V E N T I L A T I O N   P R O B L E M S

O F   T H E   T O N O P A H - B E L M O N T   M I N E .

A THESIS.

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IN CANDIDACY FOR THE DEGREE OF

ENGINEER OF MINES.

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By

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VENTILATION PROBLEMS OF THE TONOPAH-BELMONT MINE.

In May, 1922, Mr. E. D. Gardner, Mining Engineer, United States Bureau of Mines, made an examination of underground air and dust conditions in the mines of the Tonopah-Belmont Development Co., Tonopah, Nevada. In June, 1926, at the request of Mr. L. R. Robbins, General Manager of the company, Mr. B. O. Pickard, District Engineer for the United States Bureau of Mines, made another investigation of the property to make a supplementary report covering the extensive development work and air control since 1921 and to prepare a set of ventilation maps of the mine. The writer assisted Mr. Pickard in the investigation and was detailed to do practically all the field work, compilation of data and preparation of the maps. Mr. Pickard has given the writer much valuable assistance in the preparation of this report through reading and criticizing the manuscript.

PERSONNEL.

Mr. G. A. Heller is President of the Tonopah-Belmont Development Co. with offices at 500 Bullitt Building, Philadelphia. The company is operating several mining properties in Nevada and Arizona under the direction of Mr. L. R. Robbins, General Manager. Mr. P. W. Racey is General Superintendent of the Nevada properties. The Underground Superintendent of the Belmont Mine is Mr. Earl B. Belding and the Chief Engineer, Mr. H. J. Hershey.

The officials of the company cooperated in every way possible. Free access to every opening and working place underground was given. Mr. Racey and Mr. Belding assisted in the work with helpful suggestions. Mr. George Dowd, timberman and ventilation assistant, acted as guide for eight days. Much of the success of the investigation is due to Mr. Dowd's interest in the work and knowledge of air conditions. He had installed most of the ventilation improvements in the mine.

LOCATION.

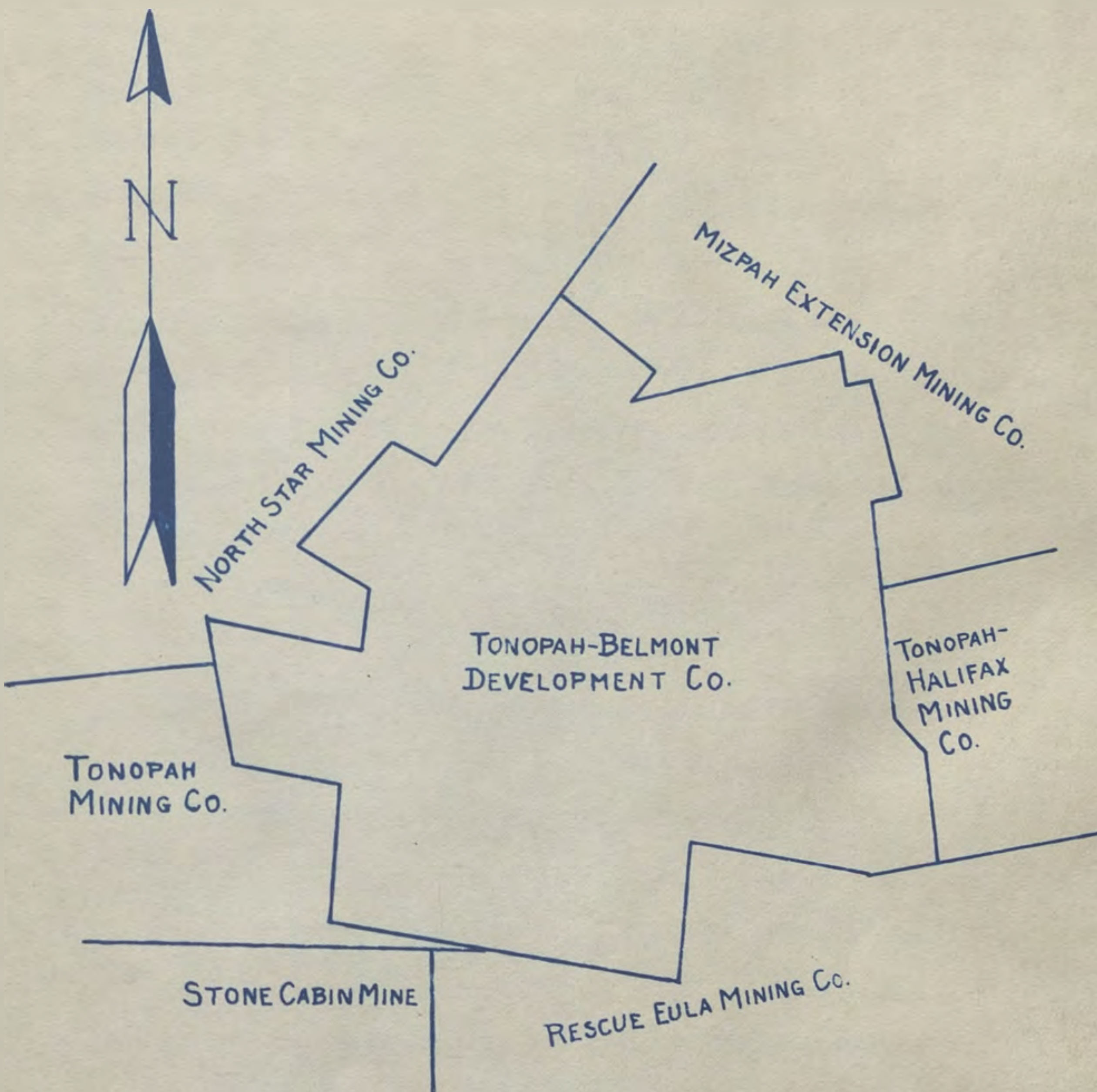
The Belmont Mine and the main offices of the company are situated in Tonopah, western Nye County, Nevada. Tonopah has an elevation of 6090 feet above sea level. It lies in a group of mountains about 1000 feet above the surrounding valleys. It has broad gauge railroad connections to the north and to the south by the Tonopah

Tonopah, looking towards Belmont.

South end of Tonopah, looking from Belmont and Goldfield Railroad and the Tonopah and Tidewater Railroad, respectively. Water for domestic purposes is piped seventeen miles from the Rye Patch springs. Most of the water used for milling, compressor cooling and mining purposes is pumped from the mines. The population is about 3500. In general, the temperature is mild but for short times in the winter the thermometer may drop to 0 degrees and in summer rise to 90 degrees. The climate is typical of most of Nevada, humidity being very low and precipitation slight, 5.44 inches per annum average.

HISTORY.

Ore was first discovered in Tonopah by Mr. James Butler in 1900 on the Mizpah vein of the present Tonopah Mining Co. The district quickly developed into a flourishing mining camp with scores of mining companies, many of which became producers and dividend payers. One of the earliest companies to be organized was the Tonopah-Belmont Development Co. in 1902, adjoining the Tonopah Mining Co. on the east. The Desert Queen shaft was located on the boundary line between the two companies and cut the Mizpah vein at a depth of about 500 feet.



A Portion of the Tonopah Mining District

Later the Belmont shaft was sunk thru 700 feet of capping rhyolite before entering the vein bearing formations. The company has been in continuous operation since it was organized. In 1912 a 60-stamp mill was erected and later enlarged to 100 stamps. The method of treatment was by cyanidation. At present the mill is not in operation; in fact, much of the machinery has been removed to other properties of the company. The ore now mined is transported by railroad to a custom cyanide mill at Millers. Nevada.

PRODUCTION.

The following data on production from the Tonopah district was obtained from Mr. Henry Rives, Secretary of the Nevada Mine Operators' Association:

Production Tonopah District	over	$150,000,000.00
Production Tonopah-Belmont	Over	30,000,000.00
Dividends Tonopah District		34,346,970.00
Dividends Tonopah-Belmont		10.793.630.00

ORE OCCURENCE.

The geology of the Tonopah district was writen by Mr. J. E. Spurr for the United States Geological

Belmont Office.

Belmont Mine, looking from Mizpah Extension.

Yard Belmont Mine.

Collar Belmont Shaft.

Belmont Shaft.

Main working shaft, upcast above 1000 level.

Desert Queen Shaft, downcast.

A small amount of air intakes at collar of shaft.

Survey in Professional Paper No. 42, "Geology of the Tonopah Mining District." This is an exhaustive and thorough report and is generally considered authentic. The rocks of the district are mainly andesites and rhyolites, the earlier of which have been broken by much faulting. There has been identified four periods of vein formation following periods of eruption, but only the oldest veins, those in the early andesite have produced ore bodies.

The vein system of the Belmont Mine consists of twenty or more veins extending roughly east and west and dipping at various angles from vertical to twenty degrees. There is much intersecting and faulting of veins. The stoping width varies from a couple of feet to eighty feet. The vein-forming minerals are chiefly quartz and orthoclase containing the silver minerals stephanite, polybasite and argentite. But little pyrite and practically no galena or sphalerite is found.

MINING METHODS.

(a) Developments.

Very little development work is being done at the present time. Three large Ingersoll-Rand drifter machines, type S80, are used for prospecting purposes.[1] These

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1. "Exploratory Deep Hole Drilling" by R. K. Brown, Compressed Air Magazine, April, 1926.

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machines have drilled holes a horizontal distance of more than 200 feet, and at a 40° angle to a depth of 75 feet. Three carbide cans in series are used to catch the sludge from the holes and samples of the drillings are taken at regular intervals. After ore is discovered by a drill hole, it is opened up by driving a cross cut or a raise to the ore body and then stoped in the usual manner.

(b) <u>General Operations</u>.

The mine is worked thru two three-compartment vertical shafts, the Belmont and the Desert Queen. The Belmont is the main working shaft. Thru it all the ore is hoisted, the crew goes on and off shift, and most of the supplies are handled. Beginning with the 700 level, laterals are driven from the shaft every 100 feet with the exception of the 800 level which has no connection with the shaft. The lowest level, the 1500, has been abandoned, pumps, fans, etc., have been removed, and it is now filled with water.

The Desert Queen shaft is on the western edge of the property about 2000 feet from the Belmont shaft. It is only used occasionally to lower supplies. It has levels every 100 feet from the 400 level to the 1100 foot level. Only two of the levels, the 900 and 1000, connect direct to both shafts.

Most of the working places are nearer the Belmont shaft. The only exceptions are two stopes on the 900 level that are a little closer to the Desert Queen. This is the only level in the Desert Queen workings that is producing any ore at the present time. But in the Belmont workings ore is being mined or developed on every level above the 1300 level.

Mining is now in the narrower veins of width from three to ten feet. Portions of the old square set stopes are still accessable but only one such stope is being worked. The usual method of mining is overhand stoping and supporting the hanging wall with stulls. Filling is not necessary in these stopes. About ten per cent of the ore is from underhand stopes.

Ore from the upper levels is trammed to ore passes to the 1000 level, the main haulage level. Storage battery locomotives are then used to transport the ore from these ore passes to another ore pass near the

Belmont shaft where it drops to an ore pocket below the 1100 level. Ore from the 1100, 1166, and 1200 levels passes thru raises to the 1200 level where it is trammed by hand to an ore pocket at the 1200 station. Three-ton skips in balance are used to hoist the ore.

The production, 100 tons per day, is only 20% of the output of the mine when the price of silver was higher. No data was obtained in this investigation as to the assay value of the ore, mining costs, ore reserves, or future possibilities of the mine. Mining costs must be relatively high, however, because of the small tonnage, high overhead, and the number of times the ore is handled underground.

Pumps are located on the 1200 and 1400 levels. Water is piped from a concrete bulkhead below the Halifax shaft to the pump on the 1400 station which lifts it to a tank on the 1200 level. Here a second pump elevates the water to the surface where it is used to cool the compressor and for surface and underground water lines. The pumps only run a few hours a week as water is needed. The Halifax shaft which supplies the water belongs to the Tonopah-Halifax Mining Co., an adjoining property to the east. The Belmont Mine is dry.

The wage scale in Tonopah is as follows:

Surface labor	$5.25
Muckers and trammers	5.25
Miners	5.75
Timbermen	5.75
Hoisting Engineers	6.00
Mechanics	6.00

There are about 115 men on the pay roll. Over 50% of the men are Americans. While many nationalities are represented, Mexicans form by far the greater part of the foreign laborers.

(c) Operations Affecting Ventilation.

