1,N
      K1=K+1
      BIG=0.0
C **
C **  FIND THE ELEMENT LARGEST IN MAGNITUDE IN THE K'TH COLUMN
C **  BIG WILL HAVE THIS VALUE WHEN THE LOOP EXITS
      DO 2 J=K,N
      ISJ=IS(J)
      TEMP=CABS(A(ISJ,K))
      IF(TEMP.LE.BIG) GO TO 2
C **
C **  BRANCHES TO HERE IF A NEW ELEMENT IS FOUND
      BIG=TEMP
      KBIG=J
2     CONTINUE
C **
C **  IF ALL THE ELEMENTS IN THE K'TH COLUMN ARE ZERO GO TO 20
      IF(BIG.EQ.0) GO TO 20
C **
C **  STORE THE ROW NUMBER THAT WILL BE USED TO ELIMINATE THE K'TH
C **  VARIABLE -- ISK HAS THE VALUE OF THE ROW NUMBER IN WHICH THE
C **  ELEMENT LARGEST IN MAGNITUDE IS FOUND
      ISK=IS(KBIG)
      IS(KBIG)=IS(K)
      IS(K)=ISK
      T=A(ISK,K)
C **  NOW DIVIDE THE PIVOT ROW BY THE PIVOT ELEMENT
      DO 3 J=K1,N1
3     A(ISK,J)=A(ISK,J)/T
C **
C **  ELIMINATE THE VARIABLE X(K) FROM EVERY ROW EXCEPT THE PIVOT ROW
      DO 4 I=1,N
```

```
      IF(I.EQ.ISK) GO TO 4
      T=A(I,K)
      DO 5 J=K1,N1
5     A(I,J)=A(I,J)-T*A(ISK,J)
4     CONTINUE
1     CONTINUE
C **
C **  START REARRANGING THE SOLUTION IN THE N+1 ' TH COLUMN
      NM1=N-1
      DO 6 K=1,NM1
C **
C **  THE VARIABLE X(K) IS PLACED IN THE POSITION A(K,N+1)
      ISK=IS(K)
      T=A(K,N1)
      A(K,N1)=A(ISK,N1)
      A(ISK,N1)=T
C **
C **  UPDATE 'IS' VECTOR TO RECORD THE INTERCHANGE OF ROWS
      DO 7 J=K,N
      IF(K.EQ.IS(J)) GO TO 8
7     CONTINUE
8     IS(J)=IS(K)
6     CONTINUE
C **
C **  AFTER LOOP IS DONE NORMAL RETURN
      RETURN
C **
C **  ERROR  MATRIX IS NOT SOLVABLE
20    ISOL=0
      RETURN
      END
```

```
      SUBROUTINE MXLOD1
C     ******************************************************************************
C     **                                                                          **
C     **                       SUBROUTINE MXLOD1                                  **
C     **                                                                          **
C     **              CALCULATION OF LINE TO GROUND FAULT                         **
C     **                                                                          **
C     ******************************************************************************
      COMMON /LOD001/ YPWR,IP,NACJ
      COMMON /LOD005/ ZNACJ,ZL2,ZL1,EA1,ZT
      COMPLEX YPWR,IP,ZNACJ,ZL2,ZL1,EA1,ARRAY(5,6),ZG,ZE1,ZE2,
     1 IA1,IA0,IA2,A,A2,PPS,PNS,PZS,EA,EB,EC
      COMPLEX LIST(7),ZT
      REAL IA,IB,IC,IF
      REAL ANGL(7)
C  **
C  **  READ THE GROUND RESISTOR
C  **
      READ 1000,ZG
      PRINT 1003,ZG
      ZE1=1./YPWR
      ZE2=.2*ZE1
C  **
C  **  CLEAR OUT THE ARRAY
C  **
      DO 1 I=1,5
      DO 1 J=1,6
1     ARRAY(I,J)=(0.0,0.0)
C  **
C  **  LOAD THE MATRIX
C  **
      ARRAY(1,1)=-1.*ZL1
      ARRAY(1,2)=ARRAY(1,1)
      ARRAY(1,3)=-1.*ZL2
      ARRAY(1,4)=ARRAY(1,3)
      ARRAY(1,5)=3.*(ZL1+ZL2+ZG)
      ARRAY(1,6)=-1.*EA1
      ARRAY(2,1)=ZL1+ZE1
      ARRAY(2,3)=-1.*ZE1
      ARRAY(2,5)=ARRAY(1,1)
      ARRAY(2,6)=EA1
      ARRAY(3,1)=ARRAY(2,3)
      ARRAY(3,3)=ZNACJ+ZL2+ZE1
      ARRAY(3,5)=ARRAY(1,3)
      ARRAY(4,2)=ZL1+ZE2
      ARRAY(4,4)=-1.*ZE2
      ARRAY(4,5)=ARRAY(2,5)
      ARRAY(5,2)=ARRAY(4,4)
      ARRAY(5,4)=ZE2+ZL2+.2*ZNACJ
      ARRAY(5,5)=ARRAY(3,5)
C  **
C  **  CALL THE MATRIX SOLUTION ROUTINE
C  **
```

```
      I1=5
      I2=6
      CALL GAUSS(ARRAY,I1,I2,ISOL)
C **
C **  DID WE GET A SOLUTICN ?
C **
      IF(ISOL.EQ.0) GO TC 30
C **
C **  IF SO THEN CALCULATE THE LINE CURRENTS AND THE LINE TO LINE
C **  VOLTAGES
C **
      IA1=ARRAY(1,6)-ARRAY(5,6)
      IA2=ARRAY(2,6)-ARRAY(5,6)
      IA0=-1.*ARRAY(5,6)
      A=CMPLX(-.5,SQRT(3.)/2.)
      A2=CMPLX(-.5,-1.*SQRT(3.)/2.)
      LIST(4)=IA1+IA2+IA0
      LIST(5)=IA0+A2*IA1+A*IA2
      LIST(6)=IA0+A2*IA2+A*IA1
      IA=CABS(LIST(4))
      IB=CABS(LIST(5))
      IC=CABS(LIST(6))
      LIST(7)=-3.*ARRAY(5,6)
      PPS=EA1-(IA1*ZT)
      PNS=-1.*(IA2*ZT)
      PZS=-1.*(IA0*ZT)
      EA=PPS+PNS+PZS
      EB=PZS+A2*PPS+A*PNS
      EC=PZS+A*PPS+A2*PNS
      LIST(1)=EC-EB
      LIST(2)=EA-EC
      LIST(3)=EB-EA
      EA$=CABS(LIST(1))
      EB$=CABS(LIST(2))
      EC$=CABS(LIST(3))
      IF=CABS(LIST(7))
      CNST=180./3.1415
C **
C **  CONVERT ANGLES TO PROPER QUADRANT
C **
      DO 7 I=1,7
      ANGL(I)=ATAN(AIMAG(LIST(I))/REAL(LIST(I)))*CNST
      IF(REAL(LIST(I)).GE.0..AND.AIMAG(LIST(I)).GE.0.) GO TO 7
      IF(REAL(LIST(I)).GE.0..AND.AIMAG(LIST(I)).LT.0.) ANGL(I)=ANGL(I)+3
     -60.
      IF(REAL(LIST(I)).LT.0.) ANGL(I)=ANGL(I)+180.
7     CONTINUE
C **
C **  PRINT INFORMATICN CN FAULT
C **
      PRINT 2000
      PRINT 3000,LIST(1),EA$,ANGL(1),LIST(2),EB$,ANGL(2),LIST(3),EC$,ANG
     -L(3),LIST(4),IA,ANGL(4),LIST(5),IB,ANGL(5),LIST(6),IC,ANGL(6),
```

```
     - LIST(7),IF,ANGL(7)
2000  FORMAT(/////////,' ',T54,'FAULTED PANEL PARAMETERS',/,'+',T54,'____
     1_____________________',/,'0',' LINE TO LINE VOLTAGES AND LINE CURR
     1NTS')
3000  FORMAT('0',T19,'REAL',9X,'REACTIVE',6X,'MAGNITUDE',7X,'ANGLE',/,'
     1VOLTAGES (VOLTS)',/,'0','E  B TO C =',1X,3(F10.3,5X),2X,F6.2,/,'0'
     1,'E  C TO A =',1X,3(F10.3,5X),2X,F6.2,/,'0','E  A TO B =',1X,3(F1
     1.3,5X),2X,F6.2,/,'0','CURRENT (AMPS)',/,'0IA =' ,8X,3(F10.3,5X),
     1X,F6.2,/,'0','IB =',8X,3(F10.3,5X),2X,F6.2,/,'0','IC =',8X,3(F10.
     1,5X),2X,F6.2,/,'0','FAULT CURRENT',/,'0','IF =',8X,3(F10.3,5X),2X,
     1F6.2)
      RETURN
30    PRINT 2001
2001  FORMAT(' NO SOLUTION IN GAUSS ELIMINATION, ONE OR MORE COLUMNS AL
     1 ZERO')
1000  FORMAT(2(10X,F10.2))
1003  FORMAT(//,' FAULT IMPEDANCE = ',F10.2,2X,F10.2,' * J')
      RETURN
      END
```

```
      SUBROUTINE MXLOD2
C     ******************************************************************
C     **                                                              **
C     **                     SUBROUTINE MXLOD2                        **
C     **                                                              **
C     **          CALCULATION OF TWO LINES TO GROUND                  **
C     **                                                              **
C     ******************************************************************
      COMMON/LOD001/ YPWR,IP,NACJ
      COMMON/LOD005/ ZNACJ,ZL2,ZL1,EA1,ZT
      COMPLEX ARRAY(6,7),YPWR,IP,ZNACJ,ZL2,ZL1,EA1,ZG,ZE1,ZE2,IA1,IA0,IA
     -0,A,A2,PPS,PNS,PZS,EA,EB,EC,LIST(7),ZF,ZT
      REAL ANGL(7)
      REAL IA,IB,IC,IF
      ZE1=1.0/YPWR
      ZE2=.2*ZE1
C **
C **  READ THE FAULT RESISTANCE AND THE GROUND RESISTOR
C **
      READ 1000,ZG,ZF
      PRINT 1003,ZG,ZF
      ZF=ZF/2.
C **
C **  CLEAR OUT THE ARRAY
C **
      DO 1 I=1,6
      DO 1 J=1,7
1     ARRAY(I,J)=(0.0,0.0)
C **
C **  LOAD THE MATRIX
C **
      ARRAY(1,1)=ZL1+ZE1
      ARRAY(1,3)=-1.*ZE1
      ARRAY(1,7)=EA1
      ARRAY(2,1)=-1.*ZE1
      ARRAY(2,3)=ZL2+ZNACJ+ZE1
      ARRAY(2,5)=-1.*ZNACJ
      ARRAY(3,2)=-1.*ZL1
      ARRAY(3,3)=-1.*ZNACJ
      ARRAY(3,4)=-1.*ZL2
      ARRAY(3,5)=2.*ZF+ZL2+ZL1+ZNACJ
      ARRAY(3,6)=-1.*ZF
      ARRAY(4,2)=ZL1+ZE2
      ARRAY(4,4)=-1.*ZE2
      ARRAY(4,5)=-1.*ZL1
      ARRAY(5,2)=-1.*ZE2
      ARRAY(5,4)=ZL2+.2*ZNACJ+ZE2
      ARRAY(5,5)=-1.*ZL2
      ARRAY(5,6)=-.2*ZNACJ
      ARRAY(6,4)=-.2*ZNACJ
      ARRAY(6,5)=-1.*ZF
      ARRAY(6,6)=2.*ZF+3.*ZG+ZL2+ZL1+.2*ZNACJ
C **
```

```
C **  CALL THE MATRIX SOLUTICN ROUTINE
C **
      I1=6
      I2=7
      CALL GAUSS(ARRAY,I1,I2,ISOL)
C **
C **  DID WE GET A SOLUTICN ?
C **
      IF(ISOL.EQ.0) GO TO 30
C **
C **  IF SO THEN CALCULATE THE LINE CURRENTS ANC THE LINE TO LINE
C **  VOLTAGES
C **
      A=CMPLX(-.5,SQRT(3.)/2.)
      A2=CMPLX(-.5,-1*SQRT(3.)/2.)
      IA1=ARRAY(1,7)
      IA2=ARRAY(2,7)-ARRAY(5,7)
      IA0=ARRAY(6,7)*(-1.)
      LIST(4)=IA1+IA2+IA0
      LIST(5)=IA0+A2*IA1+A*IA2
      LIST(6)=IA0+A2*IA2+A*IA1
      IA=CABS(LIST(4))
      IB=CABS(LIST(5))
      IC=CABS(LIST(6))
      LIST(7)=3.*ARRAY(6,7)
      IF=CABS(LIST(7))
      PPS=FA1-(IA1*ZT)
      PNS=-1.*(IA2*ZT)
      PZS=-1.*(IA0*ZT)
      EA=PPS+PNS+PZS
      EB=PZS+A2*PPS+A*PNS
      EC=PZS+A*PPS+A2*PNS
      LIST(1)=EC-EB
      LIST(2)=EA-EC
      LIST(3)=EB-EA
      EA$=CABS(LIST(1))
      EB$=CABS(LIST(2))
      EC$=CABS(LIST(3))
      CNST=180./3.1415
C **
C **  PUT ANGLES IN PROPER QUACRANTS
C **
      DO 7 I=1,7
      ANGL(I)=ATAN(AIMAG(LIST(I))/REAL(LIST(I)))*CNST
      IF(REAL(LIST(I)).GE.0..AND.AIMAG(LIST(I)).GE.0.) GO TO 7
      IF(REAL(LIST(I)).GE.0..AND.AIMAG(LIST(I)).LT.0.) ANGL(I)=ANGL(I)+3
     -60.
      IF(REAL(LIST(I)).LT.0.) ANGL(I)=ANGL(I)+180.
7     CONTINUE
C **
C **  PRINT THE FAULT INFORMATICN
C **
      PRINT 2000
```

```
      PRINT 3000,LIST(1),FA$,ANGL(1),LIST(2),EB$,ANGL(2),LIST(3),EC$,ANG
     -L(3),LIST(4),IA,ANGL(4),LIST(5),IB,ANGL(5),LIST(6),IC,ANGL(6),
     - LIST(7),IF,ANGL(7)
2000  FORMAT(/////////,' ',T54,'FAULTED PANEL PARAMETERS',/,'+',T54,'____
     1_________________________',/,'0',' LINE TO LINE VOLTAGES AND LINE CURRE
     1NTS')
3000  FORMAT('0',T19,'REAL',9X,'REACTIVE',6X,'MAGNITUDE',7X,'ANGLE',/,'0
     1VOLTAGES (VOLTS)',/,'0','E  B TO C =',1X,3(F10.3,5X),2X,F6.2,/,'0'
     1,'E  C TO A =',1X,3(F10.3,5X),2X,F6.2,/,'0','E  A TO B =',1X,3(F10
     1.3,5X),2X,F6.2,/,'0','CURRENT (AMPS)',/,'0IA =',  8X,3(F10.3,5X),2
     1X,F6.2,/,'0','IB =',8X,3(F10.3,5X),2X,F6.2,/,'0','IC =',8X,3(F10.3
     1,5X),2X,F6.2,/,'0','FAULT CURRENT',/,'0','IF =',8X,3(F10.3,5X),2X,
     1F6.2)
      RETURN
30    PRINT 35
35    FORMAT(' NO SOLUTION IN GAUSS ELIMINATION, ONE OR MORE COLUMNS ARE
     - ALL ZERO')
1000  FORMAT(4(10X,F10.2))
1003  FORMAT(//,' FAULT IMPEDANCE (LINE TO GRND) = ',F10.2,2X,F10.2,' *
     1 J',5X,'FAULT IMPEDANCE (LINE TO LINE) = ',F10.2,2X,F10.2,' * J')
      RETURN
      END
```

```
      SUBROUTINE MXLOD3
C     ******************************************************************************
C     **                                                                          **
C     **                        SUBROUTINE MXLOD3                                 **
C     **                                                                          **
C     **              CALCULATION OF LINE TO LINE FAULT                           **
C     **                                                                          **
C     ******************************************************************************
      COMMON /LOD001/ YPWR,IP,NACJ
      COMMON /LOD005/ ZNACJ,ZL2,ZL1,EA1,ZT
      COMPLEX ARRAY(5,6),YPWR,IP,ZNACJ,ZL2,ZL1,EA1,ZF,ZE1,ZE2,IA1,IA2,I
     -0,A,A2,PPS,PNS,PZS,EA,EB,EC,LIST(7),ZT
      REAL IA,IB,IC,IF
      REAL ANGL(7)
      ZE1=1.0/YPWR
      ZE2=.2*ZE1
C **
C **  READ THE FAULT RESISTANCE
C **
      READ 1000,ZF
      PRINT 1003,ZF
C **
C **  CLEAR OUT THE ARRAY
C **
      DO 1 I=1,5
      DO 1 J=1,6
1     ARRAY(I,J)=(0.0,0.0)
C **
C **  LOAD THE MATRIX
C **
      ARRAY(1,1)=ZL1+ZE1
      ARRAY(1,3)=-1.*ZE1
      ARRAY(1,5)=-1.*ZL1
      ARRAY(1,6)=EA1
      ARRAY(2,1)=-1.*ZE1
      ARRAY(2,3)=ZE1+ZL2+ZNACJ
      ARRAY(2,5)=-1.*ZL2
      ARRAY(3,2)=ZL1+ZE2
      ARRAY(3,4)=-1.*ZE2
      ARRAY(4,2)=-1.*ZE2
      ARRAY(4,4)=ZE2+ZL2+ZNACJ*.2
      ARRAY(4,5)=-.2*ZNACJ
      ARRAY(5,1)=-1.*ZL1
      ARRAY(5,3)=-1.*ZL2
      ARRAY(5,4)=-.2*ZNACJ
      ARRAY(5,5)=ZNACJ*.2+ZF+ZL2+ZL1
      ARRAY(5,6)=-1.*EA1
C **
C **  CALL THE MATRIX SOLUTION ROUTINE
C **
      I1=5
      I2=6
      CALL GAUSS(ARRAY,I1,I2,ISCL)
```