Blasting is done when going off shift. As the mine is only worked one shift, there is ample time for the gases from the powder to be removed from the mine. One miner was noted who does not abide with the 3:00 PM blasting hour and is in the habit of spitting his holes in the middle of the shift.

Drilling in stopes is with wet stoper machines. These machines are only partially successful in laying the dust. When drilling there is usually considerable dust in suspension in the stopes. In development faces a mounted leyner machine is used which is very effective in preventing dust. The large Ingersoll-Rand drifter machines used for prospecting make no dust.

The Nordberg compressor which furnishes compressed air for the mine has a capacity of 2700 c.f.m. of free air. About 25% of this air is used for ventilation purposes in poorly ventilated working places. The balance is used for drilling or for small air hoists.

Alternating current electric power at 440 volts is used for the pumps, booster fans, and the motor generator set for charging storage batteries. A lighting circuit of 110 volts is used to illuminate stations, main haulage ways and pump rooms.

Most of the timbering is with round timber, 6 to 10 inch diameter, with 2 x 12 inch or 3 x 12 inch head boards.

Water is piped alongside the air lines throughout the entire mine. The water is used for wet drilling, wetting down muck piles, spraying at chutes, and sprinkling in drifts and cross cuts.

The dust problem is a serious problem because of the dryness of the mine and the sharp quartzose dust that is stirred up in all handling of ore that has not been well soaked with water.

Several fire monitors and fire plugs are scattered over the surface plant. Fire plugs and hose have been installed on each station of the Belmont and Desert Queen shafts. Wooden ventilation doors have been erected at many places in the mine with the hope of controlling air currents should an underground fire start. A half dozen sets of oxygen breathing apparatus are kept on the surface.

METHODS USED IN VENTILATION STUDY.

This investigation was made in the early summer, June 5th to 12 inclusive, 1926. During this time the weather conditions varied considerably, three of the days being cloudy with some rain and the other days typical Nevada summer weather with low humidity. Natural ventilation is at it poorest during the summer months.

Air currents, with velocities, volumes and temperatures, were mapped throughout the mine. Working places were visited to determine the amount, velocity, temperature and humidity of the air furnished each place; also to note the presence of dust.

Velocities were usually measured with an anomometer. When the velocity was too low for this method, it was measured by observing the time required for smoke from a fuse to travel a known distance along a uniform cross-section. Small quantities of air were often estimated.

A Bureau of Mines sling psychrometer was used to determine dry- and wet-bulb temperatures. By these two readings corresponding humidities were obtained from a Bureau of Mines relative humidity chart.

Barometric pressures were not observed.

Air samples were taken at places where abnormal air conditions were thought to exist, such as return air courses and hot close stopes. These samples were taken in vacuum bottles, capacity about 250 cu. cm., by breaking off the ends of the bottles and allowing air to rush in and replace the vacuum. After the openings were sealed with wax, the samples were forwarded to the Bureau of Mines station at Pittsburgh for chemical analysis.

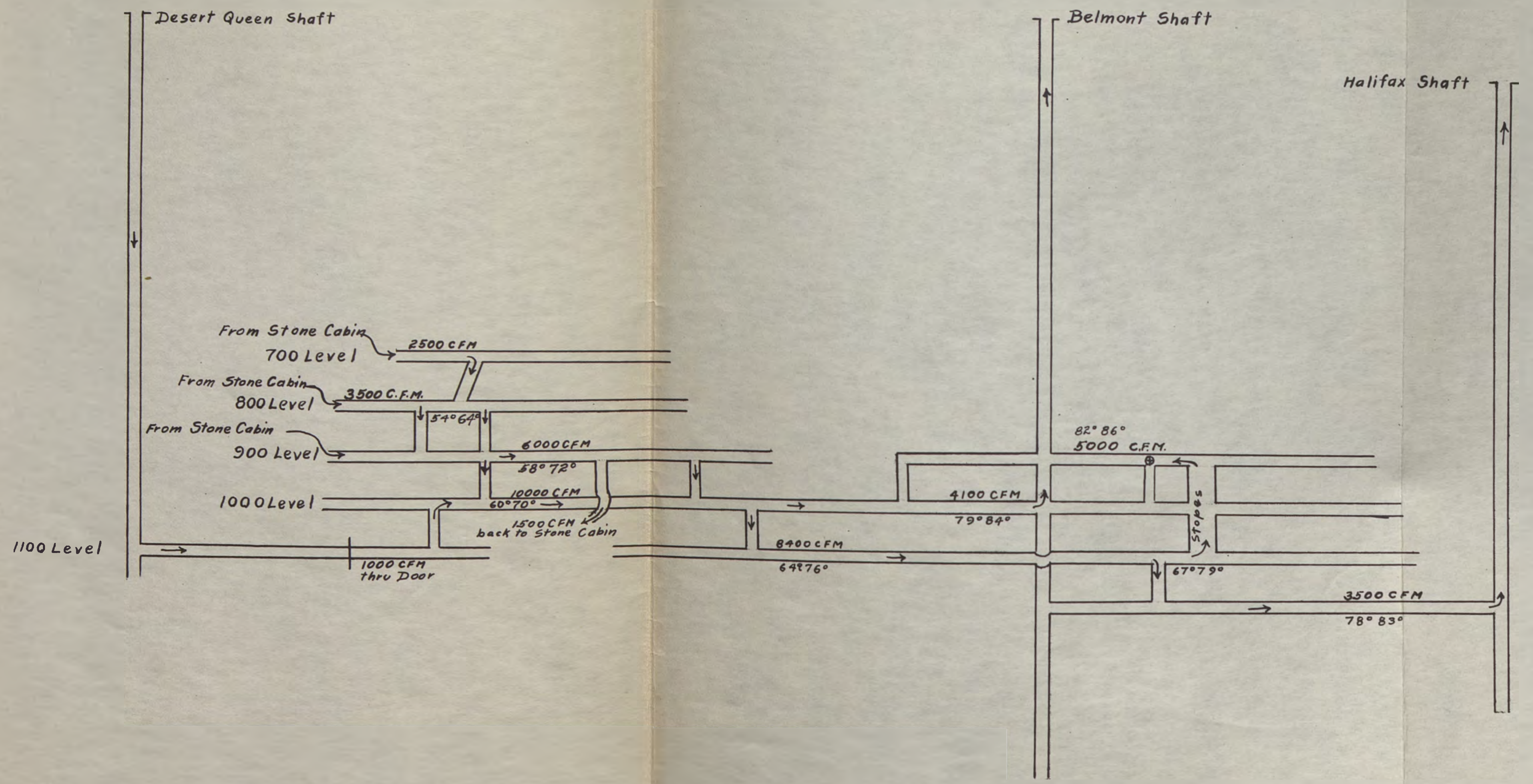
The locations of ventilation control features, such as doors, curtains, bulkheads and booster fans, were mapped. The set-ups of fans were particularly observed.

Notes were taken on conditions that presented a fire hazard or a dust hazard.

VENTILATION SUMMARY.

The Belmont Mine is dependent entirely upon natural ventilation for its air supply. The two main sources are from the Mizpah open stopes of the Tonopah Mining Company and the Stone Cabin Mine of the Jim Butler Mining Company, properties adjoining the Tonopah-Belmont Development Company on the west. The air returns to the surface up the Belmont, Mizpah Extension and Halifax shafts. The last two shafts belong to mining companies east of the Belmont Mine. As points of intake are lower by 100 to 300 feet than the collars of the upcast shafts, and the underground temperatures in the eastern part of the property are higher both summer and winter than surface temperatures, this direction of air flow should be maintained throughout the year.

There are two ventilation systems in the Belmont Mine with different intakes but which join in the return air currents. One system, which I will call the southern ventilation system, receives air from the Stone Cabin Mine on the 700, 800 and 900 levels. The air passes thru several raises and stopes to the 1000 level, where it splits, two-thirds of it going to the 1100 level. After passing working places south of the Belmont shaft, the air return to the surface up the Belmont and Halifax shafts. About 16,000 c.f.m. is the quantity of air in this system.



LONGITUDINAL SECTION

SOUTHERN VENTILATION SYSTEM

TONOPAH BELMONT DEVELOPMENT CO.

TONOPAH NEVADA

SCALE 1" = 200'

DATE JUNE 5 TO 12 1926.

BY B. O. PICKARD.

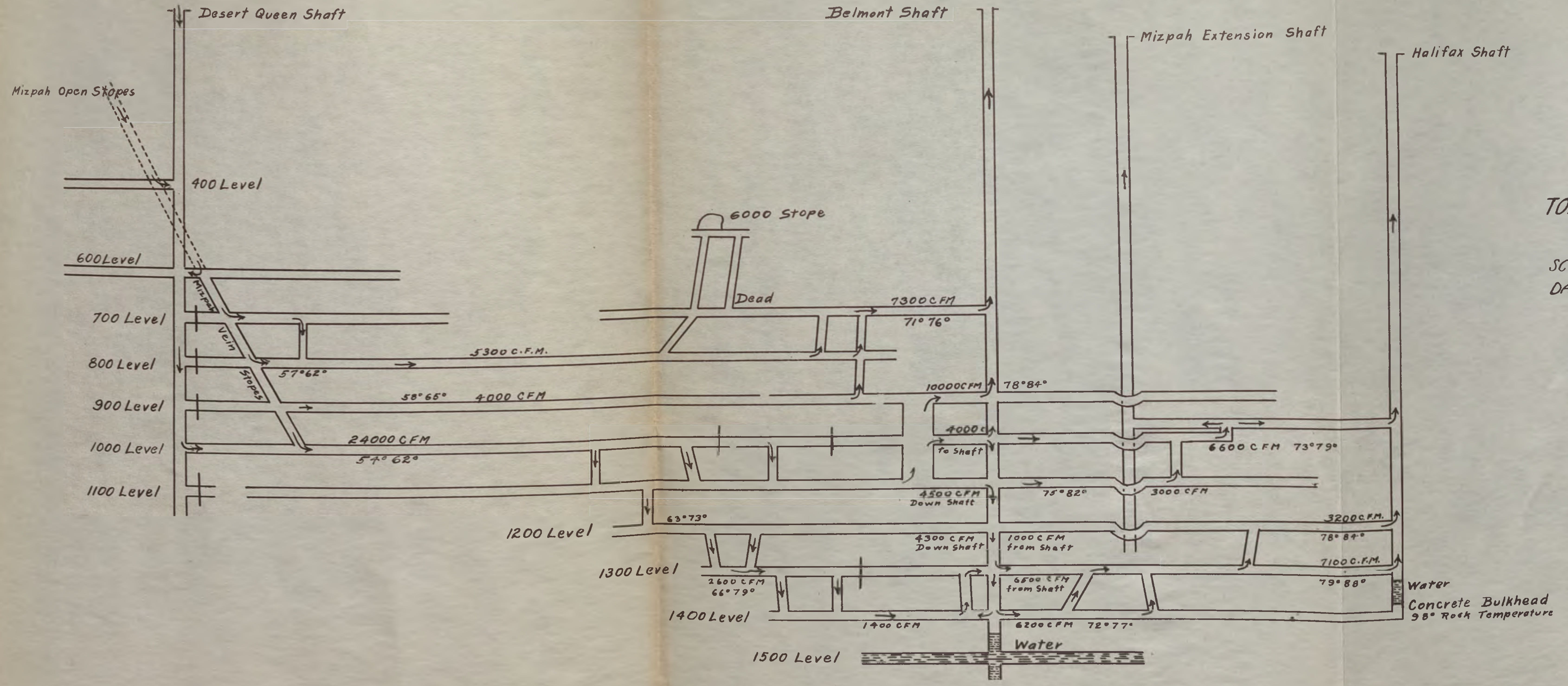
W. I. SMYTH.

LEGEND.

← Ventilation.

60° 70° = Wet and Dry Bulb Temp.

The other system, which I have called the main ventilation system, receives most of its air fron the Mizpah open stopes. A small amount, possibly 2000 c.f.m., intakes at the collar of the Desert Queen shaft. Air from the Mizpah stopes enter the Desert Queen shaft on the 400 and 600 levels. Closed doors near the shaft on the 700, 800 and 900 levels prevent short circuiting thru the upper workings of the mine. This downcast air from the shaft is the larger part of the intake air for the 1000 level. The Mizpah vein stopes furnishes all the intake air for the 800 and 900 levels and the balance of the intake air for the 1000 level. The amounts of air intaking on each level are: 800 level, 5300 c.f.m.; 900 level, 4000 c.f.m.; and the 1000 level, 24000 c.f.m. Air on the 800 level passes along an air course to stopes northwest of the Belmont shaft and then up these stopes to the 700 level upcasting to the surface thru the Belmont shaft. The air on the 900 level splits, part of it going up stopes northwest of the Belmont shaft joining the return air on the 700 level. The balance of the 900 level intake air is used in working places southwest of the Belmont shaft and returns to the surface up that shaft. About one-half of the intake air for the 1000 level enters a large stoped area northwest of the Belmont



LONGITUDINAL SECTION

MAIN VENTILATION SYSTEM

TONOPAH BELMONT DEVELOPMENT CO.