```
C **
C **  DID WE GET A SOLUTICN ?
C **
      IF(ISOL.EQ.0) GO TO 30
C **
C **  IF SO THEN CALCULATE THE LINE CURRENTS AND THE LINE TO LINE
C **  VOLTAGES
C **
      IA1=ARRAY(1,6)-ARRAY(5,6)
      IA2=ARRAY(2,6)
      IA0=(C.0,0.0)
      A=CMPLX(-.5,SQRT(3.)/2.)
      A2=CMPLX(-.5,-1.*SQRT(3.)/2.)
      LIST(4)=IA1+IA2+IA0
      LIST(5)=IA0+A2*IA1+A*IA2
      LIST(6)=IA0+A2*IA2+A*IA1
      LIST(7)=-1.*ARRAY(5,6)
      IF=CABS(LIST(7))
      IA=CABS(LIST(4))
      IB=CABS(LIST(5))
      IC=CABS(LIST(6))
      PPS=EA1-(IA1*ZT)
      PNS=-1.*(IA2*ZT)
      PZS=(C.C,0.0)
      EA=PPS+PNS+PZS
      EB=PZS+A2*PPS+A*PNS
      EC=PZS+A*PPS+A2*PNS
      LIST(1)=EC-EB
      LIST(2)=EA-EC
      LIST(3)=EB-EA
      EA$=CABS(LIST(1))
      EB$=CABS(LIST(2))
      EC$=CABS(LIST(3))
C **
C **  CONVERT ANGLES TO PROPER QUADRANT
C **
      CNST=180./3.1415
      DO 7 I=1,7
      ANGL(I)=ATAN(AIMAG(LIST(I))/REAL(LIST(I)))*CNST
      IF(REAL(LIST(I)).GE.0..AND.AIMAG(LIST(I)).GE.0.) GO TO 7
      IF(REAL(LIST(I)).GE.0..AND.AIMAG(LIST(I)).LT.0.) ANGL(I)=ANGL(I)+3
     -60.
      IF(REAL(LIST(I)).LT.0.) ANGL(I)=ANGL(I)+180.
7     CONTINUE
C **
C **  PRINT THE FAULT INFORMATICN
C **
      PRINT 2000
      PRINT 3000,LIST(1),EA$,ANGL(1),LIST(2),EB$,ANGL(2),LIST(3),EC$,ANG
     -L(3),LIST(4),IA,ANGL(4),LIST(5),IB,ANGL(5),LIST(6),IC,ANGL(6),
     - LIST(7),IF,ANGL(7)
2000  FORMAT(////////,' ',T54,'FAULTED PANEL PARAMETERS',/,'+',T54,'____
     1_________________________',/,'0',' LINE TC LINE VCLTAGES AND LINE CU
```

```
     1NTS')
3000  FORMAT('0',T19,'REAL',9X,'REACTIVE',6X,'MAGNITUDE',7X,'ANGLE',/,'0
     1VOLTAGES (VOLTS)',/,'0','E   B TO C =',1X,3(F10.3,5X),2X,F6.2,/,'0'
     1,'E   C TO A  =',1X,3(F10.3,5X),2X,F6.2,/,'0','E   A TO B =',1X,3(F10
     1.3,5X),2X,F6.2,/,'0','CURRENT (AMPS)',/,'0IA =',  8X,3(F10.3,5X),2
     1X,F6.2,/,'0','IB  =',8X,3(F10.3,5X),2X,F6.2,/,'0',' IC =',8X,3(F10.3
     1,5X),2X,F6.2,/,'0','FAULT CURRENT',/,'0','IF =',8X,3(F10.3,5X),2X,
     1F6.2)
      RETURN
30    PRINT 2001
2001  FORMAT(' NO SOLUTION IN GAUSS ELIMINATION, ONE OR MORE COLUMNS ARE
     1 ALL ZERO')
      RETURN
1000  FORMAT(50X,F10.2,10X,F10.2)
1003  FORMAT(//,' FAULT IMPEDANCE = ',F10.2,2X,F10.2,' * J')
      END
```

```
      SUBROUTINE MXLOD4
C     ******************************************************************
C     **                                                              **
C     **                    SUBROUTINE MXLOD4                         **
C     **                                                              **
C     **              SOLUTION OF THREE PHASE FAULTS                  **
C     **                                                              **
C     ******************************************************************
      COMPLEX YPWR,IP,NACJ,ZF,ZNACJ,IPNACJ,ZL1,ZL2,IF,E,ZTOT,ZE
      COMPLEX IPLL,FABC,ITCT,ZP
      REAL VMAG,IMAG,IFMAG,L,TYPE,RTL,XTL
      COMMON /LOD001/ YPWR,IP,NACJ
      COMMON /LOD004/ IPOS
C **
C **  CALCULATE THE PARALLEL LOADS BY CALLING ACLODS
C **
      CALL ACLODS(&200,1)
      ZE=1.0/YPWR
C **
C **  READ THE LAST LOAD
C **
      READ 4001,ACP,ACV,THETA,ACPF
C **
C **  CALCULATE THETA AND GET POWER FACTOR CORRECTIONAL COMPONENTS
C **
      IF(ACPF) 10,11,10
 10   THETA=ARCOS(ACPF)
 11   CALL PFCC(CX1,CX2)
      ACV=ACV/1.73205
      ACP=ACP/3.0
      ZNACJ=CMPLX((ACV**2.)*(COS(THETA)**2.)/ACP,(ACV**2.)*COS(THETA)*SI
     -N(THETA)/ACP)
      ZNACJ=1.0/(1.0/ZNACJ+CMPLX(0.0,-1.0/CX2))
      IPNACJ=ACV/ZNACJ
C **
C **  GET TRANSMISSION LINE
C **
      READ 4000,L,TYPE,RTL,XTL
      IF(RTL.NE.0.0.AND.XTL.NE.0.0) GO TO 20
      CALL FINDTL(L,TYPE,RTL,XTL)
 20   ZL2=CMPLX(L*RTL,L*XTL)
C **
C **  SET UP ZL2 TO REFLECT THE POSITION OF THE FAULT
C **
      IF(IPOS.EQ.0) GO TO 25
      IF(IPOS.EQ.9) IPOS=IPOS+1
      RLEN=FLOAT(IPOS)/10.
      ZNACJ=ZNACJ+(RLEN*ZL2)
      ZL2=ZL2-(RLEN*ZL2)
C **
C **  GET ZL1 TRANSMISSION LINE
C **
 25   READ 4000,L,TYPE,RTL,XTL
```

```
      ZNACJ=ZNACJ+CMPLX(0.0,CX1)
      IF(RTL.NE.0.0.AND.XTL.NE.0.0) GO TO 30
      CALL FINDTL(L,TYPE,RTL,XTL)
30    ZL1=CMPLX(L*RTL,L*XTL)
C **
C **  READ THE FAULT IMPEDANCE -- ZF
C **
      READ 4000,ZF
C **
C **  CALCULATE THE FAULT
C **
      ZP=ZF*ZNACJ/(ZNACJ+ZF)
      IPLL=IPNACJ*(ZF+ZNACJ)/ZF
      IF=(IPLL*ZNACJ)/(ZNACJ+ZF)
      ZP=ZP+ZL2
      ZTOT=(ZE*ZP)/(ZP+ZE)
      ITOT=IPLL*(ZP+ZE)/ZE
      ZTOT=ZTOT+ZL1
      E=ZTOT*ITOT
C **
C **  CALCULATE THE PARAMETERS FOR OUTPUT
C **
      EABC=E*CMPLX(1.5,.86602)
      VMAG=CABS(EABC)
      IFMAG=CABS(IF)
      IMAG=CABS(ITOT)
      PRINT 5000,ZF
      PRINT 5001,EABC,VMAG,ITOT,IMAG,IF,IFMAG
      RETURN
200   PRINT 4002
4002  FORMAT(' ERROR -----> NO LOADS SPECIFIED FOR FAULT')
      RETURN
5000  FORMAT(/////,' FAULT IMPEDANCE = ',F10.2,2X,F10.2,' * J')
5001  FORMAT(////////,' ',T54,'FAULTED PANEL PARAMETERS',/,'+',T54,'____
     1_________________________',/,'0',' LINE TO LINE VOLTAGES AND LINE CURR
     1NTS',/,'0',T19,'REAL',9X,'REACTIVE',6X,'MAGNITUDE',/,'0','VOLTAGE
     1(VOLTS)',/,'0E  B TO C =',1X,3(F10.3,5X),/,'0NOTE:  BALANCED SYST
     1M, E  A TO B AND E  C TO A EQUAL TO ABOVE VALUE',/,'0CURRENT (AMPS
     1)',/,'0IA =',8X,3(F10.3,5X),/,'0NOTE:  BALANCED SYSTEM, IB AND IC
     1EQUAL TO ABOVE VALUE',/,'0FAULT CURRENT',/,'0IF =',8X,3(F10.3,5X))
4000  FORMAT(2(10X,F10.2),2(10X,F10.9))
4001  FORMAT(4(10X,F10.2))
      END
```

APPENDIX VII

STRIP CHART SOFTWARE

APPENDIX VII - STRIP CHART SOFTWARE

General

The program to analyze strip chart recordings with the Hewlett-Packard 9810A calculator consists of three main sections: data input, individual time study output, and final output. Each of these sections will be discussed first in general terms followed by an example of input-output format information. The complete calculator program listing concludes the appendix.

Data Input Section

Data input is inclusive of steps 0000 to 0591 of the program, and the actual machine operations begin with clearing the data storage registers and printing the title and operational instructions. A printout follows to request which power parameter (power, current, voltage, and power factor) and horizontal and vertical scales are represented by the strip chart. The calculator then hesitates for the operator to assign a maximum of time study designations to the numbers zero through nine. After the first time study number is entered into the calculator, data are requested by way of the curve digitizer (cursor).

Data are received by the calculator in sets of two. Each set is used to define a line equation, and the programming enters information from the equation in storage registers (in statistical form) by using 0.01 inch increments of the time (horizontal) axis. The cursor can dititize a curve 99.99 inches horizontally or vertically. To avoid the restriction, a routine is contained to upgrade the horizontal axis each time the maximum range is reached. At the end of digitizing all important points on a particular time study event, the calculator is manually stopped and directed to go to the second main section.

Individual Time Study Output

The second section is primarily a statistical printout and inclusive of programming steps 0592 to 1006. The output is as follows:

1. output number, time study type number, and a count of the number of this particular time study type output

2. statistical mean, standard deviation, maximum, and minimum of the digitized curve

3. event time and the number of digitized points

4. the kilowatt-hours used if applicable.

After the information is printed, the calculator ceases operation. If more data (for a different time study type) are to be entered, the operator simply addresses the machine to continue, and the next time study number is requested (a return to the first major section). If the digitization process is to be terminated (end of a chart), the operator sets a flag, and the calculator proceeds to the third major section.

Final Output

Steps 1007 through 1658 contain the final output programming which is again a printout section. The initial output of the routing is for the complete strip chart curve and contains:

1. power parameter type

2. statistical mean, standard deviation, maximum, and minimum

3. total chart time

4. total kilowatt-hours used (if applicable).

Following the above output, a directed "do-loop" is employed to obtain the average single variable statistics for each time study type. If a time study number is not used, a statement is printed accordingly.

Input-Output Information

Contained on the following (two) pages is an example of the actual printout of the Hewlett-Packard 9810A utilizing the software just described for an hypothetical situation. The vertical and horizontal scales are both one inch/inch, and two points, (0,0) and (2,2), are digitized under the time study number "3." The calculator has been directed to go to the final output immediately after the first individual time study output.

Calculator Software

The complete program listing is presented immediately after the foregoing example. Power Factor analysis within the program is for linear vertical scale charts. However, the strip charts used for this power parameter have a logarithmic scale.

```
MINER ANALYSIS

RECT CHARTS
RIGHT TO LEFT
ONLY

ENTER
TIME→Y
VERT→X
           1.0000
           1.0000

ENTER
AMPS=0
VOLTS=1
KW=2
PF=3

             2.*

DEFINE T S # 0-9

SELECT
TIME STUDY
              3.*

DIGITIZE

END OF DATA?
PRESS
STOP
GTO LBL 1

IND TIME STUDY
OUTPUT #
              1.00

TYPE #
              3.00

SERIES #
              1.00

MEAN
STAN DEV
YMAX
YMIN

              1.00
              0.58
              2.00
              0.00

CYCLE TIME
              2.00
DIGITIZED PTS
            200.00

KWH USED
              0.03
```

```
FINAL OUTPUT
KWATTS
TOTAL
MEAN
STAN DEV
YMAX
YMIN
            1.00
            0.58
            2.00
            0.00

TOTAL TIME
            2.00

TOTAL KWH USED
            0.03

AVE STAT OUTPUT
FOR EACH T.S.
TYPE

NO DATA
T.S. TYPE
            0.

NO DATA
T.S. TYPE
            1.

NO DATA
T.S. TYPE
            2.

T.S. TYPE
            3.

NO OF CYCLES
            1.00
AVE MEAN
            1.00
AVE STAN DEV
            0.58
AVE YMAX
            2.00
AVE YMIN
            0.00
AVE TIME
            2.00

NO DATA
T.S. TYPE
            4.

NO DATA
T.S. TYPE
            5.

NO DATA
T.S. TYPE
            6.

NO DATA
T.S. TYPE
            7.

NO DATA
T.S. TYPE
            8.

NO DATA
T.S. TYPE
            9.

END
```

```
0000--CLR---20
0001-- K ---55
0002-- 3 ---03
0003--CLX---37
0004-- UP---27
0005--YTO---40
0006--IND---31
0007-- a ---13
0008-- 1 ---01
0009--XTO---23
0010-- + ---33
0011-- a ---13
0012-- 1 ---01
0013-- 0 ---00
0014-- 7 ---07
0015-- UP---27
0016-- a ---13
0017--X<Y---52
0018-- 0 ---00
0019-- 0 ---00
0020-- 0 ---00
0021-- 3 ---03
0022--FMT---42
0023--FMT---42
0024-- M ---70
0025-- I ---65
0026-- N ---73
0027-- E ---60
0028-- a ---13
0029--CNT---47
0030-- A ---62
0031-- N ---73
0032-- A ---62
0033-- L ---72
0034--XFR---67
0035--YTO---40
0036-- I ---65
0037--YTO---40
0038--CLR---20
0039--CLR---20
0040-- a ---13
0041-- E ---60
0042-- C ---61
0043--XTO---23
0044--CNT---47
0045-- C ---61
0046-- H ---74
0047-- A ---62
0048-- a ---13
0049--XTO---23
0050--YTO---40
0051--CLR---20
0052-- a ---13
0053-- I ---65
0054-- G ---15
0055-- H ---74
0056--XTO---23
0057--CNT---47
0058--XTO---23
0059-- D ---71
0060--CNT---47
0061-- L ---72
0062-- E ---60
0063-- F ---16
0064--XTO---23
0065--CLR---20
0066-- D ---71
0067-- N ---73
0068-- L ---72
0069--XFR---67
0070--CLR---20
0071--CLR---20
0072-- E ---60
0073-- N ---73
0074--XTO---23
0075-- E ---60
0076-- a ---13
0077--CLR---20
0078--XTO---23
0079-- I ---65
0080-- M ---70
0081-- E ---60
0082--EEX---26
0083--XFR---67
0084--CLR---20
0085--INT---64
0086-- E ---60
0087-- a ---13
0088--XTO---23
0089--EEX---26
0090-- YE---24
0091--FMT---42
0092--FMT---42
0093-- 4 ---04
0094-- . ---21
0095-- 0 ---00
0096-- 0 ---00
0097-- . ---21
0098-- 4 ---04
0099--CLR---20
0100--STP---41
0101--XEY---30
0102--PNT---45
0103--XTO---23
0104-- 1 ---01
0105-- 4 ---04
0106--XEY---30
0107--PNT---45
0108--PNT---45
0109--XTO---23
0110-- 1 ---01
0111-- 5 ---05
0112--CLR---20
0113--FMT---42
0114--FMT---42
0115-- E ---60
0116-- N ---73
0117--XTO---23
0118-- E ---60
0119-- a ---13
0120--CLR---20
0121-- A ---62
0122-- M ---70
0123-- π ---56
0124--YTO---40
0125--SFL---54
0126-- 0 ---00
0127--CLR---20
0128--INT---64
0129-- D ---71
0130-- L ---72
0131--XTO---23
0132--YTO---40
0133--SFL---54
0134-- 1 ---01
0135--CLR---20
0136-- K ---55
0137--IND---31
0138--SFL---54
0139-- 2 ---02
0140--CLR---20
0141-- π ---56
0142-- F ---16
0143--SFL---54
0144-- 3 ---03
0145--FMT---42
0146--FMT---42
0147-- 4 ---04
0148-- . ---21
0149-- 0 ---00
```