TONOPAH NEVADA

SCALE 1" = 200'

DATE JUNE 5 TO 12 1926.

B. O. PICKARD

W. I. SMYTH.

LEGEND

← Ventilation.

58° 65° Wet and Dry Bulb Temp.

shaft thru which it could not be definitely traced but returns to the surface up the Belmont, Mizpah Extension and Halifax shafts. The other half of the intake air for the 1000 level goes thru a series of raises to the 1100, 1200, 1300 and 1400 levels, some air being taken out on each level for ventilation on that level. This air returns to the surface up the Mizpah Extension and Halifax shafts. It will be noted that air entering the Belmont shaft on the 1000 level splits part going up and part going down. In the lower levels the Belmont shaft is downcast. Longitudinal sections of the two ventilation systems which accompany this report show the ventilation scheme of the Tonopah-Belmont Mine.

The company has given considerable thought to their ventilation problems and has been successful in maintaining good air conditions in most of their working places. By the use of ventilation doors and brattice cloth curtains and bulkheads, air courses are maintained throughout the mine. Booster fans are used where necessary to force air to dead ends and poorly ventilated stopes. Air is prevented from circulating to the North Star Mine on the north or to the Rescue Eula Mine on the south by doors and burlap bulkheads. The management is to be congratulated

Halifax Shaft.

Some of the used air of the Belmont Mine returns to the surface thru this shaft of an adjoining property.

Mizpah Extension Shaft.

This shaft of another adjoining mining company is used to return some of the air from the Belmont Mine to the surface.

on perfecting such a good ventilation scheme with natural ventilation.

In the course of this report it will be shown that the present ventilation scheme is not furnishing proper working conditions in some of the stopes, how it has increased timber decay, and how it could not be relied upon should a fire break out underground.

VENTILATION REQUIREMENTS.

At the present time there are twenty-six working places in the mine. They are distributed as follows:

600 level	....	1 working place
800 level	....	5 working places
900 level	....	6 working places
1000 level	....	3 working places
1100 level	....	7 working places
1166 level	....	2 working places
1200 level	....	1 working places
1300 level	....	1 working place

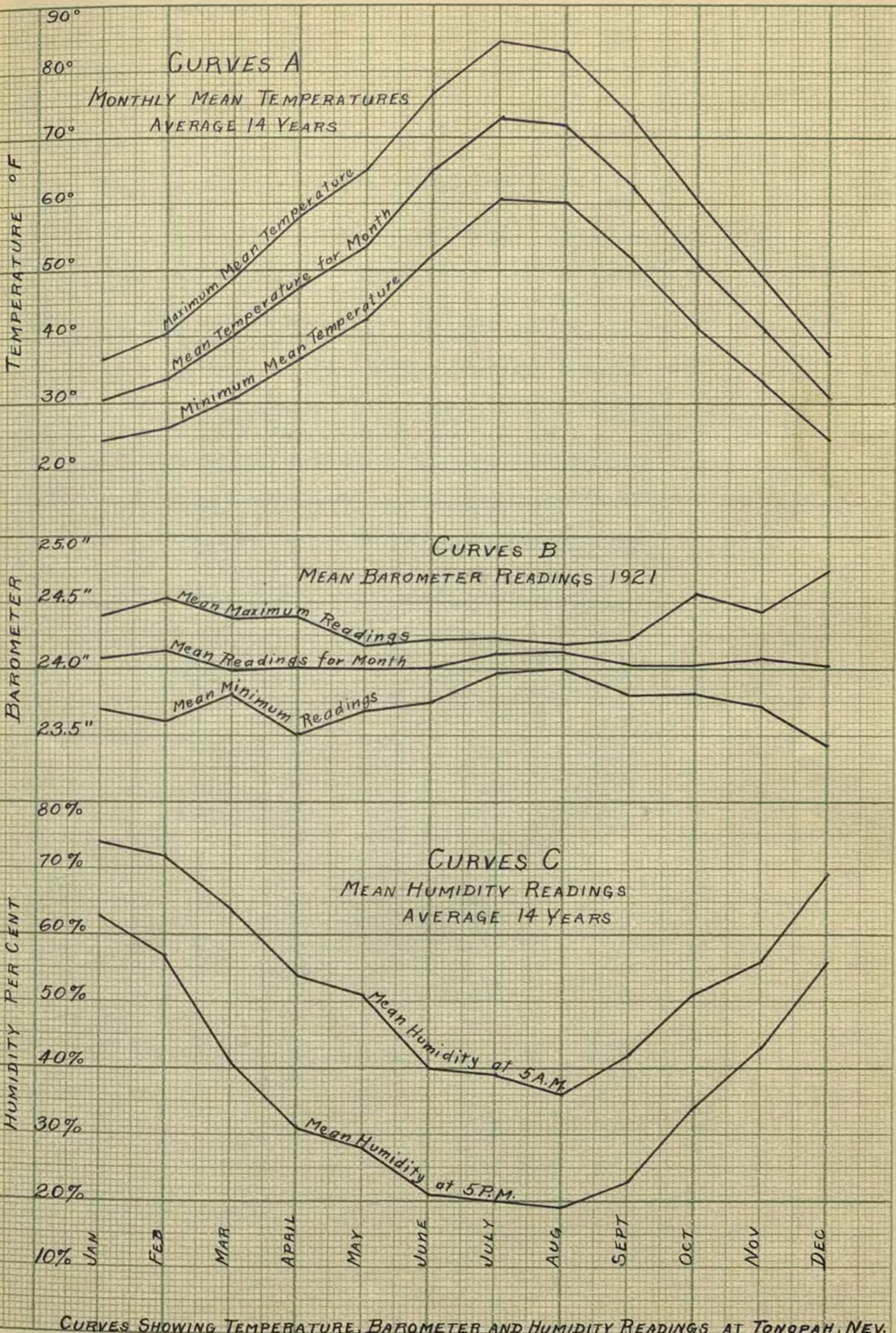
The essential requirement is that each of the above places be supplied with fresh unused air with sufficient velocity to insure comfortable, healthful working conditions, and with sufficient gross amount to insure the cleaning out of all dust and the dilution of all powder and inert gases as fast as generated. The amount of air necessary will depend on the temperature, humidity, cross section, and other conditions in each place.

DETAILS OF STUDY DATA.

The field work on the ventilation conditions at the Tonopah-Belmont Mine was begun on June, 5, 1926. Mr. Pickard spent three days underground and, assisted by Mr. Dowd, ventilation assistant in the Belmont organization, and the writer, studied the intake and return air for the mine as a whole and for each level, mapped the main features of the ventilation scheme, and outlined the balance of the field work. Mr. Dowd and the writer then mapped and measured all air currents in the mine, mapped ventilation control features, made detailed studies of fans, working places, etc., and took several samples of mine air. Eight days were spent in the gathering of data. An order according to levels will be followed in presenting this data rather than chronological order.

SURFACE.

The chart, page 28, showing mean temperature, humidity, and barometer readings at Tonopah were prepared from United States Weather Bureau tables published under the title, "Summary of Climatological Data for the United States, Section 12, Nevada." It will be noted that the mean maximum temperature for July is



CURVES SHOWING TEMPERATURE, BAROMETER AND HUMIDITY READINGS AT TONOPAH, NEV.

85° F. and the mean minimum temperature for January is 24° F., a difference of 61°. Likewise, the mean humidity readings show a variation from 74% in winter to 19% in summer. The highest temperature and the lowest temperature for Tonopah on the Weather Bureau records are 96° and -7°, respectively. The mean of the barometer readings is very near 24 inches of mercury and in all calculations involving barometric pressures that figure will be used.

During the period of the examination, surface temperatures and humidities were observed near the collar of the Belmont shaft.

Date June	Time	Wet Bulb	Dry Bulb	Humidity	Remarks
5	Noon	55°	89°	4%	
5	3 PM	55°	85°	8%	
6	7 AM	55°	75°	24%	close, hazy
6	Noon	62°	82°	31%	
7	7 AM	53°	69°	32%	
7	Noon	58°	82°	20%	
7	3 PM	53°	67°	37%	cloudy
8	7 AM	53°	56°	82%	slight rain
8	Noon	59°	61°	89%	
9	7 AM	53°	54°	94%	cloudy
9	Noon	59°	60°	94%	Raining
9	3 PM	59°	64°	75%	
10	7 AM	53°	59°	67%	
10	Noon	53°	71°	26%	
10	3 PM	56°	75°	27%	
11	7 AM	50°	65°	31%	
11	Noon	55°	77°	20%	
11	3 PM	58°	76°	27%	
12	7 AM	50°	66°	28%	
12	Noon	55°	77°	20%	
Average		55°	71°	42°	

600 LEVEL DESERT QUEEN.

No maps of the 600 level were available. This level is important in the ventilation scheme, however, because 16,000 c.f.m. of air was here measured intaking to the Desert Queen shaft. The air comes from the Mizpah stopes of the Tonopah Mining Co. A door, which should be kept open, is located in the cross cut leading to the shaft. We found the door closed and it sign reversed to read "Keep Closed" when we visited the level on June 7th. Apparently, leasers working in the Tonopah Mining Company's stopes had closed the door and changed the sign accordingly. We closed the door and made the sign read "Keep Open". The temperature of the air then intaking to the shaft was 51° 59° 57%[2]

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2. These readings mean 51° wet-bulb temperature, 59° dry-bulb temperature, and 57% humidity. Hereafter the readings will be recorded without the words, temperature and humidity. Wet-bulb temperatures will always be recorded first.

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and the quantity, 700 x 3.7 x 6.2[3], 16,000 c.f.m.

---

3. These readings mean 700 feet per minute velocity, 3.7 feet by 6.2 feet cross section. The product of the velocity times the cross section equals the volume of air.

By adding this amount of air to that already downcasting thru the shaft, it would be expected that air conditions in the lower levels would be changed somewhat from how we found them on the preceding two days.

600 LEVEL BELMONT.

This is a small level 180 feet above the 700 Level. It is reached from the 700 level by raise EO[4], a two-compartment raise divided into an ore passage and a manway. The manway is supposed to be used for an air course but no air was travelling up it to thelevel at the time of this investigation.

There is one working place from this level, the 6000 stope which extends about 30 feet above the level at a steep angle. The temperature in the stope was 75° 76° and the humidity 96%. A gas sample from the stope analysed 0.27% carbon dioxide, 20.43% oxygen, 79.30% ~~carbon monoxide~~ nitrogen, and no carbon monoxide. It is evident that the men in this stope were working under poor air conditions.

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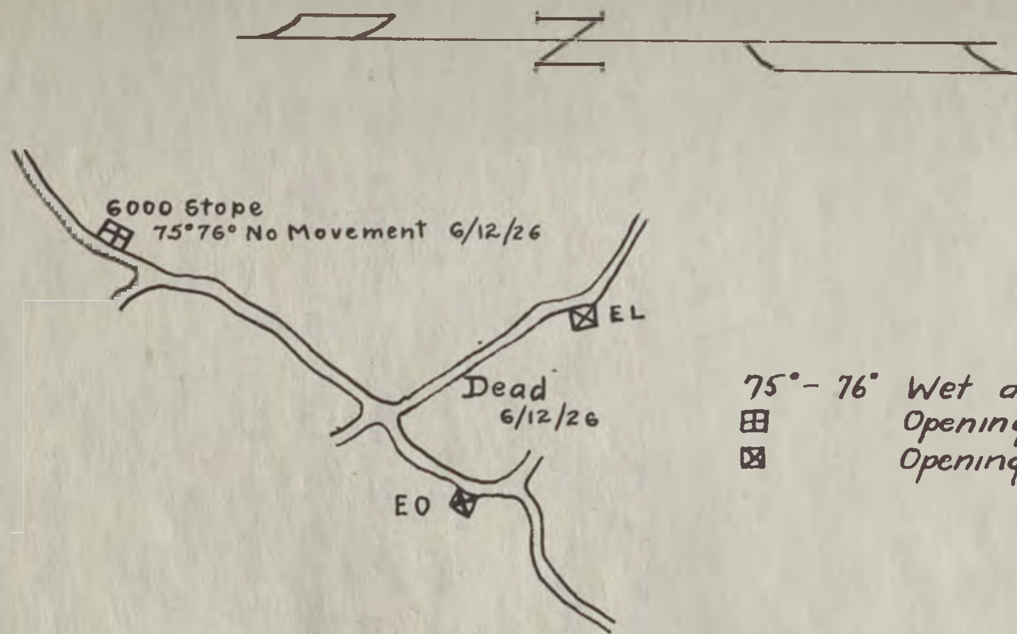
4. See map of 600 level Belmont for location of raise EO. Letters from the alphabet will be used throughout this report to locate on the maps places where notes were taken.