```
0150-- 0 ---00
0151-- . ---21
0152-- 0 ---00
0153--STP---41
0154--PNT---45
0155--PNT---45
0156--XTO---23
0157-- 1 ---01
0158-- 6 ---06
0159--CLX---37
0160--FMT---42
0161--FMT---42
0162-- D ---63
0163-- E ---60
0164-- F ---16
0165-- I ---65
0166-- N ---73
0167-- E ---60
0168--CNT---47
0169--XTO---23
0170--CNT---47
0171--YTO---40
0172--CNT---47
0173--GTO---44
0174--CNT---47
0175-- 0 ---00
0176-- - ---34
0177-- 9 ---11
0178--FMT---42
0179-- A ---62
0180-- O ---71
0181-- A ---62
0182-- N ---73
0183--GTO---44
0184--S/R---77
0185--LBL---51
0186-- A ---62
0187--FMT---42
0188-- 4 ---04
0189-- . ---21
0190-- 0 ---00
0191-- 0 ---00
0192-- . ---21
0193-- 2 ---02
0194--CNT---47
0195--CNT---47
0196-- 0 ---00
0197--XTO---23
0198-- 9 ---11
0199-- 0 ---00
0200--CLX---37
0201-- 5 ---05
0202-- 0 ---00
0203--XTO---23
0204-- 9 ---11
0205-- 1 ---01
0206--CLX---37
0207-- 6 ---06
0208-- 0 ---00
0209--XTO---23
0210-- 9 ---11
0211-- 2 ---02
0212--CLX---37
0213-- 7 ---07
0214-- 0 ---00
0215--XTO---23
0216-- 9 ---11
0217-- 3 ---03
0218--CLX---37
0219-- 8 ---10
0220-- 0 ---00
0221--XTO---23
0222-- 9 ---11
0223-- 4 ---04
0224--CLX---37
0225--XTO---23
0226-- 9 ---11
0227-- 5 ---05
0228--CLX---37
0229-- 9 ---11
0230-- 9 ---11
0231-- . ---21
0232-- 9 ---11
0233-- 0 ---00
0234--XTO---23
0235-- 9 ---11
0236-- 6 ---06
0237--CLX---37
0238--FMT---42
0239--FMT---42
0240-- D ---63
0241-- I ---65
0242-- G ---15
0243-- I ---65
0244--XTO---23
0245-- I ---65
0246--XSQ---12
0247-- E ---60
0248--CLR---20
0249--CLR---20
0250-- E ---60
0251-- N ---73
0252-- D ---63
0253--CNT---47
0254-- O ---71
0255-- F ---16
0256--CNT---47
0257-- D ---63
0258-- A ---62
0259--XTO---23
0260-- A ---62
0261--IFG---43
0262--CLR---20
0263-- π ---56
0264-- a ---13
0265-- E ---60
0266--YTO---40
0267--YTO---40
0268--CLR---20
0269--YTO---40
0270--XTO---23
0271-- O ---71
0272-- π ---56
0273--CLR---20
0274-- G ---15
0275--XTO---23
0276-- O ---71
0277--CNT---47
0278-- L ---72
0279-- B ---66
0280-- L ---72
0281--CNT---47
0282-- 1 ---01
0283--FMT---42
0284--FMT---42
0285-- 4 ---04
0286-- 9 ---11
0287--PNT---45
0288--CLX---37
0289-- UP---27
0290-- UP---27
0291--FMT---42
0292-- 3 ---03
0293-- 9 ---11
0294-- . ---21
0295--CHS---32
0296-- UP---27
0297-- DN---25
0298--PSE---57
0299--XTO---23
```

```
0300-- 1 ---01
0301-- 0 ---00
0302--YTO---40
0303-- 1 ---01
0304-- 1 ---01
0305--XTO---23
0306-- 2 ---02
0307-- 8 ---10
0308--YTO---40
0309-- 2 ---02
0310-- 9 ---11
0311-- 0 ---71
0312-- N ---73
0313--CNT---47
0314--CLX---37
0315-- UP---27
0316-- UP---27
0317--FMT---42
0318-- 4 ---04
0319-- 9 ---11
0320--PNT---45
0321--FMT---42
0322-- 3 ---03
0323-- 9 ---11
0324-- . ---21
0325--CHS---32
0326-- UP---27
0327--XTO---23
0328-- a ---13
0329--IFG---43
0330-- 0 ---00
0331-- 3 ---03
0332-- 7 ---07
0333-- 9 ---11
0334--XFR---67
0335-- 9 ---11
0336-- 5 ---05
0337--XEY---30
0338-- 1 ---01
0339-- 0 ---00
0340-- 0 ---00
0341-- X ---36
0342-- a ---13
0343-- + ---33
0344--XFR---67
0345-- 9 ---11
0346-- 6 ---06
0347--X<Y---52
0348-- 3 ---03
0349-- 5 ---05
0350-- 7 ---07
0351--CNT---47
0352--GTO---44
0353-- 4 ---04
0354-- 1 ---01
0355-- 3 ---03
0356--CNT---47
0357-- 1 ---01
0358--XTO---23
0359-- + ---33
0360-- 9 ---11
0361-- 5 ---05
0362--CLX---37
0363-- 1 ---01
0364-- 0 ---00
0365-- 0 ---00
0366--XTO---23
0367-- + ---33
0368-- 9 ---11
0369-- 6 ---06
0370-- a ---13
0371--XEY---30
0372--CNT---47
0373--SFL---54
0374--GTO---44
0375-- 4 ---04
0376-- 1 ---01
0377-- 3 ---03
0378--CNT---47
0379-- 5 ---05
0380--X<Y---52
0381-- 4 ---04
0382-- 0 ---00
0383-- 0 ---00
0384--CNT---47
0385--XFR---67
0386-- 9 ---11
0387-- 5 ---05
0388--XEY---30
0389-- 1 ---01
0390-- 0 ---00
0391-- 0 ---00
0392-- X ---36
0393-- a ---13
0394-- + ---33
0395--GTO---44
0396-- 4 ---04
0397-- 1 ---01
0398-- 3 ---03
0399--CNT---47
0400--XFR---67
0401-- 9 ---11
0402-- 5 ---05
0403--XEY---30
0404-- 1 ---01
0405-- - ---34
0406-- 1 ---01
0407-- 0 ---00
0408-- 0 ---00
0409-- X ---36
0410-- a ---13
0411-- + ---33
0412--CNT---47
0413--PSE---57
0414-- DN---25
0415--XTO---23
0416-- a ---13
0417--XTO---23
0418-- 9 ---11
0419-- 8 ---10
0420--YTO---40
0421-- 9 ---11
0422-- 9 ---11
0423--XFR---67
0424-- 2 ---02
0425-- 9 ---11
0426-- - ---34
0427--XFR---67
0428-- 9 ---11
0429-- 8 ---10
0430-- UP---27
0431--XFR---67
0432-- 2 ---02
0433-- 8 ---10
0434-- - ---34
0435--CLX---37
0436--X>Y---53
0437-- 5 ---05
0438-- 4 ---04
0439-- 0 ---00
0440--CNT---47
0441--X=Y---50
0442-- 5 ---05
0443-- 4 ---04
0444-- 0 ---00
0445--CNT---47
0446-- DN---25
0447--DIV---35
0448--YTO---40
0449-- 9 ---11
```

```
0450-- 7 ---07
0451--XFR---67
0452-- 2 ---02
0453-- 8 ---10
0454-- X ---36
0455--XFR---67
0456-- 2 ---02
0457-- 9 ---11
0458--XEY---30
0459-- - ---34
0460--YTO---40
0461-- 1 ---01
0462-- 0 ---00
0463-- 6 ---06
0464--CNT---47
0465-- . ---21
0466-- 0 ---00
0467-- 1 ---01
0468--XTO---23
0469-- + ---33
0470-- 2 ---02
0471-- 8 ---10
0472--XFR---67
0473-- 2 ---02
0474-- 8 ---10
0475-- UP---27
0476--XFR---67
0477-- 9 ---11
0478-- 7 ---07
0479-- X ---36
0480--YTO---40
0481-- + ---33
0482-- 1 ---01
0483-- 0 ---00
0484-- 6 ---06
0485--XFR---67
0486-- 1 ---01
0487-- 0 ---00
0488-- 6 ---06
0489-- UP---27
0490-- UP---27
0491--XFR---67
0492-- 2 ---02
0493-- 8 ---10
0494-- D ---71
0495-- N ---73
0496-- UP---27
0497--XFR---67
0498-- 9 ---11
0499-- 8 ---10
0500--X=Y---50
0501-- 5 ---05
0502-- 2 ---02
0503-- 3 ---03
0504--CNT---47
0505--XFR---67
0506-- 2 ---02
0507-- 8 ---10
0508-- UP---27
0509--XFR---67
0510-- 9 ---11
0511-- 7 ---07
0512-- X ---36
0513--YTO---40
0514-- - ---34
0515-- 1 ---01
0516-- 0 ---00
0517-- 6 ---06
0518--GTO---44
0519-- 4 ---04
0520-- 6 ---06
0521-- 5 ---05
0522--CNT---47
0523--XFR---67
0524-- 9 ---11
0525-- 8 ---10
0526--XTO---23
0527-- 2 ---02
0528-- 8 ---10
0529--XFR---67
0530-- 9 ---11
0531-- 9 ---11
0532--XTO---23
0533-- 2 ---02
0534-- 9 ---11
0535--GTO---44
0536-- 3 ---03
0537-- 1 ---01
0538-- 4 ---04
0539--CNT---47
0540--FMT---42
0541--FMT---42
0542-- E ---60
0543-- a ---13
0544-- a ---13
0545-- D ---71
0546-- a ---13
0547--FMT---42
0548--GTO---44
0549-- 3 ---03
0550-- 1 ---01
0551-- 4 ---04
0552--CNT---47
0553--S/R---77
0554--LBL---51
0555-- A ---62
0556--CLX---37
0557--FMT---42
0558-- 4 ---04
0559-- . ---21
0560-- 0 ---00
0561-- 0 ---00
0562-- . ---21
0563-- 0 ---00
0564--FMT---42
0565--FMT---42
0566--CLR---20
0567--YTO---40
0568-- E ---60
0569-- L ---72
0570-- E ---60
0571-- C ---61
0572--XTO---23
0573--CLR---20
0574--XTO---23
0575-- I ---65
0576-- M ---70
0577-- E ---60
0578--CNT---47
0579--YTO---40
0580--XTO---23
0581--1/X---17
0582-- D ---63
0583--XFR---67
0585--FMT---42
0585--STP---41
0586--PNT---45
0587--PNT---45
0588--XTO---23
0589-- 1 ---01
0590-- 3 ---03
0591--CLX---37
0592--S/R---77
0593--LBL---51
0594-- 1 ---01
0595--FMT---42
0596-- 4 ---04
0597-- 9 ---11
0598--PNT---45
0599--PSE---57
```

```
0600--FMT---42
0601-- 4 ---04
0602-- 9 ---11
0603--PNT---45
0604--FMT---42
0605--FMT---42
0606--CLR---20
0607-- I ---65
0608-- N ---73
0609-- D ---63
0610--CNT---47
0611--XTO---23
0612-- I ---65
0613-- M ---70
0614-- E ---60
0615--CNT---47
0616--YTO---40
0617--XTO---23
0618--1/X---17
0619-- D ---63
0620--XFR---67
0621--CLR---20
0622-- O ---71
0623--1/X---17
0624--XTO---23
0625-- π ---56
0626--1/X---17
0627--XTO---23
0628--CNT---47
0629--GTO---44
0630--FMT---42
0631-- 1 ---01
0632--XTO---23
0633-- + ---33
0634-- 1 ---01
0635-- 7 ---07
0636--XFR---67
0637-- 1 ---01
0638-- 7 ---07
0639--PNT---45
0640--PNT---45
0641--GTO---44
0642--S/R---77
0643--LBL---51
0644-- B ---66
0645--FMT---42
0646--FMT---42
0647-- M ---70
0648-- E ---60
0649-- A ---62
0650-- N ---73
0651--CLR---20
0652--YTO---40
0653--XTO---23
0654-- A ---62
0655-- N ---73
0656--CNT---47
0657-- D ---63
0658-- E ---60
0659--INT---64
0660--CLR---20
0661--XFR---67
0662-- M ---70
0663-- A ---62
0664-- YE---24
0665--CLR---20
0666--XFR---67
0667-- M ---70
0668-- I ---65
0669-- N ---73
0670--FMT---42
0671-- C ---61
0672--XFR---67
0673-- 1 ---01
0674-- 3 ---03
0675--XTO---23
0676-- + ---33
0677-- 9 ---11
0678-- 0 ---00
0679--YTO---40
0680--IND---31
0681-- + ---33
0682-- 9 ---11
0683-- 0 ---00
0684--XTO---23
0685-- - ---34
0686-- 9 ---11
0687-- 0 ---00
0688--XTO---23
0689-- b ---14
0690--XFR---67
0691-- 1 ---01
0692-- 5 ---05
0693-- X ---36
0694--XEY---30
0695--PNT---45
0696--CLX---37
0697-- UP---27
0698-- UP---27
0699-- D ---63
0700-- b ---14
0701--XEY---30
0702-- √ ---76
0703--XEY---30
0704--XTO---23
0705-- + ---33
0706-- 9 ---11
0707-- 1 ---01
0708--YTO---40
0709--IND---31
0710-- + ---33
0711-- 9 ---11
0712-- 1 ---01
0713--XTO---23
0714-- - ---34
0715-- 9 ---11
0716-- 1 ---01
0717--XFR---67
0718-- 1 ---01
0719-- 5 ---05
0720-- X ---36
0721--XEY---30
0722--PNT---45
0723--CLX---37
0724--XFR---67
0725-- 2 ---02
0726-- 4 ---04
0727-- UP---27
0728-- b ---14
0729--XTO---23
0730-- + ---33
0731-- 9 ---11
0732-- 2 ---02
0733--YTO---40
0734--IND---31
0735-- + ---33
0736-- 9 ---11
0737-- 2 ---02
0738--XTO---23
0739-- - ---34
0740-- 9 ---11
0741-- 2 ---02
0742--XFR---67
0743-- 1 ---01
0744-- 5 ---05
0745-- X ---36
0746--XEY---30
0747--PNT---45
0748--CLX---37
0749--XFR---67
```

```
0750--  2 ---02
0751--  3 ---03
0752--  UP---27
0753--  b ---14
0754--XTO---23
0755--  + ---33
0756--  9 ---11
0757--  3 ---03
0758--YTO---40
0759--IND---31
0760--  + ---33
0761--  9 ---11
0762--  3 ---03
0763--XTO---23
0764--  - ---34
0765--  9 ---11
0766--  3 ---03
0767--XFR---67
0768--  1 ---01
0769--  5 ---05
0770--  X ---36
0771--XEY---30
0772--PNT---45
0773--PNT---45
0774--FMT---42
0775--FMT---42
0776--  C ---61
0777--XFR---67
0778--  C ---61
0779--  L ---72
0780--  E ---60
0781--CNT---47
0782--XTO---23
0783--  I ---65
0784--  M ---70
0785--  E ---60
0786--FMT---42
0787--  a ---13
0788--  UP---27
0789--XFR---67
0790--  1 ---01
0791--  0 ---00
0792--  - ---34
0793--XFR---67
0794--  1 ---01
0795--  4 ---04
0796--  X ---36
0797--  DN---25
0798--XTO---23
0799--  + ---33
0800--  1 ---01
0801--  A ---10
0802--  UP---27
0803--  b ---14
0804--XTO---23
0805--  + ---33
0806--  9 ---11
0807--  4 ---04
0808--YTO---40
0809--IND---31
0810--  + ---33
0811--  9 ---11
0812--  4 ---04
0813--XTO---23
0814--  - ---34
0815--  9 ---11
0816--  4 ---04
0817--XEY---30
0818--PNT---45
0819--  UP---27
0820--XFR---67
0821--  1 ---01
0822--  4 ---04
0823--DIV---35
0824--  1 ---01
0825--  0  --00
0826--  0 ---00
0827--  X ---36
0828--  DN---25
0829--FMT---42
0830--FMT---42
0831--  D ---63
0832--  I ---65
0833--  G ---15
0834--  I ---65
0835--XTO---23
0836--  I ---65
0837--XSQ---12
0838--  E ---60
0839--  D ---63
0840--CNT---47
0841--  π ---56
0842--XTO---23
0843--YTO---40
0844--FMT---42
0845--PNT---45
0846--PNT---45
0847--  2 ---02
0848--  UP---27
0849--XFR---67
0850--  1 ---01
0851--  6 ---06
0852--X=Y---50
0853--  0 ---00
0854--  9 ---11
0855--  1 ---01
0856--  3 ---03
0857--XFR---67
0858--  0 ---00
0859--XTO---23
0860--  + ---33
0861--  1 ---01
0862--  9 ---11
0863--STP---41
0864--IFG---43
0865--  1 ---01
0866--  0 ---00
0867--  0 ---00
0868--  6 ---06
0869--CNT---47
0870--CLX---37
0871--XTO---23
0872--  0 ---00
0873--XTO---23
0874--  1 ---01
0875--XTO---23
0876--  2 ---02
0877--XTO---23
0878--  3 ---03
0879--XTO---23
0880--  4 ---04
0881--XTO---23
0882--  5 ---05
0883--XTO---23
0884--  1 ---01
0885--  0 ---00
0886--XTO---23
0887--  1 ---01
0888--  1 ---01
0889--XTO---23
0890--  1 ---01
0891--  3 ---03
0892--XTO---23
0893--  2 ---02
0894--  2 ---02
0895--XTO---23
0896--  2 ---02
0897--  4 ---04
0898--CNT---47
0899--  2 ---02
```