LEGEND

75° - 76° Wet and Dry Bulb Temp.
⊞ Opening above level
⊠ Opening below level

PLAN 600 LEVEL BELMONT

UNDERGROUND VENTILATION REPORT

TONOPAH BELMONT DEVELOPMENT CO.

TONOPAH NEVADA

SCALE 1" = 80'
DATE JUNE 5 TO 12, 1926.

BY B.O. PICKARD.
W.I. SMYTH.

700 LEVEL DESERT QUEEN.

The intake air on the 700 level Desert Queen is from the Tonopah Mining Co. thru an open gate, FJ. This is called a~~n~~ ~~open~~ gate because it is of frame and lattice-work construction and when closed and locked would stop men from traveling from one mine to the other but would not stop air currents. The intake air then passes thru and open door, FI, and down 814 stope to the 800 level. the temperature and quantity of the air on June 7th were 53° 61° 59%, 210 x 5.2 x 7.4, 8100 c.f.m., respectively, and on June 12th, 55° 61° 68%, 280 x 3.4 x 5.8, 5500 c.f.m., respectively. A ventilation door near the Desert Queen shaft keeps this air from mixing with the downcast air in the shaft.

The rest of the level is dead except the portion connecting with the Stone Cabin property of the Jim Butler Mining Co. From this mine 2500 c.f.m. of air intakes on this level and passes thru stopes to the 800 level, this being a part of the southern ventilation system.

Temperature readings at the Desert Queen shaft were the same on both June 7th and June 12th, 53° 59° 67%.

PLAN 700 LEVEL DESERT QUEEN

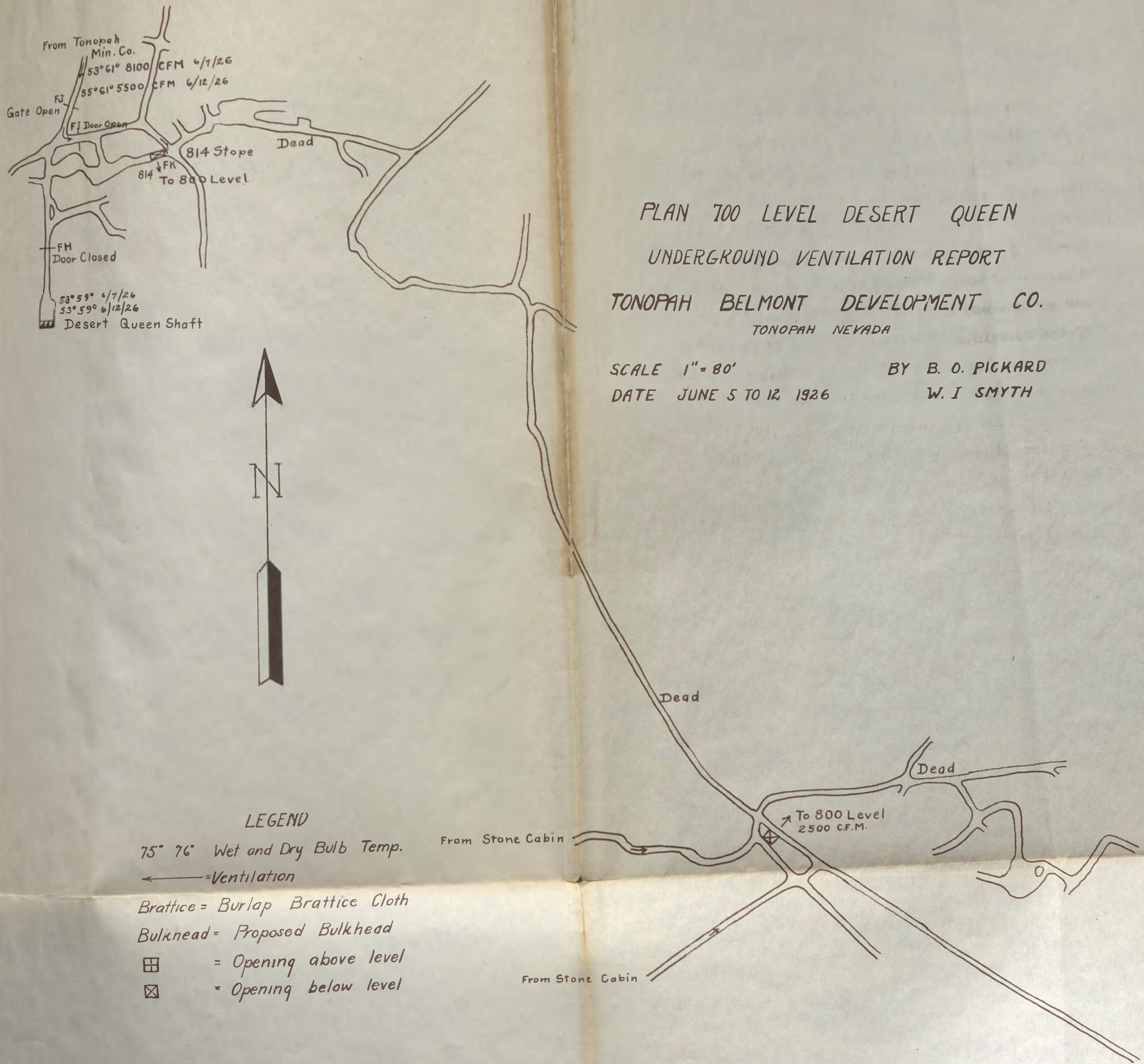
UNDERGROUND VENTILATION REPORT

TONOPAH BELMONT DEVELOPMENT CO.

TONOPAH NEVADA

SCALE 1" = 80' BY B. O. PICKARD

DATE JUNE 5 TO 12 1926 W. I SMYTH



LEGEND

75° 76° Wet and Dry Bulb Temp.

⟵ = Ventilation

Brattice = Burlap Brattice Cloth

Bulkhead = Proposed Bulkhead

⊞ = Opening above level

⊠ = Opening below level

700 LEVEL BELMONT.

Air is received on this level thru stopes from both the 800 and 900 levels. On both June 7th and June 11th there was no movement up raises, EN and EO. These raises are supposed to take air from the 800 level to the 600 level, an intermediate 180 feet above the 700 level. EL is another raise to the 600 level and is supposed to take the return air from that level. There was no movement down that raise, however. The purpose of the curtain,at EN is to force air to the 600 level. A brattice cloth tunnel at EM and a brattice cloth curtain at EJ have been installed to cut off stopes from the main cross cut. A strong wooden door at EI could be closed in case of an emergency to keep air from the Belmont shaft.

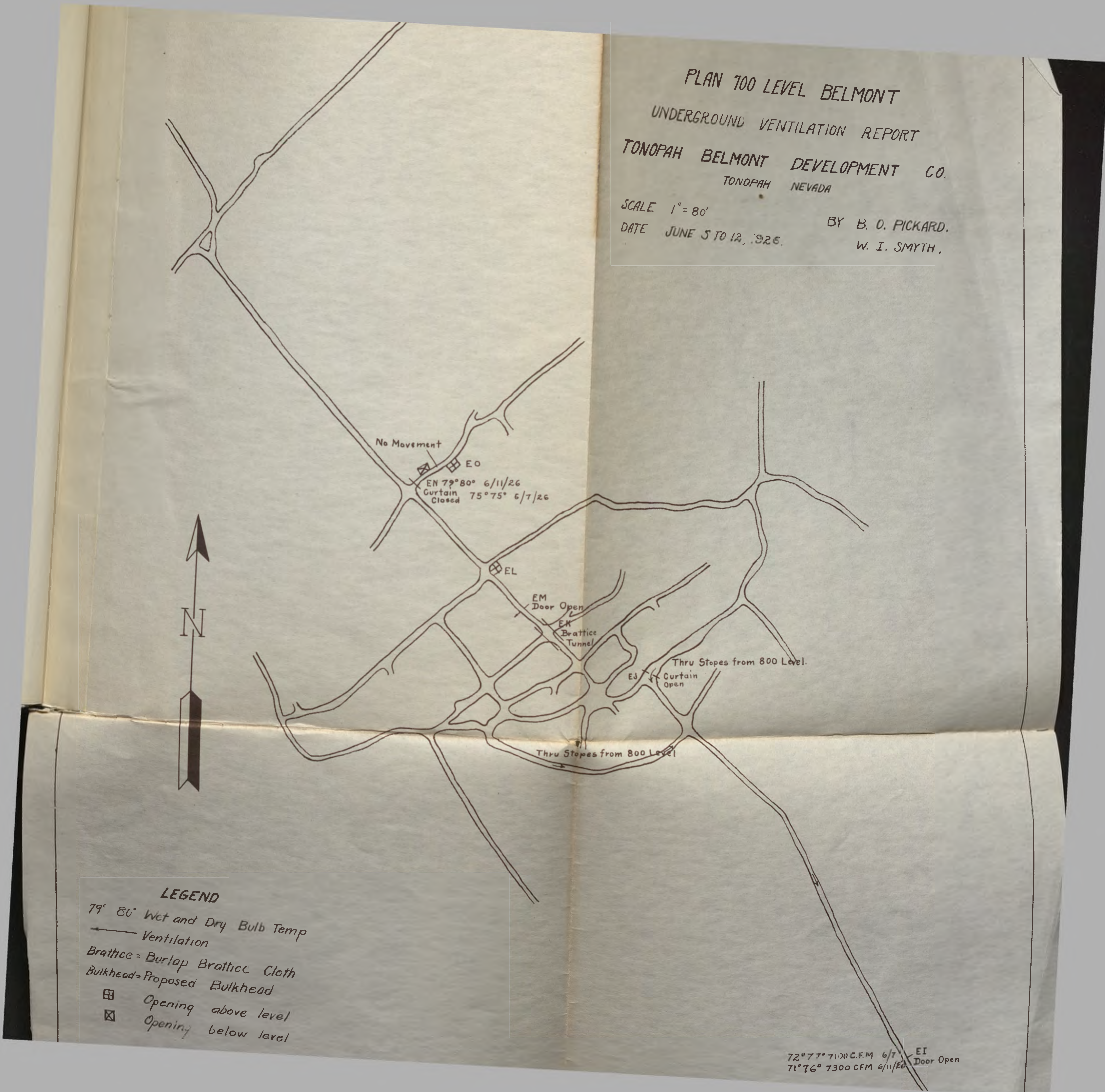
No work was being done on this level except tramming from raise, EO.

Air measurements on the level were as follows:

June 7, 1926, return air, 72° 77° 78%, 330 x 3.3 x 6.5, 7100 c.f.m.

June 11, 1926, return air, 71° 76° 78%, 340 x 3.3 x 6.5, 7300 c.f.m.

June 7, 1926, Belmont shaft, 71° 77° 74%.


PLAN 700 LEVEL BELMONT
UNDERGROUND VENTILATION REPORT
TONOPAH BELMONT DEVELOPMENT CO.
TONOPAH NEVADA
SCALE 1" = 80'
DATE JUNE 5 TO 12, 1926.
BY B. O. PICKARD.
W. I. SMYTH.
No Movement
EO
EN 79° 80° 6/11/26
Curtain Closed 75° 75° 6/7/26
EL
EM
Door Open
EK
Brattice
Tunnel
Thru Stopes from 800 Level.
EJ
Curtain Open
Thru Stopes from 800 Level
N
LEGEND
79° 80° Wet and Dry Bulb Temp
Ventilation
Brattice = Burlap Brattice Cloth
Bulkhead = Proposed Bulkhead
Opening above level
Opening below level
72° 77° 7100 C.F.M 6/7
71° 76° 7300 CFM 6/11/26
EI
Door Open

June 11, 1926, Belmont shaft, 71° 76° 78%.

June 7, 1926, top of raise EN, 75° 75° 100%, no movement.

June 11, 1926, top of raise EN, 79° 80° 96%, no movement.

800 LEVEL.

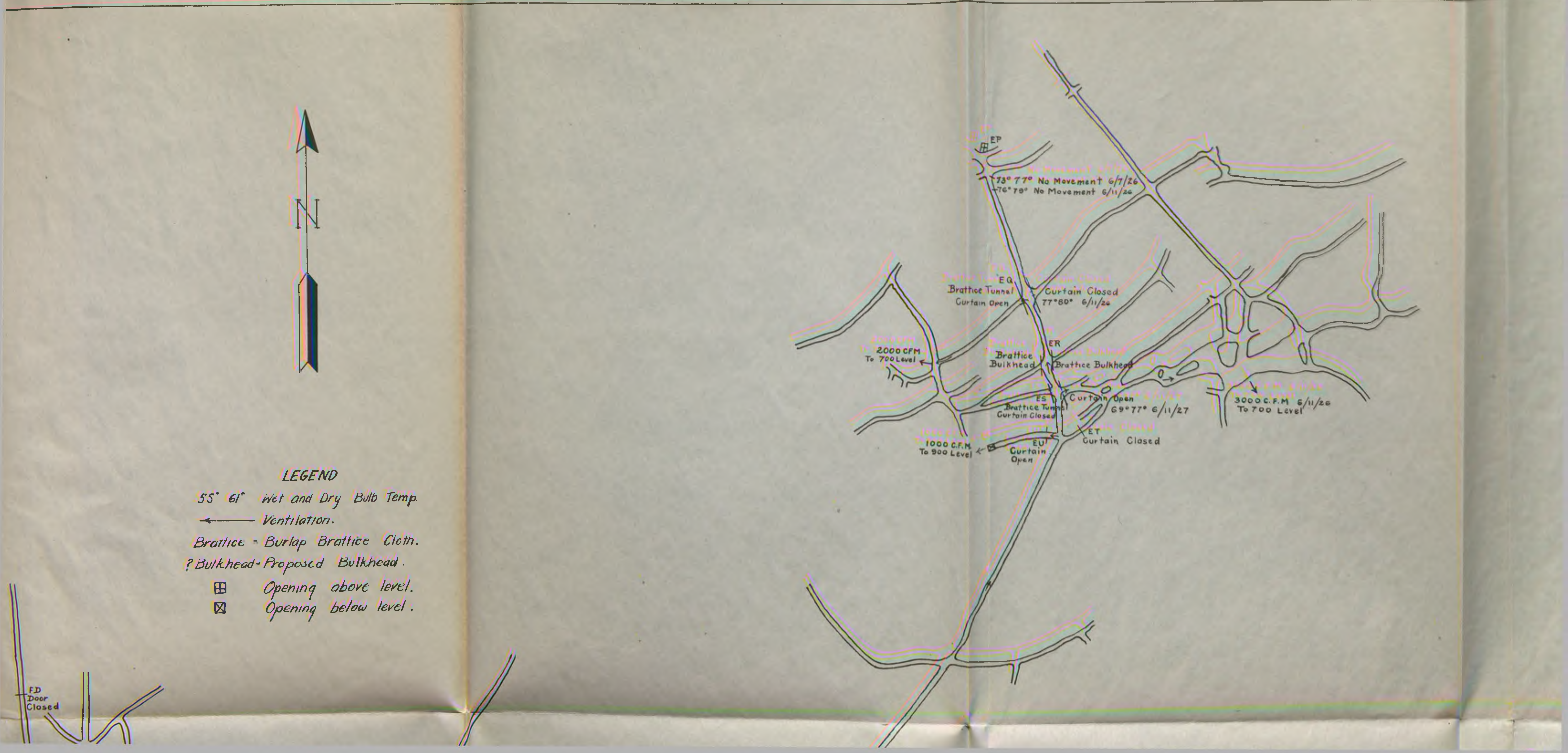
Southern Ventilation System. This system is separated from the main system by a door at EX. The southern ventilation system receives 3500 intaking direct from the Stone Cabin and 3000 c.f.m. more thru stopes from the 700 level. From the 800 level the air goes thru stopes, FM and FN, to the 900 level.

Air measurements were;

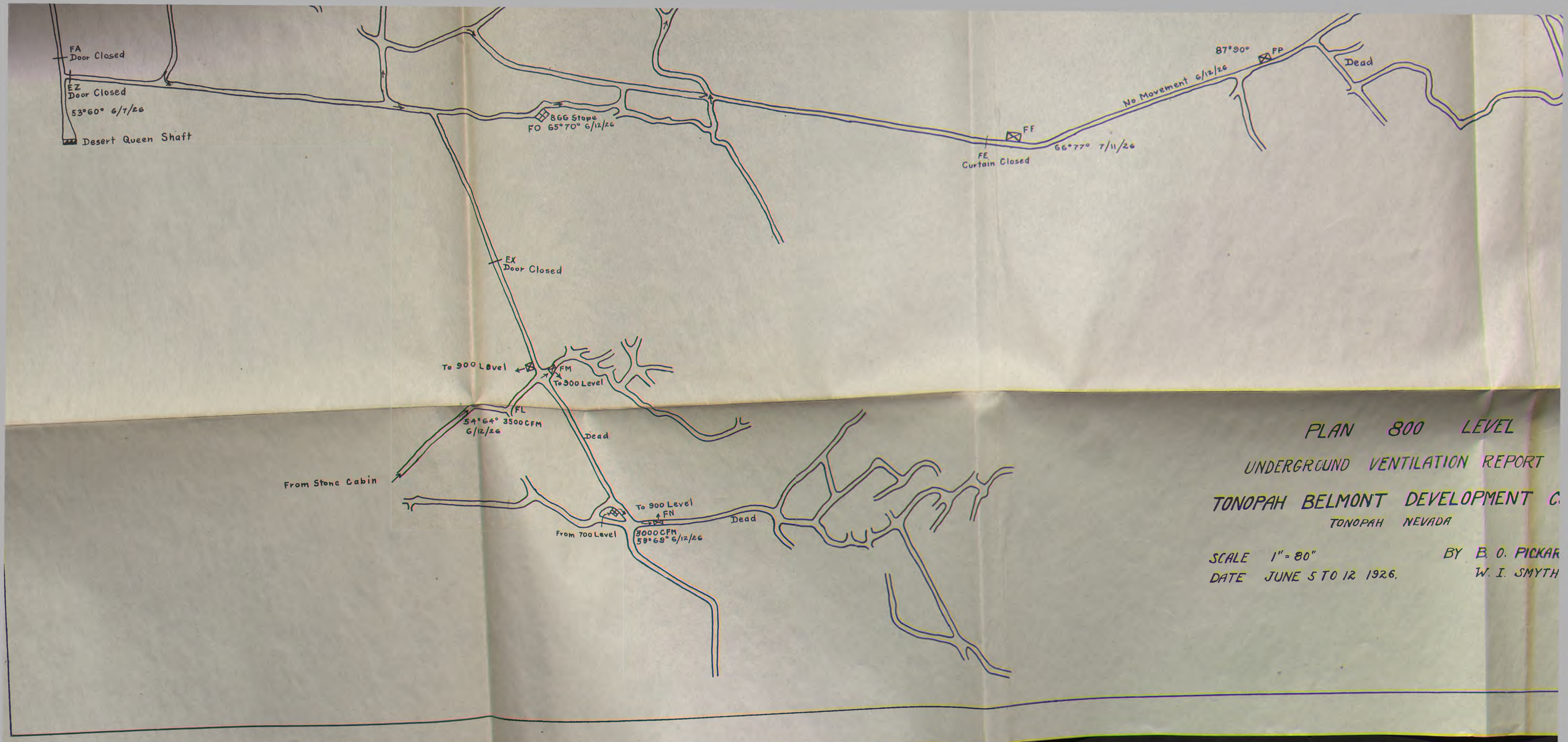
June 12, 1926, FL, intake air from Stone Cabin, 54° 64° 51%, 100 x 5 x 7, 3500 c.f.m.

June 12, 1926, FN, air from 700 level, 59° 69° 54%, 3000 c.f.m.

Main Ventilation System. The intake air for this level is from the Mizpah stopes of the Tonopah Mining Co. thru raise, FC, and from the 700 level thru the 814 stope. The amount of intake air is 8200 c.f.m. The air splits at the 814 stope, 3900 c.f.m. of air going down raise, FC, to the 900 level. The balance wanders thru three courses to the long cross cut that joins the Desert Queen


N
LEGEND
55° 61° Wet and Dry Bulb Temp.
Ventilation.
Brattice - Burlap Brattice Cloth.
? Bulkhead - Proposed Bulkhead.
Opening above level.
Opening below level.
F.D. Door Closed
EP
73° 77° No Movement 6/7/26
76° 79° No Movement 6/11/26
EQ
Brattice Tunnel
Curtain Open
Curtain Closed
77° 80° 6/11/26
2000 CFM
To 700 Level
ER
Brattice
Bulkhead
Brattice Bulkhead
ES
Brattice Tunnel
Curtain Closed
Curtain Open
69° 77° 6/11/27
3000 C.F.M 6/11/26
To 700 Level
1000 C.F.M.
To 900 Level
EU
Curtain
Open
ET
Curtain Closed


Belmont Shaft
losed
From Mizpah
To 900 Level
FG
From 700 Level
EY
814 Stope
FA
Door Closed
EZ
Door Closed
Desert Queen Shaft
EV
Door Open
62° 72° 4900 C.F.M. 6/7/26
66°73° 5300 C.F.M 6/11/26
EW
1000 CFM
866 Stope
FO 65°70° 6/13/26
FF
FE
Curtain Closed
66°77° 7/11/26
No Movement 6/12/26
87°90°
FP
Dead
EX
Door Closed
To 800 Level
FM
Dead



PLAN 800 LEVEL

UNDERGROUND VENTILATION REPORT

TONOPAH BELMONT DEVELOPMENT C

TONOPAH NEVADA

SCALE 1" = 80"

DATE JUNE 5 TO 12 1926.

BY B. O. PICKAR
W. I. SMYTH

and Belmont workings. Brattice cloth curtains and tunnels placed at EU, ET, ES, ER and EQ made a course for the air thru the stopes in the Belmont portion of the level to raise, EP. Several of these stopes were being worked at this time and the men would leave the curtains up instead of closed, thus short circuiting the air thru the stopes to such an extent that no air reached raise, EP. Consequently, stope 6000, a hot stope above the 600 level dependent on EP for ventilation was suffering greatly for want of fresh air.

Air measurements were as follows:

June 11, 1926, intake air at 814 stope, 57° 62° 74%.

June 12, 1926, FG, air to 900 level, 55° 61° 68%, 180 x 3.0 x 7.2, 3900 c.f.m.

June 7, 1926, EV, intake air for Belmont workings, 62° 72° 56%, 245 x 3.3 x 6.0, 4900 c.f.m.

June 11, 1926, EV, intake air for Belmont workings, 66° 73° 69%, 260 x 3.4 x 6.0, 5300 c.f.m.

June 11, 1926, ES, to stope, 69° 77° 67%, 2000 c.f.m.

June 11, 1926, EQ, to stope, 70° 80° 61%, 2000 c.f.m.

June 7, 1926, raise EP, 73° 77° 82%, no movement.

June 11, 1926, raise EP, 72° 79° 87%, no movement.

June 12, 1926, FO, stope 866, 65° 70° 77%, 2000 c.f.m.

June 12, 1926, west stope 6 off raise FP, 87° 90° 89%.

West stope 6 is the hottest working place we found in the mine. It is supposed to receive air from the 900 level thru raise, FF, and then along the drift to raise, FP. There was no air following this circuit, however, and the only air entering this stope was from the compressed air line. A more positive scheme should be devised to get air to this stope.

Several doors have been installed on this level. Doors EZ and FA prevent downcast air in the Desert Queen shaft from short circuitingthru this level. Door FB shuts off the North Star workings. Door FD is an old door formerly used to shut off the North Star. The latter door should be removed because it is in very bad order and not needed because FB forms an effective barrier to the North Star. As before mentioned, door EX prevents mixing of the two ventilation systems. Door EV, an open door in the crosscut joining the Belmont and Desert Queen workings, could be closed to stop air from the Desert Queen side entering the Belmont in case of a fire in the Mizpah stopes.