```
0900-- 0 ---00
0901-- 0 ---00
0902-- 0 ---00
0903--XTO---23
0904-- 2 ---02
0905-- 1 ---01
0906--XTO---23
0907-- 2 ---02
0908-- 3 ---03
0909--GTO---44
0910-- 1 ---01
0911-- 8 ---10
0912-- 3 ---03
0913--CNT---47
0914--FMT---42
0915--FMT---42
0916-- K ---55
0917--IND---31
0918-- H ---74
0919--CNT---47
0920--1/X---17
0921--YTO---40
0922-- E ---60
0923-- D ---63
0924--FMT---42
0925-- a ---13
0926-- UP---27
0927--XFR---67
0928-- 1 ---01
0929-- 0 ---00
0930-- - ---34
0931--XFR---67
0932-- 1 ---01
0933-- 4 ---04
0934-- X ---36
0935-- 6 ---06
0936-- 0 ---00
0937--DIV---35
0938--YTO---40
0939-- a ---13
0940-- C ---61
0941--XFR---67
0942-- 1 ---01
0943-- 5 ---05
0944-- X ---36
0945-- a ---13
0946-- X ---36
0947-- DN---25
0948--PNT---45
0949--PNT---45
0950--GTO---44
0951-- 8 ---10
0952-- 5 ---05
0953-- 7 ---07
0954--CNT---47
0955--S/R---77
0956--LBL---51
0957-- B ---66
0958-- 3 ---03
0959-- 0 ---00
0960--XTO---23
0961-- 2 ---02
0962-- 0 ---00
0963--FMT---42
0964--FMT---42
0965--XTO---23
0966--XFR---67
0967-- π ---56
0968-- E ---60
0969--CNT---47
0970--GTO---44
0971--FMT---42
0972--XFR---67
0973-- 1 ---01
0974-- 3 ---03
0975--PNT---45
0976--PNT---45
0977--XTO---23
0978-- + ---33
0979-- 2 ---02
0980-- 0 ---00
0981-- UP---27
0982-- 1 ---01
0983--XTO---23
0984--IND---31
0985-- + ---33
0986-- 2 ---02
0987-- 0 ---00
0988--XFR---67
0989--IND---31
0990-- 2 ---02
0991-- 0 ---00
0992--FMT---42
0993--FMT---42
0994--YTO---40
0995-- E ---60
0996-- a ---13
0997-- I ---65
0998-- E ---60
0999--YTO---40
1000--CNT---47
1001--GTO---44
1002--FMT---42
1003--PNT---45
1004--PNT---45
1005--S/R---77
1006--CNT---47
1007--FMT---42
1008-- 4 ---04
1009-- 9 ---11
1010--PNT---45
1011--PSE---57
1012--FMT---42
1013-- 4 ---04
1014-- 9 ---11
1015--PNT---45
1016--PSE---57
1017--FMT---42
1018-- 4 ---04
1019-- 9 ---11
1020--PNT---45
1021--FMT---42
1022--FMT---42
1023-- F ---16
1024-- I ---65
1025-- N ---73
1026-- A ---62
1027-- L ---72
1028--CNT---47
1029-- O ---71
1030--1/X---17
1031--XTO---23
1032-- π ---56
1033--1/X---17
1034--XTO---23
1035--FMT---42
1036--CLX---37
1037-- UP---27
1038--XFR---67
1039-- 1 ---01
1040-- 6 ---06
1041--X=Y---50
1042-- 1 ---01
1043-- 0 ---00
1044-- 8 ---10
1045-- 6 ---06
1046--CNT---47
1047-- UP---27
1048-- 1 ---01
1049--X=Y---50
```

```
1050-- 1 ---01
1051-- 0 ---00
1052-- 9 ---11
1053-- 9 ---11
1054--CNT---47
1055-- 2 ---02
1056--X=Y---50
1057-- 1 ---01
1058-- 1 ---01
1059-- 1 ---01
1060-- 3 ---03
1061--CNT---47
1062-- 3 ---03
1063--X=Y---50
1064-- 1 ---01
1065-- 1 ---01
1066-- 2 ---02
1067-- 8 ---10
1068--CNT---47
1069--FMT---42
1070--FMT---42
1071--1/X---17
1072-- N ---73
1073-- D ---63
1074-- E ---60
1075-- F ---16
1076-- I ---65
1077-- N ---73
1078-- E ---60
1079-- D ---63
1080--FMT---42
1081--GTO---44
1082-- 1 ---01
1083-- 1 ---01
1084-- 3 ---03
1085-- 5 ---05
1086--CNT---47
1087--FMT---42
1088--FMT---42
1089-- A ---62
1090-- M ---70
1091-- π ---56
1092--YTO---40
1093--FMT---42
1094--GTO---44
1095-- 1 ---01
1096-- 1 ---01
1097-- 3 ---03
1098-- 5 ---05
1099--CNT---47
1100--FMT---42
1101--FMT---42
1102--INT---64
1103-- O ---71
1104-- L ---72
1105--XTO---23
1106--YTO---40
1107--FMT---42
1108--GTO---44
1109-- 1 ---01
1110-- 1 ---01
1111-- 3 ---03
1112-- 5 ---05
1113--CNT---47
1114--FMT---42
1115--FMT---42
1116-- K ---55
1117--IND---31
1118-- A ---62
1119--XTO---23
1120--XTO---23
1121--YTO---40
1122--FMT---42
1123--GTO---44
1124-- 1 ---01
1125-- 1 ---01
1126-- 3 ---03
1127-- 5 ---05
1128--CNT---47
1129--FMT---42
1130--FMT---42
1131-- π ---56
1132--CNT---47
1133-- F ---16
1134--FMT---42
1135--XFR---67
1135-- 1 ---01
1137-- 9 ---11
1138--XTO---23
1139-- 0 ---00
1140-- C ---61
1141-- DN---25
1142--XFR---67
1143-- 1 ---01
1144-- 5 ---05
1145-- X ---36
1146-- DN---25
1147--FMT---42
1148--FMT---42
1149--XTO---23
1150-- O ---71
1151--XTO---23
1152-- A ---62
1153-- L ---72
1154--CLR---20
1155-- M ---70
1156-- E ---60
1157-- A ---62
1158-- N ---73
1159--CLR---20
1160--YTO---40
1161--XTO---23
1162-- A ---62
1163-- N ---73
1164--CNT---47
1165-- D ---63
1166-- E ---60
1167--INT---64
1168--CLR---20
1169--XFR---67
1170-- M ---70
1171-- A ---62
1172-- YE---24
1173--CLR---20
1174--XFR---67
1175-- M ---70
1176-- I ---65
1177-- N ---73
1178--FMT---42
1179--PNT---45
1180-- D ---63
1181--RUP---22
1182-- √ ---76
1183-- UP---27
1184--XFR---67
1185-- 1 ---01
1186-- 5 ---05
1187-- X ---36
1188-- DN---25
1189--PNT---45
1190--XFR---67
1191-- 2 ---02
1192-- 6 ---06
1193-- UP---27
1194--XFR---67
1195-- 1 ---01
1196-- 5 ---05
1197-- X ---36
1198-- DN---25
1199--PNT---45
```

```
1200--XFR---67
1201-- 2 ---02
1202-- 5 ---05
1203-- UP---27
1204--XFR---67
1205-- 1 ---01
1206-- 5 ---05
1207-- X ---36
1208-- DN---25
1209--PNT---45
1210--PNT---45
1211--XFR---67
1212-- 1 ---01
1213-- 8 ---10
1214--FMT---42
1215--FMT---42
1216--XTO---23
1217-- 0 ---71
1218--XTO---23
1219-- A ---62
1220-- L ---72
1221--CNT---47
1222--XTO---23
1223-- I ---65
1224-- M ---70
1225-- E ---60
1226--FMT---42
1227--PNT---45
1228--PNT---45
1229--XFR---67
1230-- 1 ---01
1231-- 6 ---06
1232-- UP---27
1233-- 2 ---02
1234--X>Y---53
1235-- 1 ---01
1236-- 2 ---02
1237-- 7 ---07
1238-- 2 ---02
1239--X<Y---52
1240-- 1 ---01
1241-- 2 ---02
1242-- 7 ---07
1243-- 2 ---02
1244-- C ---61
1245-- DN---25
1246--XFR---67
1247-- 1 ---01
1248-- 5 ---05
1249-- X ---36
1250--XFR---67
1251-- 1 ---01
1252-- 8 ---10
1253-- X ---36
1254-- 6 ---06
1255-- 0 ---00
1256--DIV---35
1257-- DN---25
1258--FMT---42
1259--FMT---42
1260--XTO---23
1261-- 0 ---71
1262--XTO---23
1263-- A ---62
1264-- L ---72
1265--CNT---47
1266-- K ---55
1267--IND---31
1268-- H ---74
1269--CNT---47
1270--1/X---17
1271--YTO---40
1272-- E ---60
1273-- D ---63
1274--FMT---42
1275--PNT---45
1276--PNT---45
1277--FMT---42
1278--FMT---42
1279-- A ---62
1280--INT---64
1281-- E ---60
1282--CNT---47
1283--YTO---40
1284--XTO---23
1285-- A ---62
1286--XTO---23
1287--CNT---47
1288-- 0 ---71
1289--1/X---17
1290--XTO---23
1291-- π ---56
1292--1/X---17
1293--XTO---23
1294--CLR---20
1295-- F ---16
1296-- 0 ---71
1297-- a ---13
1298--CNT---47
1299-- E ---60
1300-- A ---62
1301-- C ---61
1302-- H ---74
1303--CNT---47
1304--XTO---23
1305-- . ---21
1306--YTO---40
1307-- . ---21
1308--CLR---20
1309--XTO---23
1310--XFR---67
1311-- π ---56
1312-- E ---60
1313--CLR---20
1314--CLR---20
1315--FMT---42
1316-- 3 ---03
1317-- 0 ---00
1318--XTO---23
1319-- 2 ---02
1320-- 0 ---00
1321--CLX---37
1322-- 4 ---04
1323-- 0 ---00
1324--XTO---23
1325-- 1 ---01
1326-- 0 ---00
1327-- 0 ---00
1328-- 5 ---05
1329-- 0 ---00
1330--XTO---23
1331-- 1 ---01
1332-- 0 ---00
1333-- 1 ---01
1334-- 6 ---06
1335-- 0 ---00
1336--XTO---23
1337-- 1 ---01
1338-- 0 ---00
1339-- 2 ---02
1340-- 7 ---07
1341-- 0 ---00
1342--XTO---23
1343-- 1 ---01
1344-- 0 ---00
1345-- 3 ---03
1346-- 8 ---10
1347-- 0 ---00
1348--XTO---23
1349-- 1 ---01
```

```
1350-- 0 ---00
1351-- 4 ---04
1352--GTO---44
1353--LBL---51
1354-- + ---33
1355--LBL---51
1356-- + ---33
1357--CLR---20
1358--XFR---67
1359--IND---31
1360-- 0 ---00
1361-- 2 ---02
1362-- 0 ---00
1363--X>Y---53
1364--GTO---44
1365--LBL---51
1366-- - ---34
1367--CNT---47
1368--FMT---42
1369--FMT---42
1370-- N ---73
1371-- O ---71
1372--CNT---47
1373-- D ---63
1374-- A ---62
1375--XTO---23
1376-- A ---62
1377--CLR---20
1378--XTO---23
1379-- . ---21
1370--YTO---40
1381-- . ---21
1382--CNT---47
1383--XTO---23
1384--XFR---67
1385-- π ---56
1386-- E ---60
1387--FMT---42
1388--XFR---67
1389-- 2 ---02
1390-- 7 ---07
1391--FMT---42
1392-- 4 ---04
1393-- . ---21
1394-- 0 ---00
1395-- 0 ---00
1396-- . ---21
1397-- 0 ---00
1398--PNT---45
1399--PNT---45
1400--FMT---42
1401-- 4 ---04
1402-- . ---21
1403-- 0 ---00
1404-- 0 ---00
1405-- . ---21
1406-- 2 ---02
1407--GTO---44
1408--LBL---51
1409-- √ ---76
1410--LBL---51
1411-- √ ---76
1412-- 1 ---01
1413--XTO---23
1414-- + ---33
1415-- 2 ---02
1416-- 0 ---00
1417--XTO---23
1418-- + ---33
1419-- 2 ---02
1420-- 7 ---07
1421--XTO---23
1422-- + ---33
1423-- 1 ---01
1424-- 0 ---00
1425-- 0 ---00
1426--XTO---23
1427-- + ---33
1428-- 1 ---01
1429-- 0 ---00
1430-- 1 ---01
1431--XTO---23
1432-- + ---33
1433-- 1 ---01
1434-- 0 ---00
1435-- 2 ---02
1436--XTO---23
1437-- + ---33
1438-- 1 ---01
1439-- 0 ---00
1440-- 3 ---03
1441--XTO---23
1442-- + ---33
1443-- 1 ---01
1444-- 0 ---00
1445-- 4 ---04
1446-- 1 ---01
1447-- 0 ---00
1448-- UP---27
1449--XFR---67
1450-- 2 ---02
1451-- 7 ---07
1452--X<Y---52
1453--GTO---44
1454--LBL---51
1455-- + ---33
1456--CNT---47
1457--FMT---42
1458--FMT---42
1459-- E ---60
1460-- N ---73
1461-- D ---63
1462--CLR---20
1463--CLR---20
1464--CLR---20
1465--CLR---20
1466--CLR---20
1467--CLR---20
1468--CLR---20
1469--CLR---20
1470--FMT---42
1471--GTO---44
1472-- 0 ---00
1473--LBL---51
1474-- - ---34
1475--FMT---42
1476--FMT---42
1477--XTO---23
1478-- . ---21
1479--YTO---40
1480-- . ---21
1481--CNT---47
1482--XTO---23
1483--XFR---67
1484-- π ---56
1485-- E ---60
1486--FMT---42
1487--XFR---67
1488-- 2 ---02
1489-- 7 ---07
1490--FMT---42
1491-- 4 ---04
1492-- . ---21
1493-- 0 ---00
1494-- 0 ---00
1495-- . ---21
1496-- 0 ---00
1497--PNT---45
1498--PNT---45
1499--FMT---42
```

```
1500-- 4 ---04
1501-- . ---21
1502-- 0 ---00
1503-- 0 ---00
1504-- . ---21
1505-- 2 ---02
1506--XFR---67
1507--IND---31
1508-- 2 ---02
1509-- 0 ---00
1510--XTO---23
1511-- b ---14
1512--FMT---42
1513--FMT---42
1514-- N ---73
1515-- O ---71
1516--CNT---47
1517-- O ---71
1518-- F ---16
1519--CNT---47
1520-- C ---61
1521--XFR---67
1522-- C ---61
1523-- L ---72
1524-- E ---60
1525--YTO---40
1526--FMT---42
1527--PNT---45
1528--XFR---67
1529--IND---31
1530-- 1 ---01
1531-- 0 ---00
1532-- 0 ---00
1533-- UP---27
1534--CNT---47
1535-- b ---14
1536--DIV---35
1537--XFR---67
1538-- 1 ---01
1539-- 5 ---05
1540-- X ---36
1541--XTO---23
1542-- a ---13
1543-- DN---25
1544--FMT---42
1545--FMT---42
1546-- A ---62
1547--INT---64
1548-- E ---60
1549--CNT---47
1550-- M ---70
1551-- E ---60
1552-- A ---62
1553-- N ---73
1554--FMT---42
1555--PNT---45
1556--XFR---67
1557--IND---31
1558-- 1 ---01
1559-- 0 ---00
1560-- 1 ---01
1561--GTO---44
1562--S/R---77
1563--LBL---51
1564-- I ---65
1565--FMT---42
1566--FMT---42
1567-- A ---62
1568--INT---64
1569-- E ---60
1570--CNT---47
1571--YTO---40
1572--XTO---23
1573-- A ---62
1574-- N ---73
1575--CNT---47
1576-- D ---63
1577-- E ---60
1578--INT---64
1579--FMT---42
1580--PNT---45
1581--XFR---67
1582--IND---31
1583-- 1 ---01
1584-- 0 ---00
1585-- 2 ---02
1586--GTO---44
1587--S/R---77
1588--LBL---51
1589-- I ---65
1590--FMT---42
1591--FMT---42
1592-- A ---62
1593--INT---64
1594-- E ---60
1595--CNT---47
1596--XFR---67
1597-- M ---70
1598-- M ---62
1599-- YE---24
1600--FMT---42
1601--PNT---45
1602--XFR---67
1603--IND---31
1604-- 1 ---01
1605-- 0 ---00
1606-- 3 ---03
1607--GTO---44
1608--S/R---77
1609--LBL---51
1610-- I ---65
1611--FMT---42
1612--FMT---42
1613-- A ---62
1614--INT---64
1615-- E ---60
1616--CNT---47
1617--XFR---67
1618-- M ---70
1619-- I ---65
1620-- N ---73
1621--FMT---42
1622--PNT---45
1623--XFR---67
1624--IND---31
1625-- 1 ---01
1626-- 0 ---00
1627-- 4 ---04
1628-- UP---27
1629-- b ---14
1630--DIV---35
1631-- DN---25
1632--FMT---42
1633--FMT---42
1634-- A ---62
1635--INT---64
1636-- E ---60
1637--CNT---47
1638--XTO---23
1639-- I ---65
1640-- M ---70
1641-- E ---60
1642--FMT---42
1643--PNT---45
1644--PNT---45
1645--GTO---44
1646--LBL---51
1647-- √ ---76
1648--S/R---77
1649--LBL---51
```

```
1650-- I ---65
1651-- UP---27
1652-- b ---14
1653--DIV---35
1654-- a ---13
1655-- X ---36
1656-- DN---25
1657--S/R---77
1658--END---46
```

APPENDIX VIII

DIGITAL RECORDER ANALYSIS PROGRAM

```
C
C-----------------------------------------------------------------------
C
C                 MINE ELECTRICAL POWER DATA ANALYSIS
C                 MAIN PROGRAM
C
C             THIS PROGRAM ACCEPTS DIGITIZED DATA FROM MAGNETIC TAPE
C             APPLIES CORRECTION FACTORS, AND OUTPUTS THIS DATA TO DISC.
C             THE DATA RESULTED FROM ONE SECOND INTERVAL SAMPLING OF
C             UNDERGROUND MINE ELECTRICAL POWER SYSTEM PARAMETERS
C             AND CONSISTS OF THE FOLLOWING:
C                         TIME
C                         CURRENT
C                         VOLTAGE
C                         POWER
C                         POWER FACTOR
C
C             THIS DATA IS THEN SCANNED TO DEFINE THE BEGIN AND END POINTS
C             (TIMES) FOR ALL THE CURVES OR EVENTS.
C              WHEN THESE PERIODS ARE FOUND, THE
C             STATISTICS FOR EACH CURVE, AS WELL AS FOR ALL THE DATA, ARE
C             COMPUTED AND PRINTED.
C
C              THE CURVE STATISTICS ARE ANALYZED TO DEFINE ANY
C              EXISTING TYPICAL CURVES.
C
C             SUBROUTINES USED:
C                   TIME
C                   STAT
C                   TEST
C
C             REFERENCE:
C                   QUARTERLY REPORT
C
C-----------------------------------------------------------------------
C
      COMMON TP(400),CMEAN(400),VMEAN(400),PMEAN(400),PFMEAN(400)
      COMMON CSD(400),VSD(400),PSD(400),PFSD(400)
      COMMON CMIN(400),CMAX(400),VMIN(400),VMAX(400),PMIN(400),PMAX(400
      COMMON PFMIN(400),PFMAX(400),NO(400),CC(400),KWH(400)
      COMMON MINC,MAXC,MINV,MAXV,MINP,MAXP,MINPF,MAXPF,DUMMY,IMFIN
      COMMON I,IO,J,J1,C,V,P,PF
      COMMON GSLOPE,IFR,C$P
      REAL MAXC, MINC, MAXV, MINV, MAXP, MINP, MAXPF, MINPF, KWH
      REAL*8 DUMMY,UNITS(2)/'AMP/SEC ','KW/SEC  '/
      INTEGER TH, TM, TS, C$P, CP, CCC/'C'/, GGG/'G'/,GRAPH
      INTEGER IFMT(4)/'(3I2','),T 7','),4(A','4)) '/
      INTEGER TAB(3)/',T 7',',T23',',T39'/,TP
C**
      DEFINE FILE 99(29000,7,U,ID)
C**
C**     INITIALIZE, READ CORRECTION FACTORS & PARAMETERS, AND INPUT
C**     FORMAT FOR DATA.
```

```
C**
      DUMMY=0.
      I=0
      TOT1=0.0
      TOT2=0.0
      C$P=1
      READ(5,1) MACH, CP, GRAPH, IFR, GSLOPE, CCUR, CVOLT, CPWR, CPF
    1 FORMAT(I1,A1,1X,A1,4X,I2,20X,5F10.4)
      IF(MACH.LE.0) MACH=1
      IFMT(2)=TAB(MACH)
      IF(CP.NE.CCC) C$P=2
      IF(GRAPH.NE.GGG) GRAPH=1
      IF(GRAPH.EQ.GGG) GRAPH=2
      WRITE(6,99) C$P
   99 FORMAT('0','C$P = ',I1)
      WRITE(6,101) CCUR, CVOLT, CPWR, CPF, GSLOPE, IFR
  101 FORMAT('3CORRECTION FACTORS:'//' C ',F8.4/' V ',F8.4/
     1' P ',F8.4/' PF ',F8.4//' SLOPE THRESHOLD ',F8.4/
     2' FRAME SIZE ',I3)
C**
C**      READ DATA AND WRITE TO DISC;
C**      ALSO, DETERMINE MIN & MAX OF ALL DATA.
C**
    2 I=I+1
      READ(12   ,IFMT,END=10) TH,TM,TS,C,V,P,PF
      T=TH*3600.+TM*60.+TS
      C=C+.002
      P=P+.003
      C=CCUR*C
      IF(C.LT.0.) C=0.
      V=CVOLT*V
      IF(V.LT.0.) V=0.
      P=CPWR*P
      IF(P.LT.0.) P=0.
      IF(PF.LT.0.) PF=0.
      PF=PF/1.242
      IF(PF.GE..2) GO TO 200
      GO TO 201
200   PF=ALOG10(10*PF)
201   WRITE(98) C,V,P,PF,T
      TOT1=TOT1+C
      TOT2=TOT2+P
      IF(I.NE.1) GO TO 4
      MAXC=C
      MINC=C
      MAXV=V
      MINV=V
      MAXP=P
      MINP=P
      MAXPF=PF
      MINPF=PF
      GO TO 2
    4 IF(C.GT.MAXC) MAXC=C
```

```
      IF(C.LT.MINC) MINC=C
      IF(V.GT.MAXV) MAXV=V
      IF(V.LT.MINV) MINV=V
      IF(P.GT.MAXP) MAXP=P
      IF(P.LT.MINP) MINP=P
      IF(PF.GT.MAXPF) MAXPF=PF
      IF(PF.LT.MINPF) MINPF=PF
      GO TO 2
C**************************************************************************
C**
C**     PRINT MIN & MAX FIGURES, COMPUTE OPTIMUM SLOPE, CALL TIME
C**     ROUTINE TO DEFINE CURVES, AND CALL STAT ROUTINE FOR EACH
C**     CURVE.
C**
C**************************************************************************
   10 IMFIN=I-1
      ENDFILE 98
      REWIND 98
      WRITE(6,103) IMFIN
  103 FORMAT('3','TOTAL RECORDS: ',I6)
      FIND(99'1)
      WRITE(6,104)
  104 FORMAT('0',T18,'MIN',T28,'MAX')
      WRITE(6,105) MINC, MAXC
  105 FORMAT('0','CURRENT',T16,2(F8.3,2X),'AMPS.')
      WRITE(6,106) MINV, MAXV
  106 FORMAT(' ','VOLTAGE',T16,2(F8.3,2X),'VOLTS')
      WRITE(6,107) MINP, MAXP
  107 FORMAT(' ','POWER',T16,2(F8.3,2X),'KW. ')
      IF(C$P.EQ.1) OPT=(TOT1/IMFIN)/(IFR*2)
      IF(C$P.EQ.2) OPT=(TOT2/IMFIN)/(IFR*2)
      IF(GSLOPE.EQ.0.0) GSLOPE=OPT
      WRITE(6,108) MINPF, MAXPF, OPT, UNITS(C$P)
  108 FORMAT(' ','POWER FACTOR',T16,2(F8.4,2X)/'0',
     1'OPT. SLOPE THRESHOLD = ',F6.2,A8/'1')
      J1=0
C**
      CALL TIME
C**
      J1=J1-1
      IF(TP(J1).EQ.IMFIN) GO TO 11
      TP(J1+1)=IMFIN
      J1=J1+1
   11 J1MAX=J1
      JJ1=J1-1
      DO 30 K1=1,JJ1
      J1=K1
      I=TP(K1)
      J=TP(K1+1)
C**
      CALL STAT
C**
      CC(K1)=1.0
```

```
   30 CONTINUE
C*********************************************************************
C**
C**      THIS SECTION LOOKS FOR TYPICAL CURVES AND PRINTS ALL THE
C**      INFORMATION ON ALL CURVES, WHETHER THEY ARE TYPICAL OR NOT.
C**      THE OUTER LOOP (70) PICKS A CURVE (1 THEN 2 THEN 3 ....)
C**      AND THEN THE INNER LOOP (40) COMPARES THAT CURVE TO ALL THE
C**      REMAINING CURVES TO SEE IF IT MATCHES ANOTHER CURVE.  A CURVE
C**      IS TYPICAL IF THERE ARE AT LEAST 2 OTHER CURVES WHICH MATCH IT.
C**
C*********************************************************************
   35 J1=J1MAX-1
      DO 70 I=1,J1
      IF(CC(I).EQ.2.) GO TO 70
      NO(I)=1
      KOUNT=1
      I1=I+1
      IF(I1.GT.J1) GO TO 39
      DO 40 J=I1,J1
      IF(CC(J).EQ.2.) GO TO 40
      NO(J)=-1
      CALL TEST(I,J,IR)
      IF(IR.EQ.0) GO TO 40
      KOUNT=KOUNT+1
      NO(J)=1
   40 CONTINUE
C**
   39 N1=TP(I)
      M1=TP(I+1)
      K=M1-N1+1
      FIND(99'N1)
      IF(KOUNT.GE.3) GO TO 49
      WRITE(6,41) I, K
   41 FORMAT('-','THE STATISTICS OF CURVE NUMBER ',I4,' ARE:',T43,I5,
     1' POINT(S)')
      READ(99'N1) DUMMY, C, V, P, PF, T
      FIND(99'M1)
      WRITE(6,42) T, C, V, P, PF
   42 FORMAT('0','BEGINNING OF CURVE:  TIME=',F10.0,' SEC., CURRENT=',F
     1.3,' AMPS., VOLTAGE=',F8.3,' VOLTS, POWER=',F8.3,' KW., POWER FAC
     2OR=',F6.4)
      WRITE(6,110)
      WRITE(6,111) CMIN(I), CMAX(I), CMEAN(I), CSD(I)
      WRITE(6,112) VMIN(I), VMAX(I), VMEAN(I), VSD(I)
      WRITE(6,113) PMIN(I), PMAX(I), PMEAN(I), PSD(I)
      WRITE(6,114) PFMIN(I), PFMAX(I), PFMEAN(I), PFSD(I)
      WRITE(6,115) KWH(I)
  110 FORMAT('0',T18,'MIN',T28,'MAX',T38,'MEAN',T48,'STD-DEV')
  111 FORMAT('0','CURRENT',T16,4(F8.3,2X))
  112 FORMAT(' ','VOLTAGE',T16,4(F8.3,2X))
  113 FORMAT(' ','POWER',T16,4(F8.3,2X))
  114 FORMAT(' ','POWER FACTOR',T16,4(F8.6,2X))
  115 FORMAT('0',F7.2,' KWH.')
```

```
      READ(99'M1) DUMMY, C, V, P, PF, T
      WRITE(6,47)T, C, V, P, PF
   47 FORMAT('0','END OF CURVE:  TIME=',F10.0,' SEC. CURRENT=',F8.3,' A
     1PS. VOLTAGE=',F8.3,' VOLTS. POWER=',F8.3,' KW., POWER FACTOR=',F6
     24)
      GO TO 70
   49 WRITE(6,51) I, KOUNT
   51 FORMAT('-','CURVE NUMBER',I4,' IS A TYPICAL CURVE. THERE ARE ', I
     1, ' CURVES THAT ARE SIMILAR  WITHIN  THE SPECIFIED LIMITS.')
      I2=I1-1
      DO 50 K=I2,J1
      IF(NO(K).EQ.-1) GO TO 50
      IF(CC(K).NE.1.) GO TO 50
      KPT1=TP(K)
      KPT2=TP(K+1)
      READ(99'KPT1) DUMMY,C,V,P,PF,T1
      READ(99'KPT2) DUMMY,C,V,P,PF,T2
      WRITE(6,116) K, T1, T2, KWH(K)
  116 FORMAT('0',T72,I3,3X,F6.0,'-',F6.0,' SEC.',4X,F7.2,' KWH.')
      CC(K)=2.
   50 CONTINUE
      IF(GRAPH.EQ.1) GO TO 48
      IPT1=TP(I)
      IPT2=TP(I+1)
      READ(99'IPT1) DUMMY,C,V,P,PF,T1
      READ(99'IPT2) DUMMY,C,V,P,PF,T2
      K=TP(I+1)-TP(I)
      IF(K.LT.0) K=0-K
      WRITE(96,117) I, K, T1, T2, CMIN(I), CMAX(I), CMEAN(I),
     1  CSD(I), VMIN(I), VMAX(I), VMEAN(I), VSD(I), PMIN(I), PMAX(I),
     2  PMEAN(I), PSD(I), PFMIN(I), PFMAX(I), PFMEAN(I), PFSD(I)
  117 FORMAT(20(A4))
      DO 80 K=N1,M1
      READ(99'K) DUMMY, C, V, P, PF, T
   80 WRITE(96,118) C, V, P, PF, T
  118 FORMAT(5(A4))
   48 WRITE(6,110)
      WRITE(6,111) CMIN(I), CMAX(I), CMEAN(I), CSD(I)
      WRITE(6,112) VMIN(I), VMAX(I), VMEAN(I), VSD(I)
      WRITE(6,113) PMIN(I), PMAX(I), PMEAN(I), PSD(I)
      WRITE(6,114) PFMIN(I), PFMAX(I), PFMEAN(I), PFSD(I)
      WRITE(6,52)
   52 FORMAT('0',2X,'TIME',17X,'CURRENT',16X,'VOLTAGE',17X,'POWER',17X,
     1POWER FACTOR')
      WRITE(6,53)
   53 FORMAT(' ',2X,'(SEC)',16X,'(AMPS)',17X,'(VOLTS)',17X,'(KW)')
      WRITE(6,54)
   54 FORMAT('+',2X,'_____',16X,'_______',16X,'_______',17X,'_____',17X
     1'____________')
      ID=N1
      IF(CMEAN(I).LE.2..AND.M1-N1+1.GT.30) GO TO 62
      DO 60 K=N1,M1
      READ(99'ID) DUMMY,C, V, P, PF, T
```

```
   60 WRITE(6,61) T, C, V, P, PF
   61 FORMAT('0', 2X, F10.0, 11X, F8.3, 15X, F8.3, 16X, F8.3, 14X, F6.4
      GO TO 70
   62 N2=N1+30
      DO 63 K=N1,N2
      READ(99'ID) DUMMY,C, V, P, PF, T
   63 WRITE(6,61) T, C, V, P, PF
   70 ITEMP=ID
C**
      WRITE(6,100)
  100 FORMAT('1')
      IF(GRAPH.EQ.2) STOP 19
      STOP
      END
```

```
C
C-----------------------------------------------------------------------
C
C                    SUBROUTINE TIME
C
C              PURPOSE: TO DETERMINE THE BEGINNING AND END POINTS (TIMES)
C              OF ALL CURVES IN A SET OF DATA. THE ARRAY TP CONTAINS
C              THESE POINTS.
C
C              METHOD:  BY SCANNING ADJACENT POINTS AND CALCULATING SLOPE,
C              IT IS POSSIBLE TO DETECT THE BEGINNING OR END OF A CURVE
C              (IE. WHEN THE SLOPE IS > GSLOPE).  TO SAVE TIME AND AVOID
C              DEFINING CURVES FOR LOCAL OR NOISE EVENTS, THE SLOPE OVER
C              SEVERAL (IFR) POINTS IS CHECKED AND SCANNING OF INDIVIDUAL
C              POINTS BEGINS WHEN GSLOPE IS EXCEEDED.
C
C              USAGE:
C                   CALL TIME
C
C              FUNCTIONS USED:
C                   SLOPE
C                   ABS
C
C-----------------------------------------------------------------------
C
      SUBROUTINE TIME
      COMMON TP(400),CMEAN(400),VMEAN(400),PMEAN(400),PFMEAN(400)
      COMMON CSD(400),VSD(400),PSD(400),PFSD(400)
      COMMON CMIN(400),CMAX(400),VMIN(400),VMAX(400),PMIN(400),PMAX(400)
      COMMON PFMIN(400),PFMAX(400),NO(400),CC(400),KWH(400)
      COMMON MINC,MAXC,MINV,MAXV,MINP,MAXP,MINPF,MAXPF,DUMMY,IMFIN
      COMMON I,ID,J,J1,C,V,P,PF
      COMMON GSLOPE,IFR,C$P
      REAL MAXC, MINC, MAXV, MINV, MAXP, MINP, MAXPF, MINPF, KWH
      INTEGER C$P,SAVE(50),TP
      REAL R(5,2)
      REAL*8 DUMMY
C**
      SLOPE(A1,B1,A2,B2)=(A2-A1)/(B2-B1)
C**
      READ(99'1) DUMMY, R(1,1), V, R(1,2), PF, T1
      J1=2
      TP(1)=1
      I=IFR
C**
C**     THE OUTER LOOP (6-12) DOES THE COARSE SCAN (IFR POINTS AT A
C**     TIME) AND THE INNER LOOP (9-11) DOES THE FINE SCAN (1 AT A TIME)
C**     AND ACTUALLY DETERMINES THE POINTS.
C**
C>>                   READ SECOND DATA POINT AND CALCULATE SLOPE.
    6 READ(99'I) DUMMY, R(2,1), V, R(2,2), PF, T2
      IF(I+IFR.LE.IMFIN) FIND(99'I+IFR)
    7 IF(R(1,C$P).EQ.0.0.AND.R(2,C$P).EQ.0.0) GO TO 74
```

```
      D$DT=SLOPE(R(1,C$P),T1,R(2,C$P),T2)
C>>                   IF GSLOPE IS EXCEEDED GO TO INDIVIDUAL POINT
C>>                   SCAN, IF NOT STEP UP TO NEXT IFR INTERVAL SCAN
C>>                   IN OUTER LOOP.
      IF(ABS(D$DT).GE.GSLOPE) GO TO 75
   74 R(1,C$P)=R(2,C$P)
      T1=T2
      GO TO 12
C>>                   INDIVIDUAL POINT SCAN--INITIALIZE & READ DATA
   75 MFR=I-IFR
      IF(MFR.LT.2) MFR=2
      READ(99'MFR-1) DUMMY, R(3,1), V, R(3,2), PF, T3
      READ(99'MFR) DUMMY, R(4,1), V, R(4,2), PF, T4
C**
      IC=0
      KC=1
    9 IF(MFR+1.GT.IMFIN) GO TO 13
      READ(99'MFR+1) DUMMY, R(5,1), V, R(5,2), PF, T5
C>>                   CALCULATE SLOPE A BETWEEN 1ST & 2ND DATA POINTS
C>>                   AND SLOPE B BETWEEN 2ND & 3RD DATA POINTS.
      A=ABS(SLOPE(R(3,C$P),T3,R(4,C$P),T4))
      B=ABS(SLOPE(R(4,C$P),T4,R(5,C$P),T5))
C>>                   IF SLOPE A & B INDICATE A TRANSITION POINT, SAVE
C>>                   IT AND CHECK SLOPE ON THE NEXT 2 POINTS.
      IF(A.GE.GSLOPE.AND.B.GE.GSLOPE) GO TO 93
      IF(A.LT.GSLOPE.AND.B.LT.GSLOPE) GO TO 94
      SAVE(KC)=MFR
      KC=KC+1
      IC=0
      GO TO 10
   93 IC=0
      GO TO 10
   94 IC=IC+1
      IF(IC.LT.IFR) GO TO 10
      IF(SAVE(1).GE.SAVE(KC-1)) GO TO 10
      TP(J1)=SAVE(1)
      TP(J1+1)=SAVE(KC-1)
      J1=J1+2
      I=MFR+1
      IF(I.GT.IMFIN) GO TO 13
      READ(99'I) DUMMY, R(1,1), V, R(1,2), PF, T1
      IF(ID+4.LE.IMFIN) FIND(99'ID+4)
      GO TO 12
   10 R(3,C$P)=R(4,C$P)
      T3=T4
      R(4,C$P)=R(5,C$P)
      T4=T5
      MFR=MFR+1
      GO TO 9
C**
C**
   12 I=I+IFR
      IF(I.LE.IMFIN) GO TO 6
```