900 LEVEL.

Southern Ventilation System. Door CY of this system prevents the air from mixing with the air of the main system. Intake air is from the 800 level thru stopes and from the Stone Cabin Mine. On June 11th 6000 c.f.m. of air was measured at open door EE. Part of this air, 1500 c.f.m., goes down raise EF and is lost behind barriers on the 1000 level. The balance of the air goes to the ~~800~~ 1000 level thru stope EG. An eddying effect was noted at EG. About 2000 c.f.m. of air was rising from the 1000 level thru raise EH and returning down EG stope.

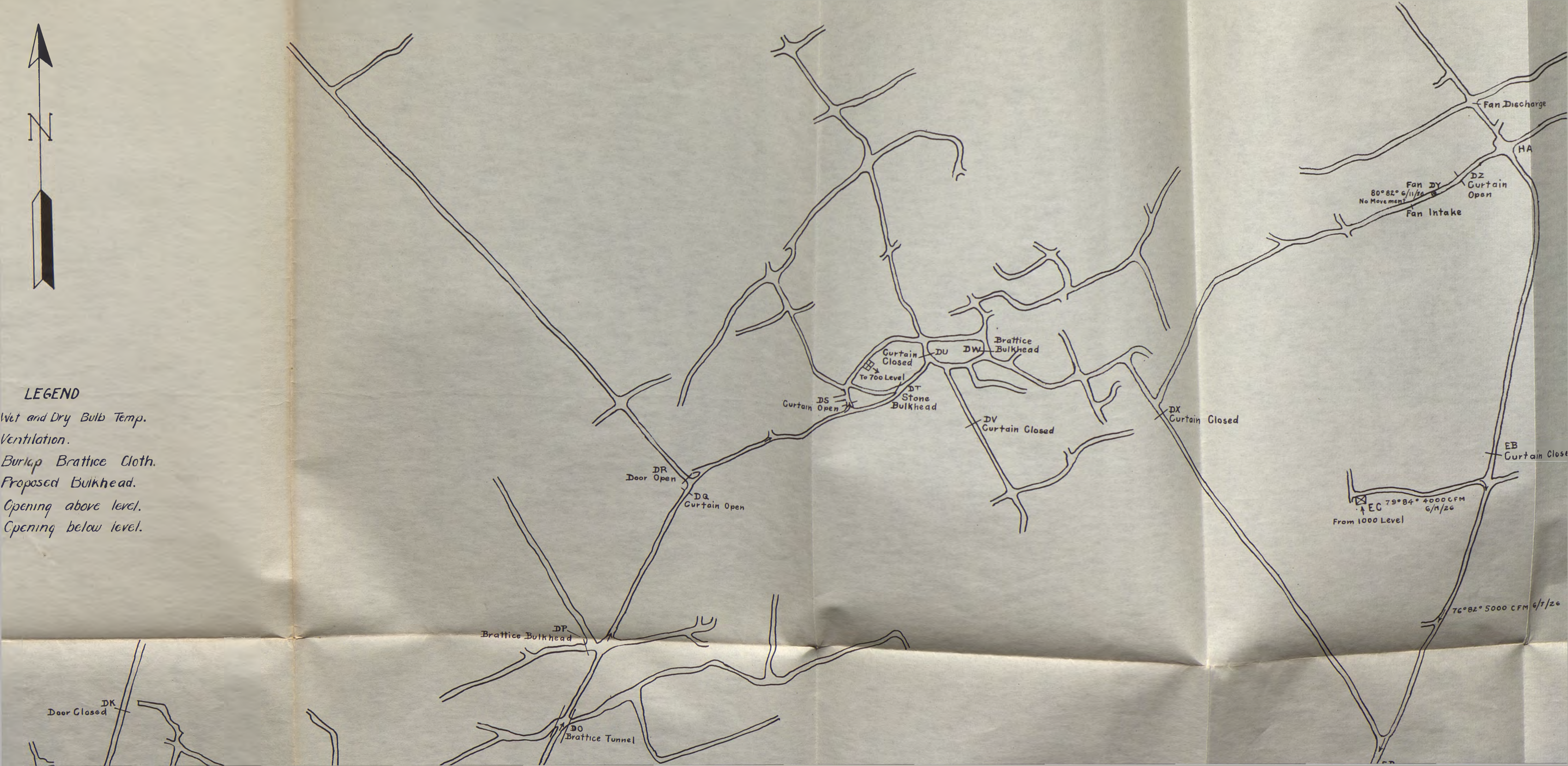
Air measurements were:

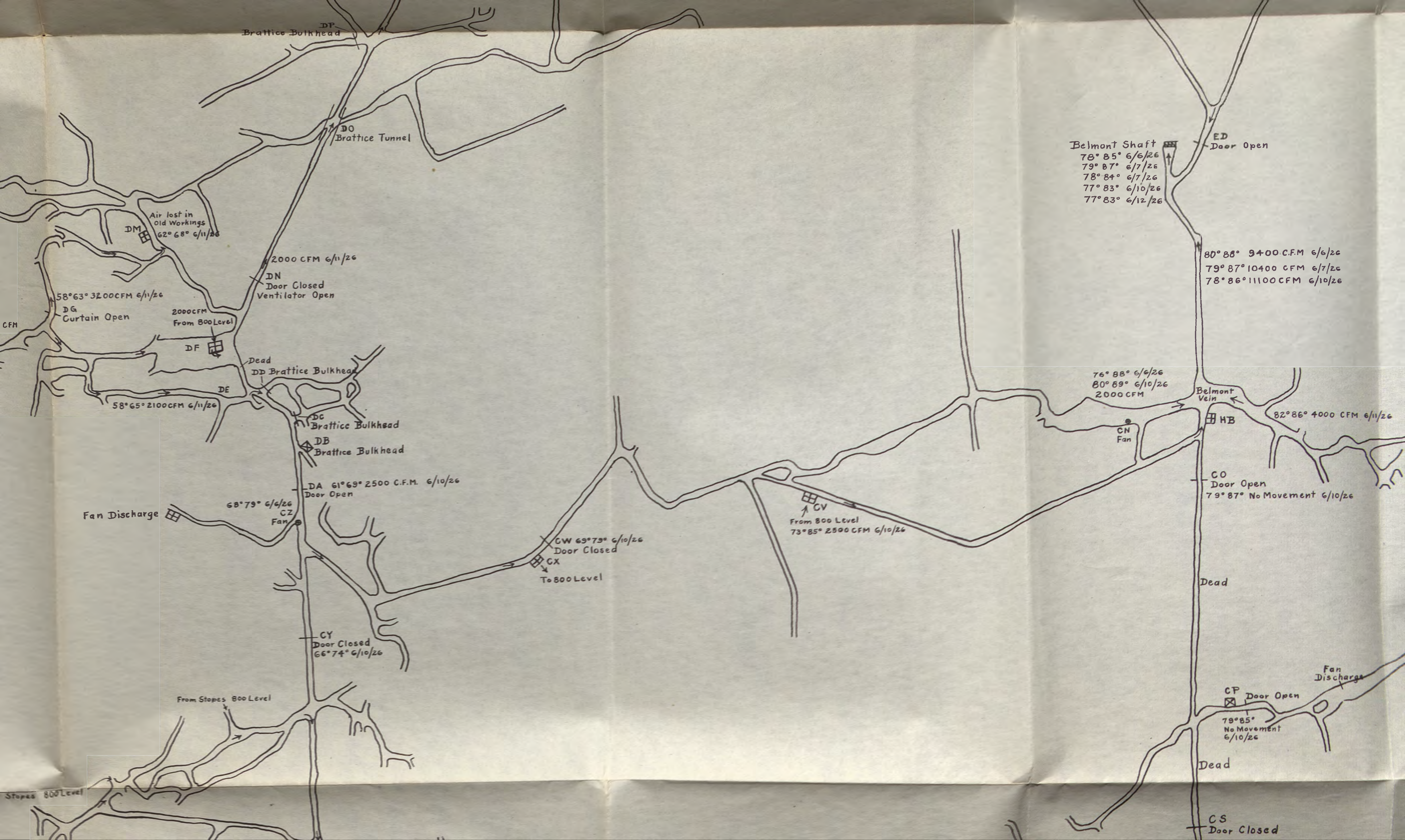
June 11, 1926, EE, open door, intake air for level,
   58° 72° 42%, 230 x 4.0 x 6.5, 6000 c.f.m.

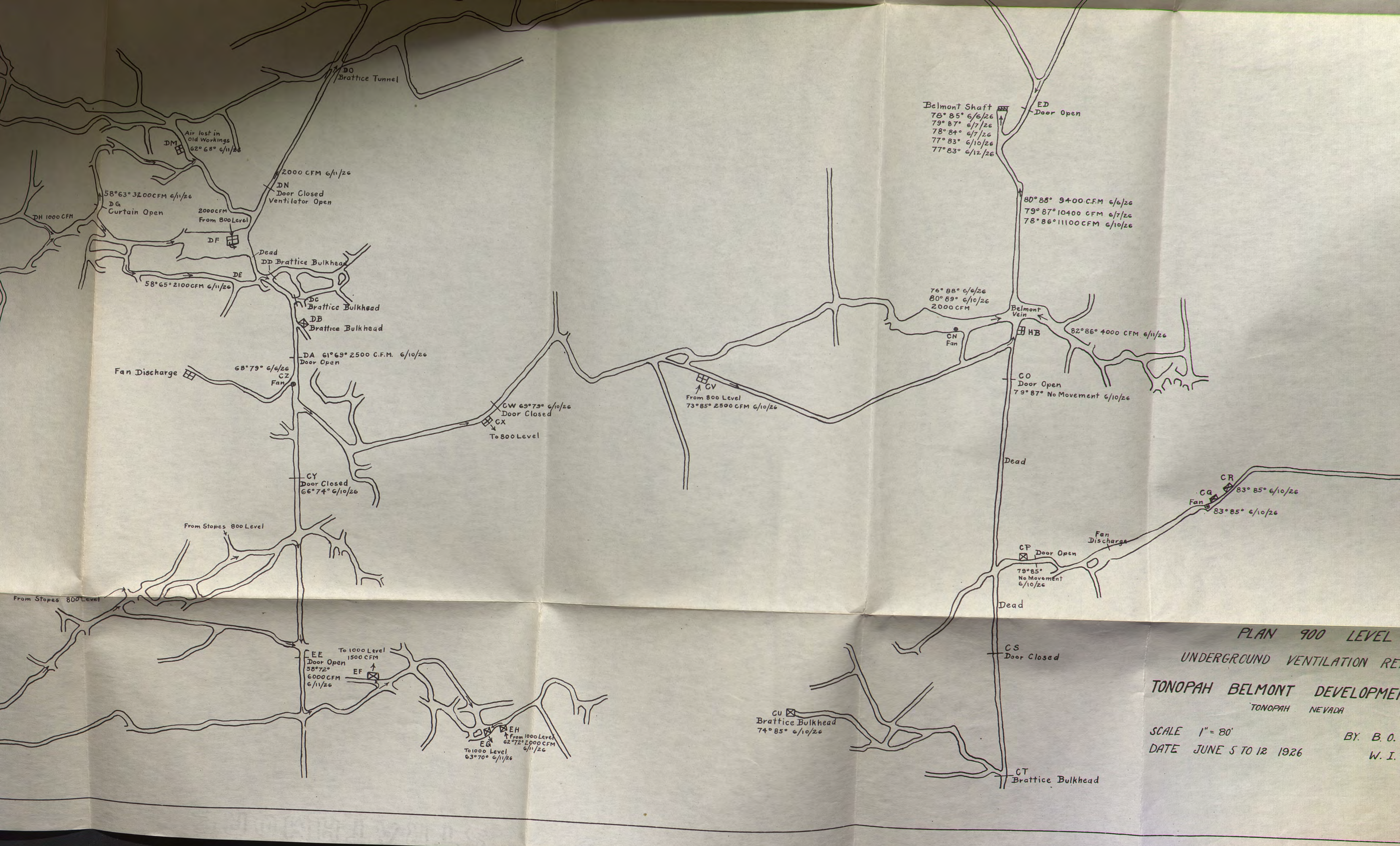
June 11, 1926, EG, abandoned stope, 63° 70° 68%.

June 11, 1926, EH, raise from 1000 level, 62° 72° 58%,
   about 2000 c.f.m.