```
C**
C**
C**
   13 RETURN
      END
```

```
C-----------------------------------------------------------------------
C
C                    SUBROUTINE STAT
C
C              PURPOSE:  THIS ROUTINE CALCULATES THE FOLLOWING STATISTICS
C              OF EACH CURVE POWER PARAMETER:
C                   MIN
C                   MAX
C                   MEAN
C                   STANDARD DEVIATION
C
C              IN ADDITION, IT CALCULATES KILOWATT-HOURS.
C
C              USAGE:
C                   CALL STAT
C
C-----------------------------------------------------------------------
C
      SUBROUTINE STAT
      COMMON TP(400),CMEAN(400),VMEAN(400),PMEAN(400),PFMEAN(400)
      COMMON CSD(400),VSD(400),PSD(400),PFSD(400)
      COMMON CMIN(400),CMAX(400),VMIN(400),VMAX(400),PMIN(400),PMAX(400
      COMMON PFMIN(400),PFMAX(400),NC(400),CC(400),KWH(400)
      COMMON MINC,MAXC,MINV,MAXV,MINP,MAXP,MINPF,MAXPF,DUMMY,IMFIN
      COMMON I,ID,J,J1,C,V,P,PF
      COMMON GSLOPE,IFR,C$P
      REAL MAXC, MINC, MAXV, MINV, MAXP, MINP, MAXPF, MINPF, KWH, KWS
      REAL*8 DUMMY
      INTEGER TP
C**
      SUMC=0.
      SUMV=0.
      SUMP=0.
      SUMPF=0.
      SUMCC=0.
      SUMVV=0.
      SUMPP=0.
      SUMPFF=0.
      KWS=0.
      ID=I
      FL=0.0
C**
C**     THIS LOOP FINDS THE MIN, MAX, KWS., AND SUMS OF THE DATA.
C**
      DO 1 I1=I,J
      IF(ID.LE.IMFIN) READ(99'ID) DUMMY, C, V, P, PF, T
      IF(ID.LE.IMFIN) FIND(99'ID)
      SUMVV=SUMVV+V*V
      SUMV=SUMV+V
      IF(FL.EQ.1.0) GO TO 2
      SUMCC=SUMCC+C*C
      SUMPP=SUMPP+P*P
      SUMPFF=SUMPFF+PF*PF
```

```
      SUMC=SUMC+C
      SUMP=SUMP+P
      SUMPF=SUMPF+PF
      IF(ID-1.GT.I) GO TO 2
      CMIN(J1)=C
      CMAX(J1)=C
      VMIN(J1)=V
      VMAX(J1)=V
      PMIN(J1)=P
      PMAX(J1)=P
      PFMIN(J1)=PF
      PFMAX(J1)=PF
      S=T
      PS=P
      GO TO 1
    2 IF(V.LT.VMIN(J1)) VMIN(J1)=V
      IF(V.GT.VMAX(J1)) VMAX(J1)=V
      IF(FL.EQ.1.0) GO TO 1
      IF(C.LT.CMIN(J1)) CMIN(J1)=C
      IF(C.GT.CMAX(J1)) CMAX(J1)=C
      IF(P.LT.PMIN(J1)) PMIN(J1)=P
      IF(P.GT.PMAX(J1)) PMAX(J1)=P
      IF(PF.LT.PFMIN(J1)) PFMIN(J1)=PF
      IF(PF.GT.PFMAX(J1)) PFMAX(J1)=PF
      KWS=KWS+(PS+P)/2*(T-S)
      IF(SUMC.EQ.0.0.AND.SUMP.EQ.0.0) FL=1.0
      S=T
      PS=P
    1 CONTINUE
C**
C**     CALCULATE KWH., MEANS, AND STANDARD DEVIATIONS.
C**
      K=J+1-I
      IF(FL.EQ.1.0) GO TO 3
      KWH(J1)=KWS/3600.
      CMEAN(J1)=SUMC/K
      VMEAN(J1)=SUMV/K
      PMEAN(J1)=SUMP/K
      PFMEAN(J1)=SUMPF/K
      SUMC=SUMCC-K*CMEAN(J1)**2
      SUMV=SUMVV-K*VMEAN(J1)**2
      SUMP=SUMPP-K*PMEAN(J1)**2
      SUMPF=SUMPFF-K*PFMEAN(J1)**2
      IF(I.LE.IMFIN) FIND (99'I)
      IF(SUMC.LT.0.) SUMC=SUMC*(-1.)
      CSD(J1)=SQRT(SUMC/K)
      IF(SUMV.LT.0.) SUMV=SUMV*(-1.)
      VSD(J1)=SQRT(SUMV/K)
      IF(SUMP.LT.0.) SUMP=SUMP*(-1.)
      PSD(J1)=SQRT(SUMP/K)
      IF(SUMPF.LT.0.) SUMPF=SUMPF*(-1.)
      PFSD(J1)=SQRT(SUMPF/K)
      RETURN
```

```
3 KWH(J1)=0.0
  CMEAN(J1)=0.0
  PMEAN(J1)=0.0
  PFMEAN(J1)=0.0
  CSD(J1)=0.0
  PSD(J1)=0.0
  PFSD(J1)=0.0
  VMEAN(J1)=SUMV/K
  SUMV=SUMVV-K*VMEAN(J1)**2
  IF(SUMV.LT.0.) SUMV=SUMV*(-1.)
  VSD(J1)=SQRT(SUMV/K)
  RETURN
  END
```

```
C
C-----------------------------------------------------------------------
C
C                 SUBROUTINE TEST
C
C            PURPOSE:  THIS ROUTINE DOES THE TEST TO DETERMINE IF A CURVE
C            IS TYPICAL.
C
C            USAGE:
C                 CALL TEST(I,J,RESLT)
C                 I & J - INDEX NUMBERS OF CURVES BEING COMPARED.
C                 RESLT - RESULT, =1 IF CURVES ARE SIMILAR,
C                                 =0 OTHERWISE.
C
C            FUNCTIONS USED:
C                   ABS
C
C-----------------------------------------------------------------------
C
      SUBROUTINE TEST(I,J,RESLT)
      COMMON TP(400),CMEAN(400),VMEAN(400),PMEAN(400),PFMEAN(400)
      COMMON CSD(400),VSD(400),PSD(400),PFSD(400)
      COMMON CMIN(400),CMAX(400),VMIN(400),VMAX(400),PMIN(400),PMAX(400
      COMMON PFMIN(400),PFMAX(400),NC(400),CC(400),KWH(400)
      COMMON MINC,MAXC,MINV,MAXV,MINP,MAXP,MINPF,MAXPF,DUMMY,IMFIN
      COMMON II,ID,JJ,J1,C,V,P,PF
      COMMON GSLOPE,IFR,C$P
      REAL MAXC, MINC, MAXV, MINV, MAXP, MINP, MAXPF, MINPF, KWH
      INTEGER C$P,TP
      REAL*8 DUMMY
      RESLT=0
      IF(C$P.NE.1) GO TO 50
C
C          PERFORM TEST CALCULATIONS IF CURRENT PARAMETER
C          WAS SPECIFIED
C
      TST1=ABS(CMEAN(I)-CMEAN(J))
      TST2=ABS(CSD(I)-CSD(J))
      TST3=ABS(CMAX(I)-CMAX(J))
      TST4=ABS(CMIN(I)-CMIN(J))
      RANGE=CMAX(I)-CMIN(I)
      GO TO 100
C
C          PERFORM TEST CALCULATIONS IF POWER PARAMETER
C          WAS SPECIFIED
C
   50 TST1=ABS(PMEAN(I)-PMEAN(J))
      TST2=ABS(PSD(I)-PSD(J))
      TST3=ABS(PMAX(I)-PMAX(J))
      TST4=ABS(PMIN(I)-PMIN(J))
      RANGE=PMAX(I)-PMIN(I)
C
C          IF THE TEST CALCULATIONS VARY BEYOND THE LIMITS
```

```
C           SPECIFIED, THE CURVE TESTED IS NOT TYPICAL.
C
  100 IF(TST1.GT.10.) RETURN
      IF(TST2.GT.(.05*RANGE)) RETURN
      IF(TST3.GT.10.) RETURN
      IF(TST4.GT.10.) RETURN
C
      RESLT=1
      RETURN
      END
```

```
      INTEGER*2 A(1400),B(1400),C(1400)
      REAL D(6,1400)
      REAL*8 CUR(2,300),PWR(2,300),VOLT(2,300),PF(2,300)
      CALL INITQ(A,B,C,D,1400)
20    READ(5,6,END=8) ISIZE
6     FORMAT(I3)
      DO 30 I=1,ISIZE
      READ 21,CC,V,P,PFF,T
21    FORMAT(5F10.3)
      CUR(1,I)=T
      VOLT(1,I)=T
      PWR(1,I)=T
      PF(1,I)=T
      CUR(2,I)=CC
      VOLT(2,I)=V
      PWR(2,I)=P
      PF(2,I)=PFF
30    CONTINUE
      CALL GRAPHQ('SECONDS$','VOLTS$',VOLT,ISIZE,1)
      CALL GRAPHQ('SECONDS$','CURRENT$',CUR,ISIZE,1)
      CALL GRAPHQ('SECONDS$','POWERS$',PWR,ISIZE,1)
      CALL GRAPHQ('SECONDS$','POWER FACTOR$',PF,ISIZE,1)
      GO TO 20
8     STOP
      END
```

```
C
C-----------------------------------------------------------------------
C
C              THIS PROGRAM CONVERTS THE DIGITIZER TAPE TO AN
C              INTERMEDIATE FORM PRIOR TO THE ANALYSIS STEP.
C              ALL ERROR RECORDS ARE BYPASSED AND RECORDS WITH
C              INCORRECT FORMAT ARE ALSO BYPASSED.
C
C              THERE IS ONE PARAMETER CARD THAT IS INPUT TO
C              THIS PROGRAM:
C
C                COL. 1-  NO. OF MACHINES FOR WHICH DATA IS BEING
C                         RECORDED ON THE INPUT TAPE.
C
C                COLS. 2-3  FILE NO. TO WHICH DATA IS BEING
C                         WRITTEN (SHOULD AGREE WITH THE DD CARD
C                         LABEL PARAMETER).
C
C-----------------------------------------------------------------------
C
      REAL*4 NUM(3,4,4)/48*0.0/,D1,D2
      LOGICAL*1 MANUAL(6),BUFF(224)
      LOGICAL*4 CEQ,CNE
      INTEGER*2 HH,MM,SS,FILE,LIT(4)/'C ','V ','P ','PF'/
      KK=0
      KERR=0
      KNT=0
      READ(5,100) MACH,FILE
  100 FORMAT(I1,I2)
      JJ=(32+MACH*64)
C             THIS SECTION READS A RECORD AND CHECKS ITS FORMAT,
C             BYPASSING IT IS WRONG OR WRITING IT TO DISC IF
C             IT IS RIGHT.
  700 KNT=KNT+1
      READ(9,701,ERR=9999,END=11) (BUFF(I),I=1,JJ)
      DO 10 I=1,32
      IF(CEQ(BUFF(I),'+',1).OR.CEQ(BUFF(I),'.',1).OR.
     1CEQ(BUFF(I),'-',1)) GO TO 9998
   10 CONTINUE
      WRITE(14,701) (BUFF(I),I=1,JJ)
  701 FORMAT(224A1)
      WRITE(19,710) KNT, (BUFF(I),I=1,JJ)
      GO TO 700
   11 ENDFILE 14
      REWIND 14
C-----------------------------------------------------------------------
C             READ RECORDS FROM DISC, ACCUMULATE STATISTICS, AND
C             WRITE TO INTERMEDIATE TAPE WHICH GOES TO ANALYSIS STEP
C
    1 READ(14,101,END=99) MANUAL,HH,MM,SS,((D1,NUM(I,J,1),D2,
     1J=1,4),I=1,MACH)
  101 FORMAT(T7,6A1,T22,I2,1X,I2,1X,I2,3X,12(A4,F11.5,A1))
      WRITE(12,200) HH,MM,SS,((NUM(I,J,1),J=1,4),I=1,3)
  200 FORMAT(3I2,12(A4))
      KK=KK+1
      IF(KK.NE.1) GO TO 2
      IH=HH
      IM=MM
      IS=SS
```

```
    2 DO 5  I=1,MACH
      DO 4  J=1,4
      IF(KK.NE.1) GO TO 3
      NUM(I,J,2)=NUM(I,J,1)
      NUM(I,J,3)=NUM(I,J,1)
      GO TO 4
    3 IF(NUM(I,J,2).GT.NUM(I,J,1)) NUM(I,J,2)=NUM(I,J,1)
      IF(NUM(I,J,3).LT.NUM(I,J,1)) NUM(I,J,3)=NUM(I,J,1)
    4 NUM(I,J,4)=NUM(I,J,4)+NUM(I,J,1)
    5 CONTINUE
      GO TO 1
C-----------------------------------------------------------------------
C              PRINT STATISTICS
C
   99 WRITE(6,102) MACH,MANUAL,FILE,IH,IM,IS,HH,MM,SS
  102 FORMAT('1',4X,I1,' MACHINE(S)  DATE: ',6A1,' FILE # = ',I2/
     1' ','TIME SPAN: ',I2,':',I2,':',I2,'-',I2,':',I2,':',I2)
      DO 12 I=1,MACH
      WRITE(6,201) I
  201 FORMAT('0','MACHINE # ',I1/' ',T12,'MIN',T24,'MAX',T36,'MEAN')
      DO 9 J=1,4
      NUM(I,J,4)=NUM(I,J,4)/KK
      WRITE(6,202) LIT(J),(NUM(I,J,K),K=2,4)
  202 FORMAT('0',T6,A2,T12,F11.5,T24,F11.5,T36,F11.5)
    9 CONTINUE
   12 CONTINUE
      ENDFILE 12
      WRITE(6,205) KK,KERR
  205 FORMAT('3',I6,' RECORDS WRITTEN -- ',I4,' ERROR RECORDS BYPASSED'/
     1'1')
      STOP
C-----------------------------------------------------------------------
C              ACCUMULATE ERROR COUNT
C
 9998 WRITE(8,710) KNT,(BUFF(I),I=1,JJ)
  710 FORMAT(' ',I4,'>',128A1/' ',96A1)
 9999 KERR=KERR+I
      GO TO 700
      END
```

APPENDIX IX

DIGITAL RECORDER ANALYSIS PROGRAM
JOB CONTROL AND DATA INPUT PARAMETERS

APPENDIX IX - DATA ANALYSIS PROGRAM JOB CONTROL AND DATA INPUT PARAMETERS

To obtain the intermediate tape using "MCNV," the original digitizer tape and the following card deck are submitted to the Penn State Computer Center:

```
/*TAPE MINE01,WRITE,L
/*TAPE RHK02,READ,D
// EXEC RUN,PROG=WTLOG,PARM='MCNV0#10'
// EXEC FHG
//DATA.DECK DD *

          (OBJECT DECK)

/*
//DATA.FT09F001 DD UNIT=2400,VOL=SER=DWN02,
// LABEL=(1,NL),DCB=(RECFM=FB,LRECL=96,BLKSIZE=96)
//DATA.FT12F001 DD UNIT=2400,DCB=(RECFM=FB,LRECL=54,BLKSIZE=5400),
// VOL=SER=MINE01,LABEL=(2,SL),DSN=STD01
//DATA.FT14F001 DD UNIT=SYSDA,SPACE=(CYL,10),DISP=(NEW,PASS),
// DCB=(RECFM=FB,LRECL=96,BLKSIZE=3360)
//DATA.FT08F001 DD SYSOUT=A
//DATA.FT19F001 DD SYSOUT=A
//DATA.INPUT DD *
102
/*
```

The data parameter card has the following format:

Column 1. The number of machines monitored

Columns 2 and 3. The file number. Data is written to the file number and should agree with the label parameter number on FT12F001 DD (data definition) job control card.

The succeeding job control changes must be considered prior to each run:

1. The DD cards for the digitizer tape (FT09F001) should be altered as follows:

   a. Set "LRECL" (record length) and "BLKSIZE" (block size) to 96, 160, or 224 to accommodate data from 1, 2, or 3 machines, respectively.

b. "VOL=SER=MINE01" should be changed to the unique name written on the tape cannister.

2. The output tape (FT12F001) job control DD cards should be changed in the following ways:

   a. "VOL=SER= __________". Insert the intermediate tape reel name in blank.

   b. "LABEL=(n,SL)". "n" will designate the tape positioned file to be written.

   c. Change "STD01" to "STD0n" (do not change FT12F001).

3. Refer to:

   IBM System/360 and System/370 Operation System: Job Control Reference, International Business Machines Corporation, 3rd Ed., March, 1972.

   Available from IBM, Programming and Systems Publications, Dept. D58, P. O. Box 390, Poughkeepsie, New York 12602.

4. The tape cards at the beginning of the run cards will tell which tapes (volume names) are being used by the current job. They also indicate the protect status for the tape:

   WRITE. The program can be read from and written to the tape.

   READ. The program can only be read from the tape.

   The names, "DMW02" and "MINE01," should be changed to correspond with current tape labels. They also indicate the tape source, either submitted with job (D) or in system library (L).

The "MC1-MC2" program accepts the intermediate tape produced as primary input. Also, one parameter card is required. A plotting program may be run using the BAT (Batch and Terminal) files created if the "GRAPH" parameter is specified.

```
//              TAPE=MINE01,OUT
//              END OF TAPE CARDS
// EXEC RUN,PROG=WTLOG,PARM='MC1-MC2@#2@'
// EXEC FHG
//DATA.DECK DD *


          (OBJECT DECK)


/*
//DATA.FT08F001 DD UNIT=SYSDA,SPACE=(CYL,10),
// DCB=(RECFM=VS,LRECL=24,BLKSIZE=28),DSM=&&T,
// DISP=(NEW,PASS)
//DATA.FT09F001 DD DSM=&&T,VOL=REF=*.FT98F001,
// DISP=(OLD,PASS)
//DATA.FT12F001 DD UNIT=2400,DCB=(RECFM=FB,LPECL=54,BLKSIZE=5400),
// VOL=SER=MINE01,LABEL=(1,SL),DSN=STD01
//FT96F001 DD UNIT=BAT,FILES=($X1,$X2,$X3)
/*USERID RHK02
//DATA.INPUT DD *
1P      05                    0.00      150.75    630.00    150.75    1.0
```

The parameter card has the following format:

Column 1. "MACH" specifies whether the first, second, or third machine is to be analyzed; if blank, "1" is assumed.

Column 2. "CP." Insert "C" or "P." "C" means the current parameter will be used to determine typical curves or events. Otherwise, power will be the determining parameter.

Column 4. "GRAPH." When set to "G," column 4 causes typical curve data to be passed to the graph program.

Columns 9 and 10. "IFR." This is the interval or frame size for scanning (filtering) data when determining curves.

Columns 31 to 40. "GSLOPE," the slope threshold for determining curves. If blank or zero, it is computed as the average of current or power (dependent on "CP") divided by IFR+2.

Columns 41 to 50. "CCUR."

Columns 51 to 60. "CVOLT."

Columns 61 to 70. "CPWR."

Columns 71 to 80. "CPF."

Columns 41 through 80 are for the correction factors (for current, voltage, power, and power factor - in that order) to transform analog to actual values.

The DD cards for the input tape (FT12F001) follow the same conventions as in "MCNV."

The "MPLOT" program is executed at a later time by inputting the BAT files (essentially card files stored on disk for later retrieval by their name assigned at creation time). This allows the user to eliminate any graphs by rejecting those cards for the typical curve definition. Further, unreasonable or "noise" data can be omitted before graphing, as in the case where little is known about the nature of the data (e.g., an error record due to the digitizer). Output of the program is a set of card decks that can be used to plot the typical curves on a Calcomp Plotter.

APPENDIX X

GLOSSARY OF DIGITAL RECORDER ANALYSIS PROGRAM VARIABLES

APPENDIX X - GLOSSARY OF VARIABLES

Analysis Program Variables

C = A particular current data entry

CC = Indicator used in determining typical curves

CCC = This character variable has the value "C"

CMIN = Current minimum of a curve

CMAX = Current maximum of a curve

CCUR = Correction factor for current

CVOLT = Correction factor for voltage

CPWR = Correction factor for power

CPF = Correction factor for power factor

CP = The character "C" or "P" is entered in "CP" to state which power parameter (current or power) is used in typical curve definition

C$P = Has the value "1" if current is used to define typical curves or Has the value "2" if power is used to define typical curves

CMEAN = Current mean of a curve

CSD = Current standard deviation of a curve

DUMMY = The accessing method requires that "RECFM" = "VS" (variable and spanned) be specified in the "DD" cards. This in turn causes eight extra bytes to be inserted at the front of each record. To retrieve a record, it is then necessary to read in the "REAL*8" variable "DUMMY" (which is ignored) along with the desired data.

GSLOPE = A slope value that must be exceeded to define curve beginning or end points. If "GSLOPE" input is zero, "OPT" value is passed to "GSLOPE."

IC = Counter in "TIME" subroutine that indicates the number of adjacent points that are surrounded by line segments having slope less than "GSLOPE"

IFR = Frame size or time interval in seconds used in calculating the slope of the current or power curve

IFMT = Input data format array

IMFIN = Total number of data entries

ID = Index to random disc file

J1MAX = Total number of curves or events in the data set

KC = Used in the "TIME" routine to identify stored possible curve begin and end points

KOUNT = Number of curves with similar statistical values. If "KOUNT" $\geq$ three the group of curves is defined "typical."

KWH = Kilowatt hours

MFR = An integer variable calculated in the "TIME" routine representing the time in seconds that individual point scanning begins for curve begin and end point definition

MINC = Current minimum of all data

MAXC = Current maximum of all data

MINV = Voltage minimum of all data

MAXV = Voltage maximum of all data

MINP = Power minimum of all data

MAXP = Power maximum of all data

MINPF = Power factor minimum of all data

MAXPF = Power factor maximum of all data

NO = Indicator used in determining typical curves

OPT = Optimum slope or a slope value calculated within the program that must be exceeded by "D$DT" of the "TIME" routine before a curve can be defined. When "GSLOPE" equals zero, the value of "OPT" passes to "GSLOPE." "OPT" = mean of power/("IFR" + 2) or mean of current/("IFR" + 2) depending on "CP" parameter.

P = A particular power data entry

PF = A particular power factor data entry

PMEAN = Power mean of a curve

PFMEAN = Power factor mean of a curve

PSD = Power standard deviation of a curve

PFSD = Power factor standard deviation of a curve

PMIN = Power minimum of a curve

PMAX = Power maximum of a curve

PFMIN = Power factor minimum of a curve

PFMAX = Power factor maximum of a curve

R = A 5 x 2 array for current and power data used in calculating curve slope in the "TIME" routine. Allows selecting current vs power for curve determination.

SAVE = A "TIME" routine array for possible curve begin and end times. If the possible points are proved to be actual curve beginnings and endings then the values of "SAVE(1)" and "SAVE(KC-1)" are passed to "TP(J1)" and "TP(J1 + 1)."

SLOPE = A statement function that calculates the slope between two points

TH = Time data entry in hours

TM = Time data entry in minutes

TP = Array containing time in seconds (index) of curve begin and end points

TS = Time data entry in seconds

TOT1 = Total of all current entries

TOT2 = Total of all power entries

V = A particular voltage data entry

VMEAN = Voltage mean of a curve

VSD = Voltage standard deviation of a curve