Main Ventilation System. Intake air is from raise DI, corresponding to raise FG on the 800 level, and thru stope DF, the air in each case coming from the 800 level. On June 11th 3200 c.f.m. of this air was passing thru open curtain DG to some old stopes near working place


N
LEGEND
Wet and Dry Bulb Temp.
Ventilation.
Burlap Brattice Cloth.
Proposed Bulkhead.
Opening above level.
Opening below level.
Fan Discharge
HA
DZ
Curtain
Open
Fan DY
80° 82° 6/11/26
No Movement
Fan Intake
Brattice
Bulkhead
DW
DU
Curtain
Closed
To 700 Level
DT
Stone
Bulkhead
DS
Curtain Open
DV
Curtain Closed
DX
Curtain Closed
EB
Curtain Close
EC 79° 84° 4000 CFM
6/11/26
From 1000 Level
76° 82° 5000 CFM 6/7/26
DR
Door Open
DQ
Curtain Open
DP
Brattice Bulkhead
DO
Brattice Tunnel
DK
Door Closed


DP
Brattice Bulkhead
DO
Brattice Tunnel
Air lost in
Old Workings
DM
62° 68° 6/11/26
2000 CFM 6/11/26
DN
Door Closed
Ventilator Open
58°63° 3200 CFM 6/11/26
DG
Curtain Open
CFM
2000 CFM
From 800 Level
DF
Dead
DD Brattice Bulkhead
DE
58°65° 2100 CFM 6/11/26
DC
Brattice Bulkhead
DB
Brattice Bulkhead
DA 61°69° 2500 C.F.M. 6/10/26
Door Open
68°79° 6/6/26
CZ
Fan
Fan Discharge
CW 69°79° 6/10/26
Door Closed
CX
To 800 Level
CY
Door Closed
66°74° 6/10/26
From Stopes 800 Level
Stopes 800 Level
CV
From 800 Level
73°85° 2500 CFM 6/10/26
Belmont Shaft
78° 85° 6/6/26
79° 87° 6/7/26
78° 84° 6/7/26
77° 83° 6/10/26
77° 83° 6/12/26
ED
Door Open
80° 88° 9400 C.F.M 6/6/26
79° 87° 10400 CFM 6/7/26
78° 86° 11100 CFM 6/10/26
76° 88° 6/6/26
80° 89° 6/10/26
2000 CFM
Belmont
Vein
CN
Fan
HB
82°86° 4000 CFM 6/11/26
CO
Door Open
79° 87° No Movement 6/10/26
Dead
Fan
Discharge
CP
Door Open
79°85°
No Movement
6/10/26
Dead
CS
Door Closed



DO
Brattice Tunnel
Belmont Shaft
78° 85° 6/6/26
79° 87° 6/7/26
78° 84° 6/7/26
77° 83° 6/10/26
77° 83° 6/12/26
ED
Door Open
Air lost in
Old Workings
62° 68° 6/11/26
DM
2000 CFM 6/11/26
DN
Door Closed
Ventilator Open
58° 63° 3200 CFM 6/11/26
DG
Curtain Open
DH 1000 CFM
2000 CFM
From 800 Level
DF
80° 88° 9400 C.F.M 6/6/26
79° 87° 10400 CFM 6/7/26
78° 86° 11100 CFM 6/10/26
Dead
DD Brattice Bulkhead
DE
58° 65° 2100 CFM 6/11/26
DC
Brattice Bulkhead
DB
Brattice Bulkhead
76° 88° 6/6/26
80° 89° 6/10/26
2000 CFM
Belmont
Vein
HB
CN
Fan
82° 86° 4000 CFM 6/11/26
DA 61° 69° 2500 C.F.M. 6/10/26
Door Open
Fan Discharge
68° 79° 6/6/26
CZ
Fan
CV
From 800 Level
73° 85° 2500 CFM 6/10/26
CO
Door Open
79° 87° No Movement 6/10/26
CW 69° 79° 6/10/26
Door Closed
CX
To 800 Level
Dead
CY
Door Closed
66° 74° 6/10/26
CR
83° 85° 6/10/26
CG
Fan
83° 85° 6/10/26
From Stopes 800 Level
Fan
Discharge
CP
Door Open
79° 85°
No Movement
6/10/26
From Stopes 800 Level
Dead
PLAN 900 LEVEL
UNDERGROUND VENTILATION RE
EE
Door Open
58° 72°
6000 CFM
6/11/26
To 1000 Level
1500 CFM
EF
CS
Door Closed
TONOPAH BELMONT DEVELOPME
TONOPAH NEVADA
CU
Brattice Bulkhead
74° 85° 6/10/26
EH
From 1000 Level
62° 72° 2000 CFM
6/11/26
EG
To 1000 Level
63° 70° 6/11/26
SCALE 1" = 80'
DATE JUNE 5 TO 12 1926
BY. B. O.
W. I.
CT
Brattice Bulkhead

DM from where it could not be followed further. In all probability this air passes down these stopes to the 1000 level where it joins the intake air for the lower levels.

2000 c.f.m. of air was mapped going thru an open ventilator in door DM from where it follows an air course to the north-eastern portion of the level. By use of brattice cloth bulkheads, tunnels and curtains and wooden ventilation doors, the air can be conveyed to fan DY. As the stopes dependent on the fan for fresh air were not being worked at the time of the investigation, the fan was not running and the 2000 c.f.m. of air passed thru open curtain DS and up stopes to the return air on the 700 level.

About 2500 c.f.m. of the intake air for this level goes thru door DA to fan CZ where it is blown thru a ventilation pipe and discharged in a raise 30 feet above the level and 200 feet west of the fan. A detailed description of the set-ups for fans will be given later under a discussion of fans. I wish to call attention, however, to the fact that the air after being used in the raise must return past the fan and some of it will be sucked thru the fan again.

The same air then goes to raise CX thru which it is supposed to go up to FF on the 800 level and then to ventilate West stope 6, marked FP on the map. It is supposed to return to the 900 level again at the bottom of raise CV. On June 11th practically no air was making the circuit to West stope 6. A more positive means to get air to the stope should be devised.

About 15,000 c.f.m. of air return to the Belmont shaft on this level and is upcast from the mine. About 5000 c.f.m. of this air comes from the 1000 level thru stope EC, about 7000 c.f.m. come from the large Belmont vein stopes and the balance from CV.

Two other fans are located on the level but neither were running. One is in the Belmont vein stopes about 100 feet west of the cross cut running south from the station. Its purpose is to supply air to an intermediate level 60 feet above the 900 level. No work was being done on the intermediate during the period of the investigation. Another fan is located near stope CQ and is to draw air from the 1000 level thru stope CQ. A miner was working in an adjoining stope CR where the temperature was 85°, humidity 92%, air movement none and dust considerable. It would have been very easy to change the discharge of the fan to the stope in which he was working because vent tube was already strung along the drift past the stope and a tee in the pipe at the fan for the connection.

The 900 level is the poorest ventilated level in the mine. We found only three places being worked on this level. The first, stope DM, had good working conditions, temperature 62° 66°, humidity 71%, and was supplied with plenty of fresh air. The temperature of the air from the fan Ca to the raise noted above was 68° 79° and the humidity 56% making good conditions under which to work. Stope CR, however, received no ventilation and had a temperature of 83° 85°. I believe the stope had only been reopened a shift or two at the time of our investigation and undoubtably the management will soon connect the fan ~~with~~ to this stope as discribed above. It will be noted that most places in shape to work on this level are dependent upon booster fans for their air supply.

In all there are 14 ventilation doors on the 900 level and numerous brattice cloth stopages. Door CS and brattice cloth bulkheads CU avd CT shut off the Rescue Eula Mine. Another door shuts off the downcast

Desert Queen shaft. By the proper manipulation of doors and curtains, it is possible to isolate nearly any portion of the level or to make an air course to any working place on the level.

The reason this level is the poorest ventilated level in the mine is apparently due to a deficiency in the amount of intake air. It has more development openings than any other level and contains the largest stoped areas in the mine but only receives 7000 c.f.m. of intake air.

Temperature measurements were:

June 6, 1926, Desert Queen shaft, 53° 61° 59%

June 11, 1926, DI, intake air from 800 level, 55° 62° 62% 140 x 5 x 7, 5300 c.f.m.

June 11, 1926, DJ, closed door North Star beyond, 57° 62° 74%, no movement after closing door.

June 11, 1926, DE, 58° 65° 66%, 200 x 3.5 x 3.0, 2100 c.f.m.

June 11, 1926, DG, air lost in old workings, 58° 63° 74%, 160 x 4.0 x 5.0, 3200 c.f.m.

June 11, 1926, DM, working place, 62° 68° 71%, considerable movement.

June 11, 1926, DY, fan not running, 80° 82° 91%, no movement.

June 7, 1926, EC, raise from 1000 level return air, 76° 82° 83%, 5000 c.f.m.

June 11, 1926, EC, 79° 84° 81%, 4000 c.f.m.

June 10, 1926, DA, open door, 61° 69° 63%, 2500 c.f.m.

June 10, 1926, CZ, fan, 68° 79° 56%.

June 10, 1926, CW, closed door to force air up CX and down CV, 69° 79° 61%, no movement.

June 10, 1926, CY, closed door between southern and main ventilation systems, 66° 74° 66%, no movement.

June 10, 1926, CV, raise from 800, 73° 85° 57%, 2500 cfm.

June 6, 1926, fan CN, not running, 76° 88° 58%, 2000 cfm.

June 10, 1926, fan CN not running, 80° 89° 68%, 2000 cfm.

June 11, 1926, Belmont vein stope east drift, 82° 86° 84%, 4000 c.f.m.

June 10, CO, open door, 79° 87° 70%, no movement, when fan CQ is running air returns to station thru this door.

June 10, 1926, stope, 79° 85° 77%, no movement.

June 10, 1926, fan CQ, 83° 85°, 92%, no movement unless fan is running.

June 10, 1926, working place, CR, 83° 85° 92%, no movement, could get air by connecting to fan CQ.

June 10, 1926, CU, brattice cloth bulkhead over raise from 1000 level, 74° 85° 59%, no movement.

June 6, 1926, station Belmont shaft, 78° 85° 73%.

June 7, 1926, station Belmont shaft, 79° 87° 70%.

June 7, 1926, station Belmont shaft 78° 84° 77%.

June 10, 1926, station Belmont shaft, 77° 83° 76%.

June 12, 1926, station Belmont shaft, 77° 83° 76%.

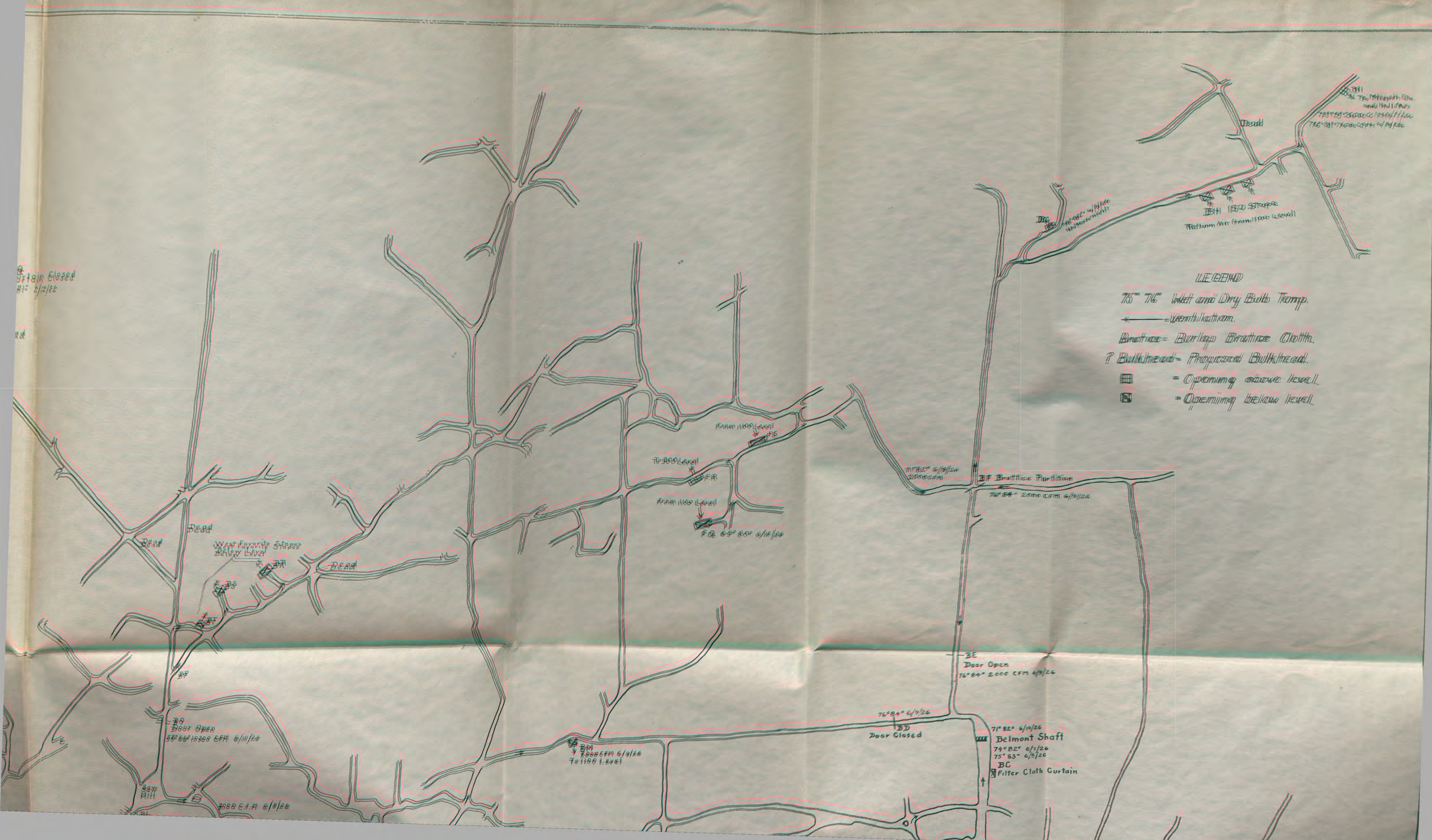
June 6, 1926, return air cross cut north of Belmont vein, 80° 88° 71%, 225 x 5.8 x 7.2, 9400c.f.m.