VMIN = Voltage minimum of a curve

VMAX = Voltage maximum of a curve

Graph Routine Variables

A = Work space for the QDGS (Quick Draw Graphics System) Subroutines

B = Work space for the QDGS Subroutines

BEG = Start point of curve in seconds

C = Work space for the QDGS Subroutines

CC	=	Individual current datum point
CVR	=	Current array
D	=	Work space for the QDGS Subroutines
END	=	End point of curve in seconds
NUM	=	The number associated with this typical curve (the occurrence order in the data)
OPTION	=	An integer (-1, 0, 1) for graph type preferred
PF	=	Power factor array
PFF	=	Individual power factor datum point
PP	=	Individual power datum point
PWR	=	Power array
SIZE	=	Number of points contained in curve to be plotted
T	=	Individual time datum point
VOLT	=	Voltage array
VV	=	Individual datum point

APPENDIX XI

DIGITAL RECORDER PROGRAM OUTPUT EXAMPLES

APPENDIX XI - DIGITAL RECORDER PROGRAM OUTPUT EXAMPLES

The program provided in Appendix VIII has two primary outputs: Standard Computer Printout and Calcomp Plotter tracings. The illustrations available in Figure 99 give an example of the latter type and represent the typical power parameter of a 48S a-c Torkar during tramming (loaded) from the mine to the dumping point. Another example of this particular operational cycle is Figure 91, Appendix II, but is from strip chart recordings. The illustrations in both figures are very similar although much greater resolution is provided with the digital system.

The maximum current level provided by the strip charts is 150A, but Figure 99b indicates that during peak loads, current reaches approximately 185A. The voltage drops in the latter part of Figure 99c are a result of the continuous miner starting (maximum, 475V; minimum, 413V). Strip charts only provide 460V maximum and 420V minimum, for the same situation.

The power factor output in Figure 99d illustrates the restrictions placed on both recording systems by the transducer. The zero output levels are (more than likely) created by the fluctuations in current. Because current turns the transducer's multivibrator off, large fluctuations in the rms current level confuse the circuit, and result in zero output.

The 8CM Joy continuous miner (operating in the same section) was having starting problems (the magnetic contactors would not hold). This resulted in several start-stop-start-stop operations. The effect on voltage levels is shown in the latter part of Figure 100, a strip chart output. Furthermore, a similar type curve from the digitizer system is illustrated in Figure 101, and again shows higher resolution of these voltage drops.

A specific advantage in the digital recorder technique is that the output can be adjusted to show the detail needed. The strip chart recordings are restricted by the original medium.

An example of computer printout is available in Table 37, and the machine was the same 48S Torkar. For reasons of brevity, only the first typical and atypical curves are given. The output includes the following:

1. Original correction factors and input parameters.
2. Overall maximum and minimum power parameters values.
3. Typical curve statistics and data points.
4. Atypical curve statistics.

Only a few examples are provided in the appendix, but these show adequately the superiority of the digital recorder system over the strip charts.

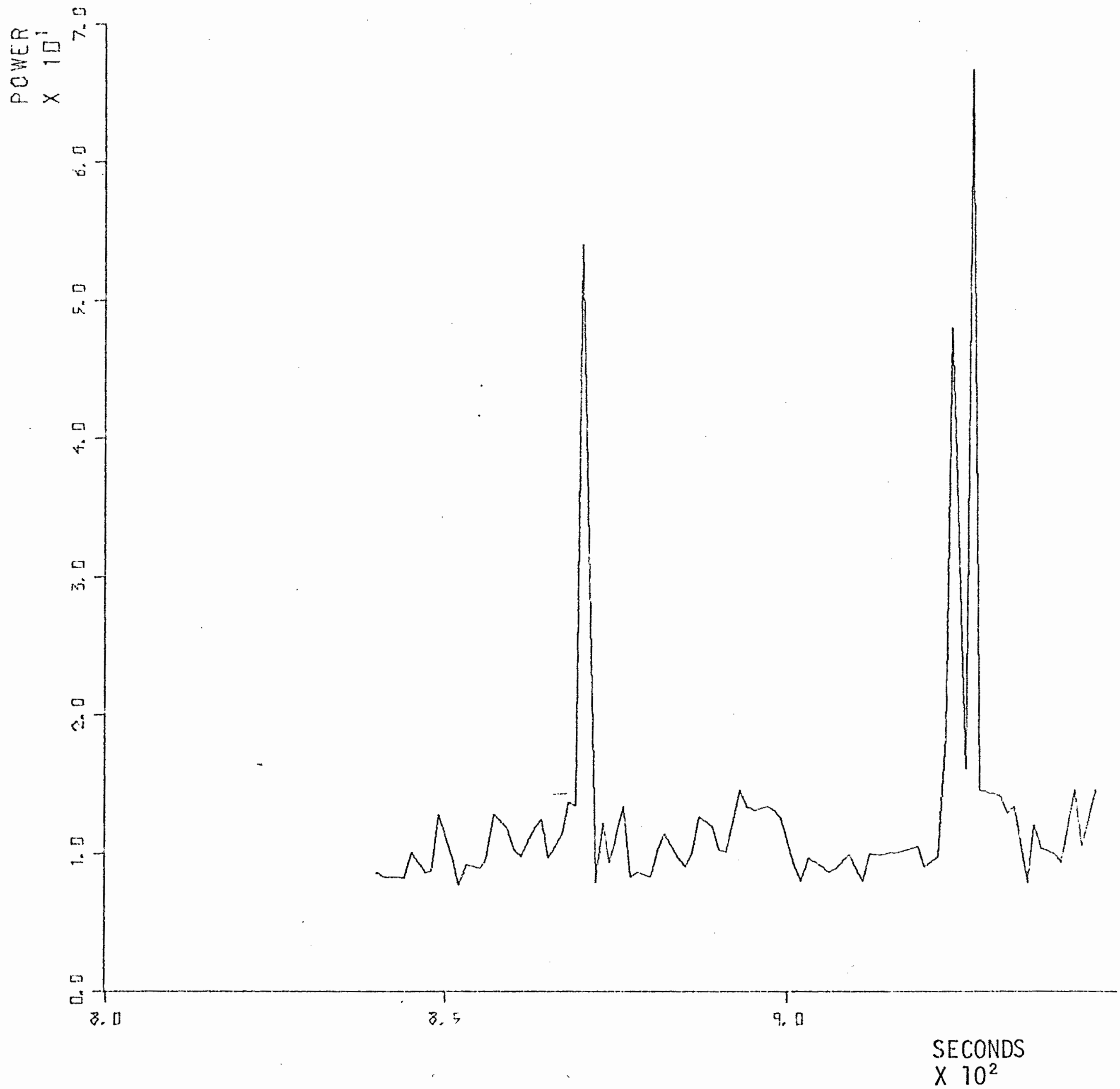

Figure 99a. Typical Tramming Power Cycle for a 48S Torkar (a-c) Traced by a Calcomp 1401.

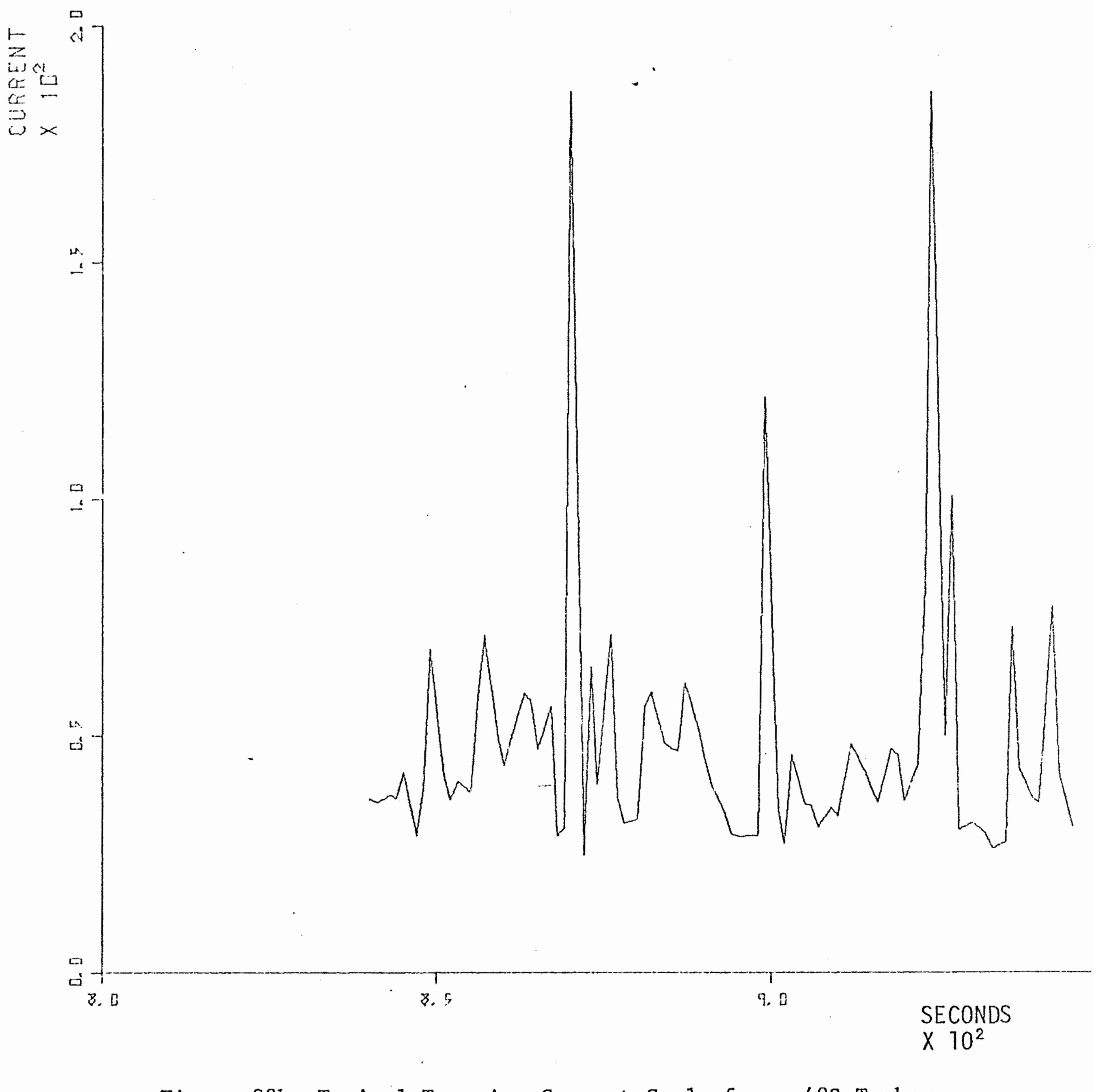

Figure 99b. Typical Tramming Current Cycle for a 48S Torkar (a-c) Traced by a Calcomp 1401.

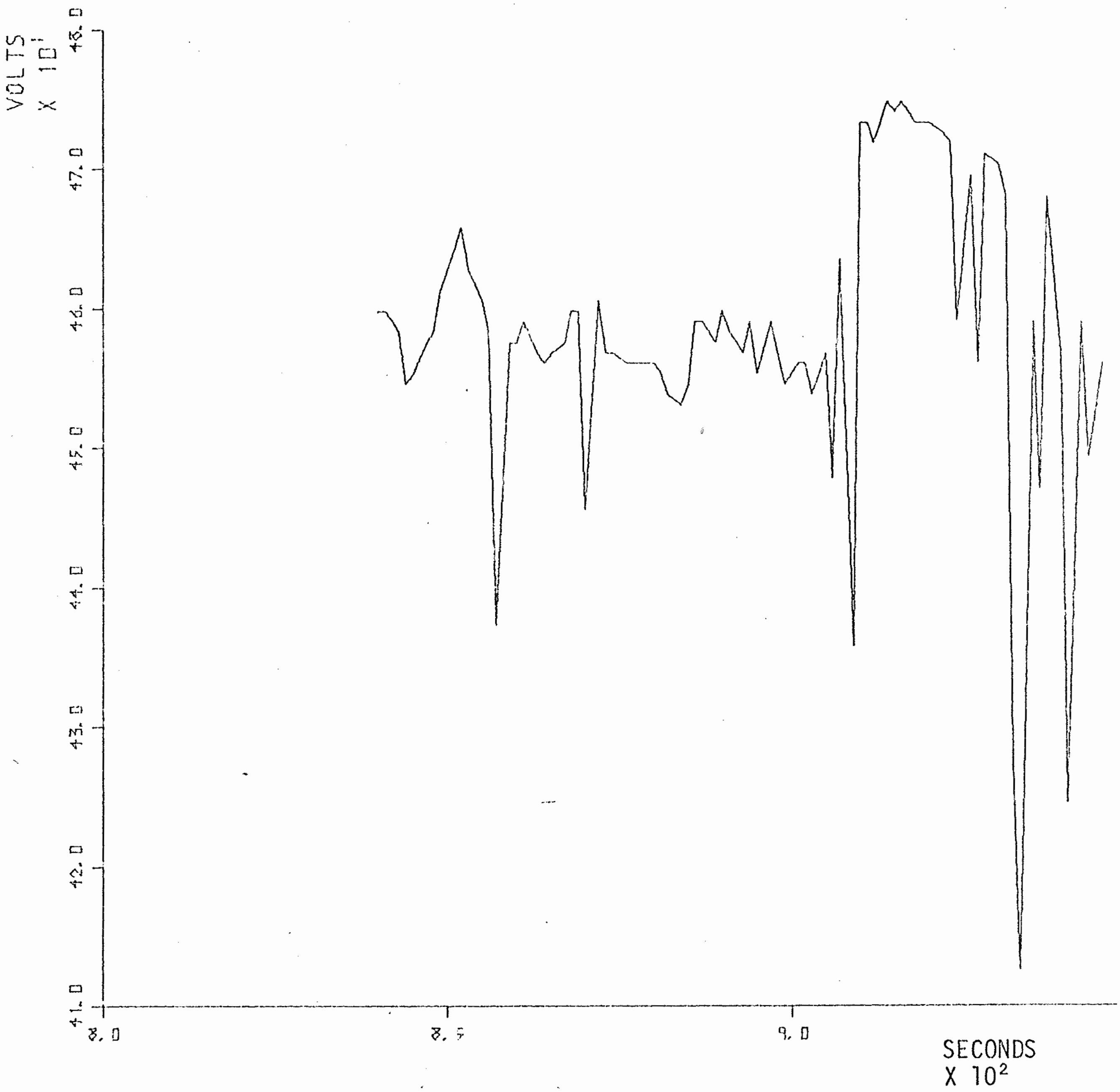

Figure 99c. Typical Tramming Voltage Cycle for a 48S Torkar
Traced by a Calcomp 1401.

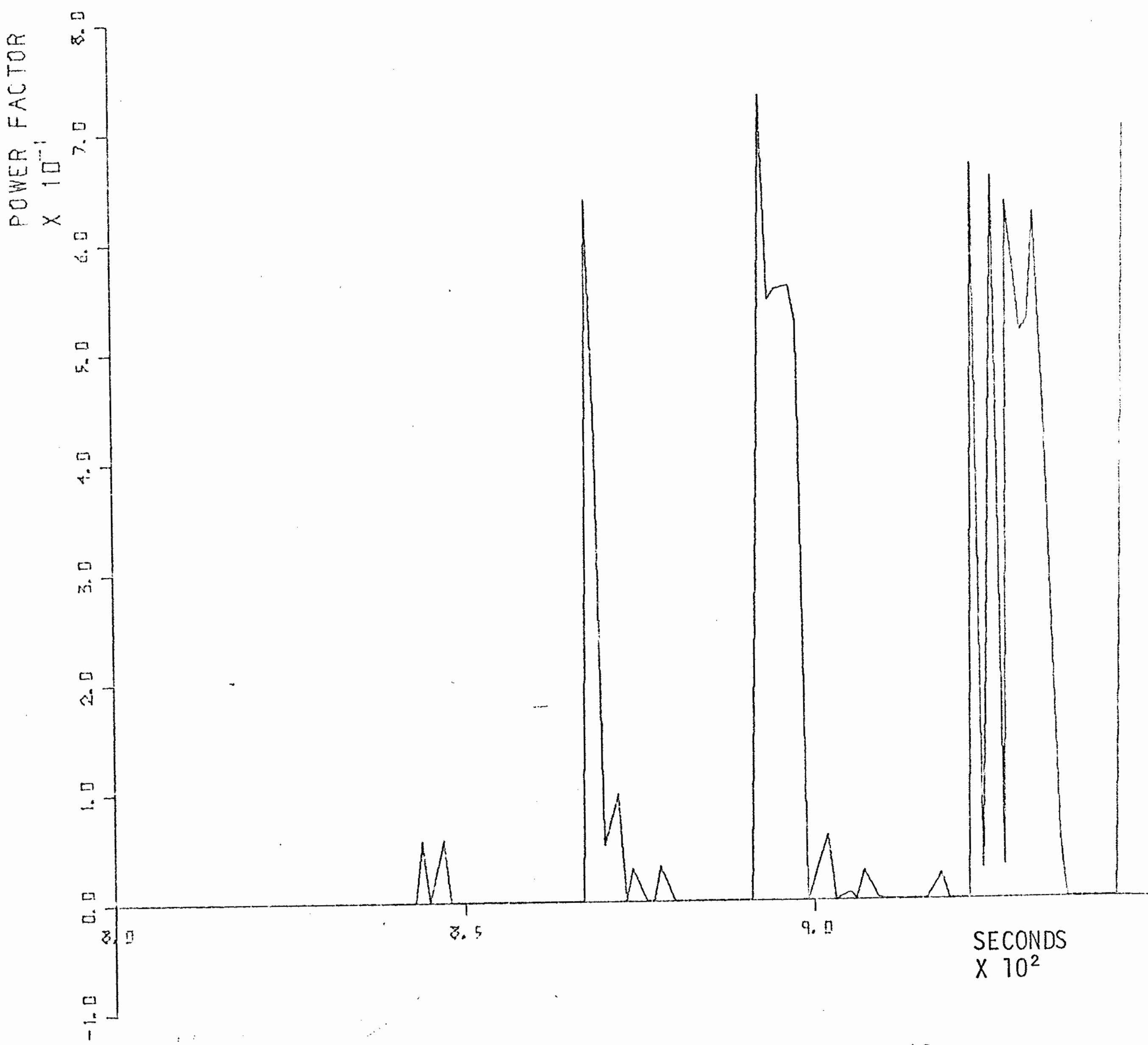

Figure 99d. Typical Tramming Power Factor Cycle for a 48S Torkar (a-c) Traced by a Calcomp 1401.

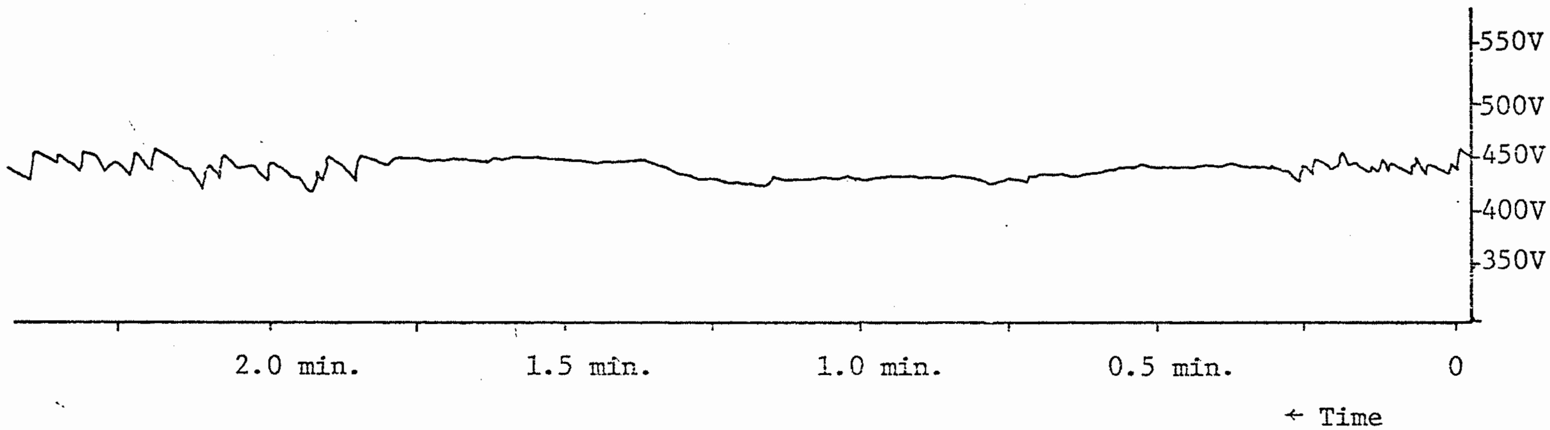

Figure 100. Strip Chart Voltage Output

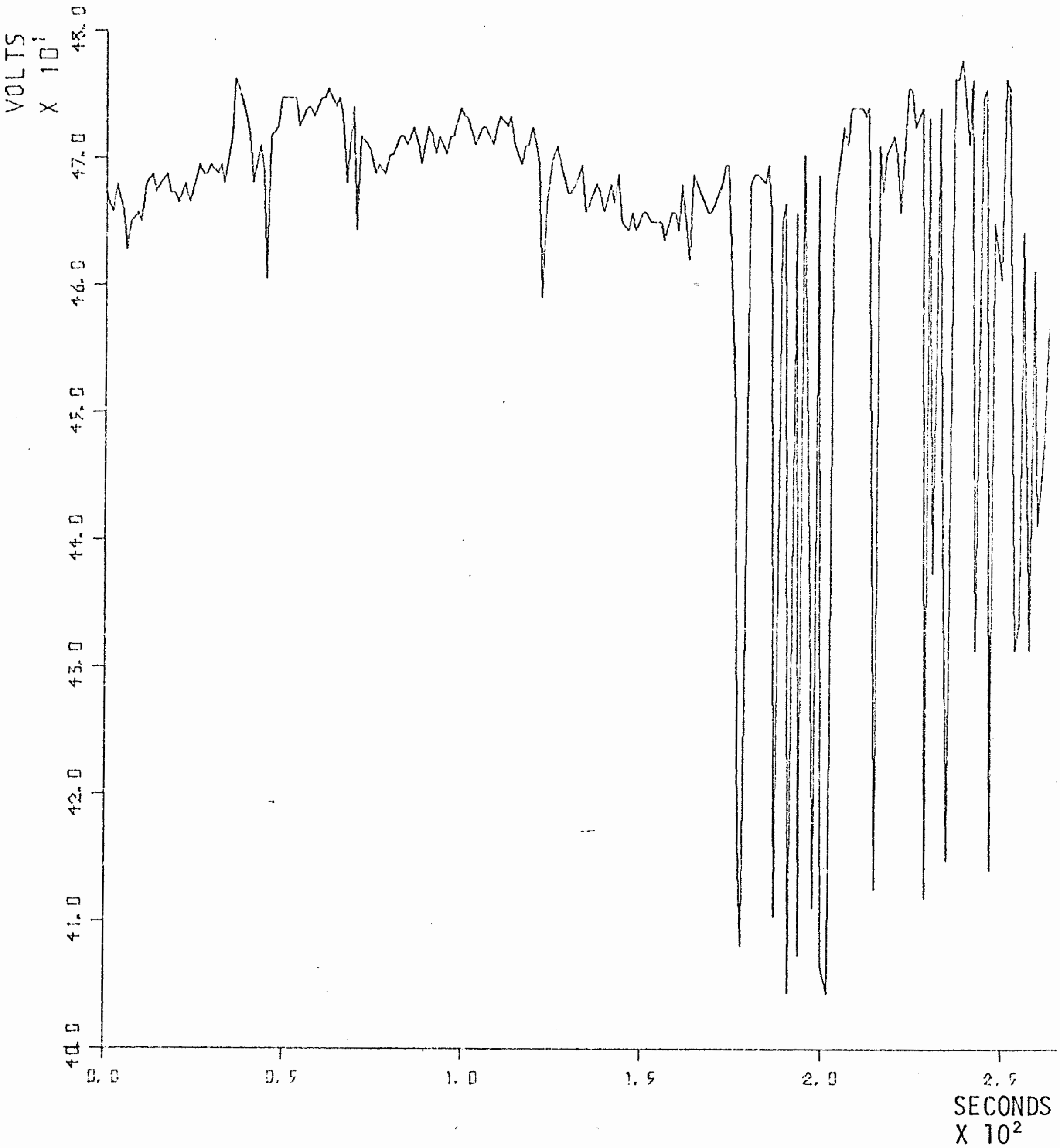

Figure 101. Calcomp 1401 - Digital Recorder Voltage Output.

Table 37. Digital Recorder Output.

CORRECTION FACTORS:

C 150.0000
V 750.0000
P 150.0000
PF 1.0001

SLOPE THRESHOLD 1.0000
FRAME SIZE 3

TOTAL RECORDS: 4769

	MIN	MAX	
CURRENT	0.0	186.600	AMPS.
VOLTAGE	395.250	490.500	VOLTS
POWER	0.0	66.750	KW.
POWER FACTOR	0.0	1.0000	

OPT. SLOPE THRESHOLD = 1.44AMP/SEC

CURVE NUMBER 1 IS A TYPICAL CURVE.
THERE ARE 6 CURVES THAT ARE SIMILAR WITHIN
THE SPECIFIED LIMITS.

1	0.- 263. SEC.	0.00 KWH.
5	314.- 407. SEC.	0.00 KWH.
19	578.- 612. SEC.	0.00 KWH.
35	1117.- 1406. SEC.	0.01 KWH.
39	1436.- 1485. SEC.	0.00 KWH.
53	1714.- 1990. SEC.	0.01 KWH.

	MIN	MAX	MEAN	STD-DEV
CURRENT	0.0	0.450	0.216	0.209
VOLTAGE	404.250	477.750	464.484	15.995
POWER	0.0	0.430	0.130	0.088
POWER FACTOR	0.985060	0.998599	0.989515	0.006434

TIME (SEC)	CURRENT (AMPS)	VOLTAGE (VOLTS)	POWER (KW)	POWER FACTOR
0.	0.450	467.250	0.0	0.9854
1.	0.0	466.500	0.150	0.9854
2.	0.300	465.750	0.150	0.9854
3.	0.450	468.000	0.150	0.9854
5.	0.450	465.750	0.150	0.9854
6.	0.450	462.750	0.150	0.9854
7.	0.450	465.000	0.150	0.9854
9.	0.300	465.750	0.0	0.9854
10.	0.450	465.000	0.0	0.9854
11.	0.300	468.000	0.150	0.9854
13.	0.450	468.750	0.0	0.9854
14.	0.0	467.250	0.0	0.9854
15.	0.300	468.000	0.075	0.9986
17.	0.450	468.750	0.075	0.9986
18.	0.0	467.250	0.0	0.9986
19.	0.0	467.250	0.0	0.9986
20.	0.0	466.500	0.075	0.9986
21.	0.300	468.000	0.150	0.9854
23.	0.0	466.500	0.150	0.9854
24.	0.0	467.250	0.0	0.9986
26.	0.0	469.500	0.075	0.9986
27.	0.0	468.750	0.150	0.9986
28.	0.0	468.750	0.0	0.9854
29.	0.0	469.500	0.0	0.9986
31.	0.0	468.750	0.150	0.9854
32.	0.0	469.500	0.0	0.9854
33.	0.0	468.000	0.150	0.9859
35.	0.0	471.750	0.0	0.9854
36.	0.0	476.250	0.150	0.9858
37.	0.450	475.500	0.43	0.9858
39.	0.0	473.250	0.150	0.9858

THE STATISTICS OF CURVE NUMBER 2 ARE: 3 POINT(S)

BEGINNING OF CURVE: TIME = 263. SEC., CURRENT = 0.450 AMPS.,
VOLTAGE = 456.750 VOLTS, POWER = 0.0 KW.,
POWER FACTOR = 0.9986

	MIN	MAX	MEAN	STD-DEV
CURRENT	0.450	57.450	28.850	23.271
VOLTAGE	450.750	456.750	453.000	2.700
POWER	0.0	54.150	22.300	22.116
POWER FACTOR	0.357665	0.998599	0.617735	0.275249

0.01 KWH.

END OF CURVE: TIME = 266. SEC., CURRENT = 28.650 AMPS.,
VOLTAGE = 451.500 VOLTS, POWER = 12.750 KW.,
POWER FACTOR = 0.4969