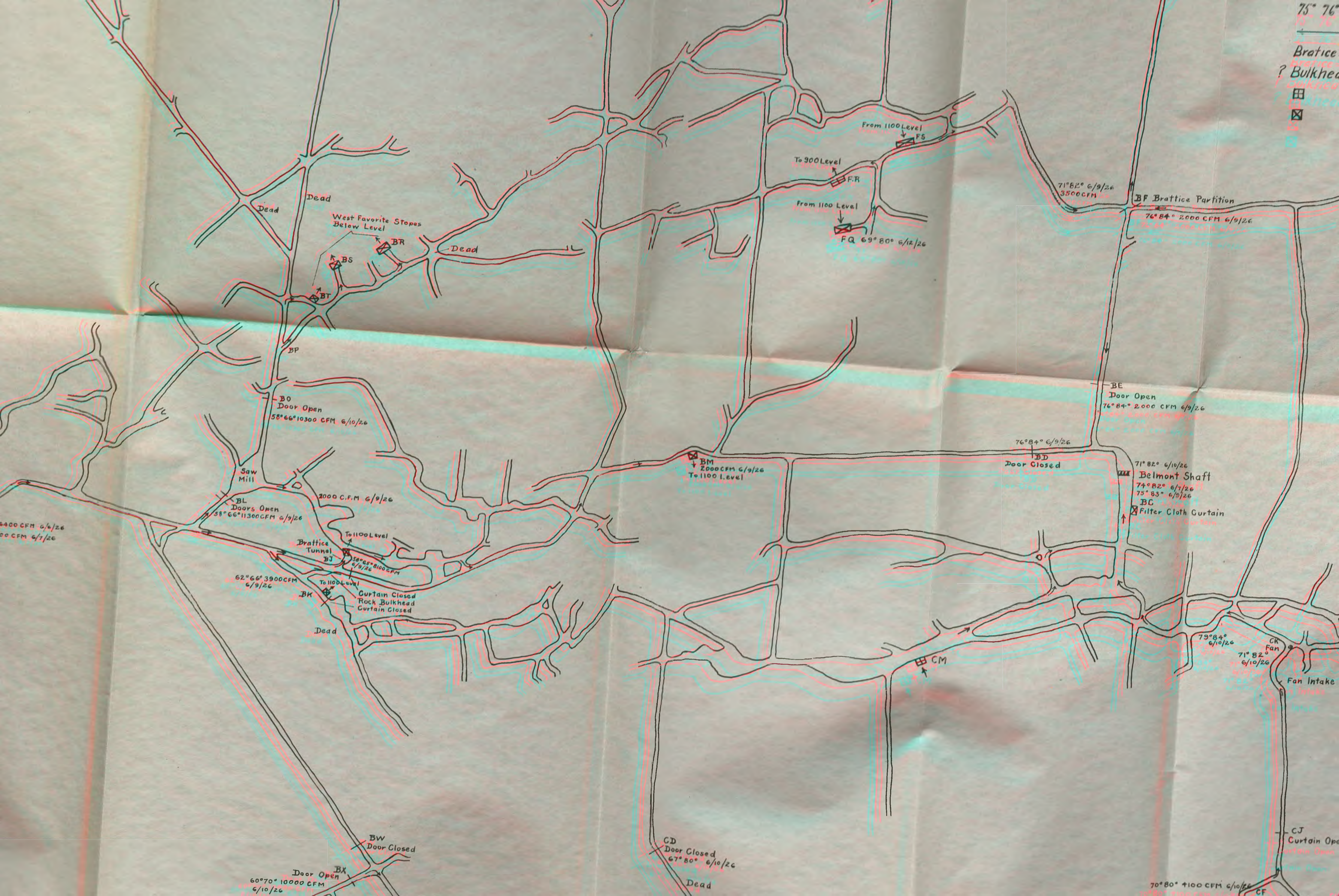
June 7, 1926, return air cross cut north of Belmont vein, 79° 87° 71%, 270 x 5.2 x 7.4, 10400 c.f.m.

June 10, 1926, return air cross cut north of Belmont vein, 78° 86° 70%, 270 x 5.5 x 7.5, 11100 c.f.m.

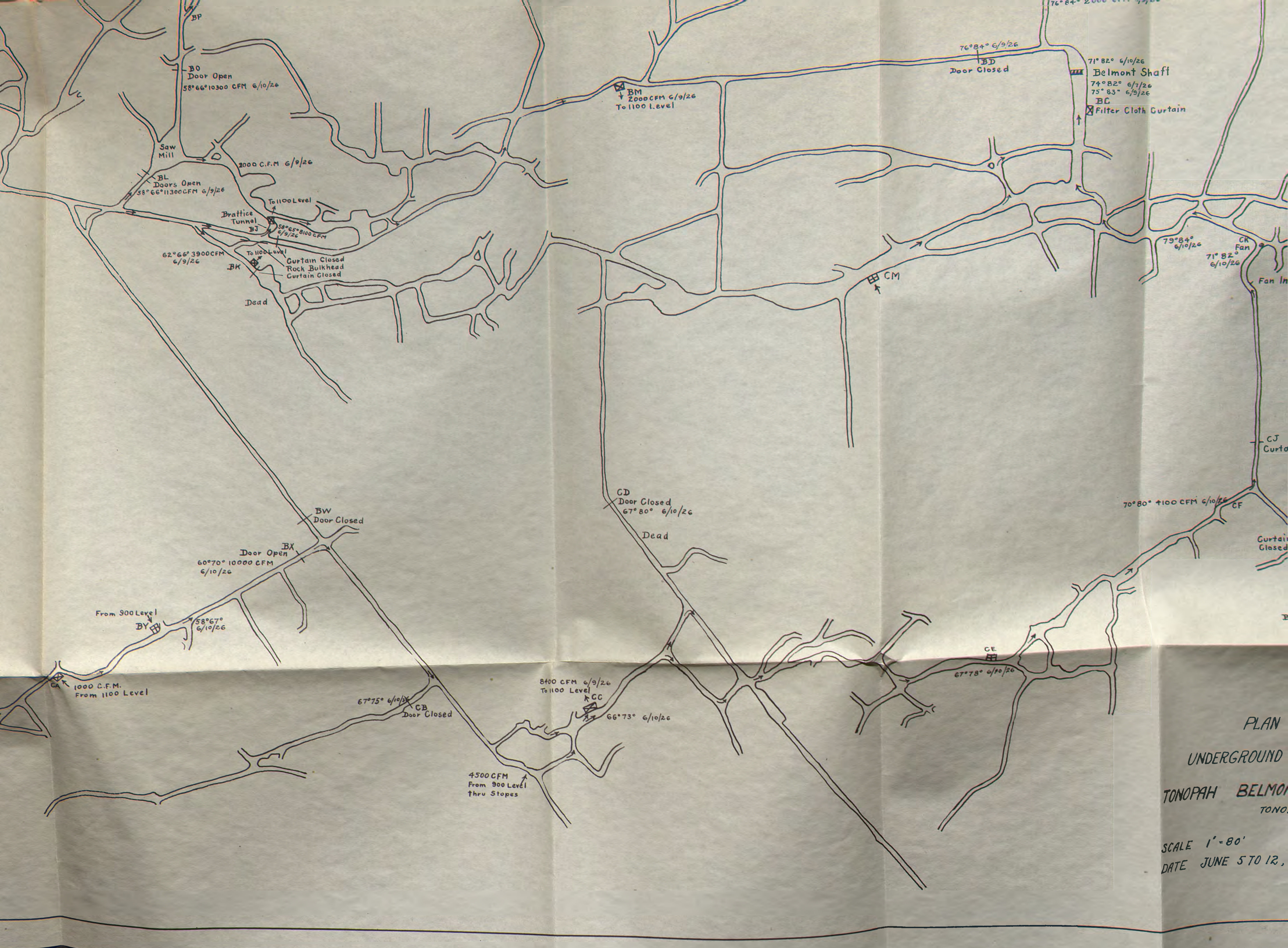
1000 Level.

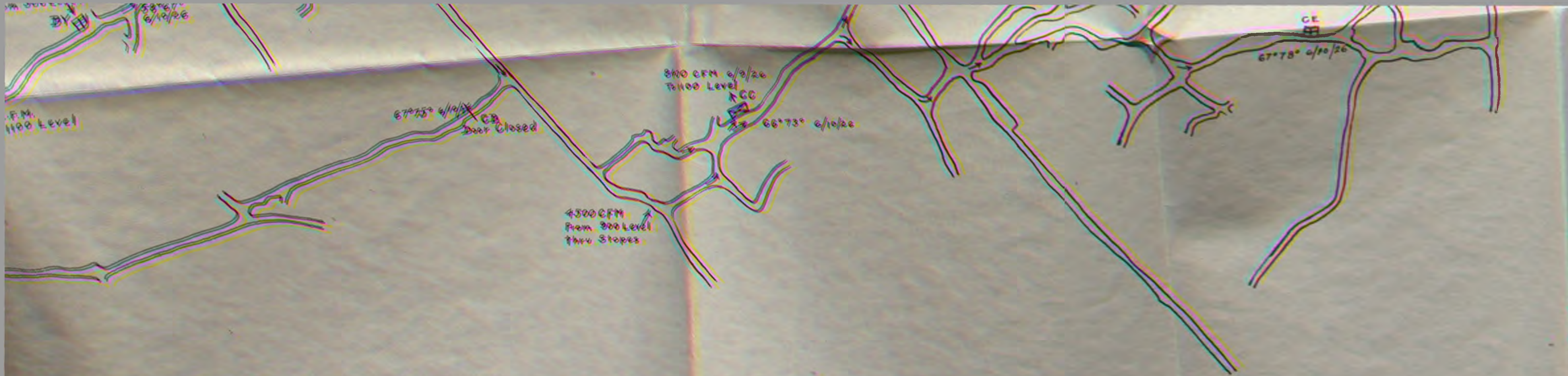
Southern Ventilation System. This system is separated from the main system by doors, BW and CD. 10,000 c.f.m. of intake air was measured at door BX, 9000 c.f.m. of which comes from the 900 level thru raise BY and 1000 c.f.m. comes up raise CA from the 1100 level. This 1000 c,f,m. is leakage from the Desert Queen shaft. 4500 c.f.m. of air is also received from the 900 level thru stopes 120 feet west of point CC on the map. The air splits at CC, 8400 c.f.m. going down raise CC to the 1100 level, and the balance traveling thru


LEGEND
75° 76° Wet and Dry Bulb Temp.
= Ventilation.
Bratice = Burlap Bratice Cloth.
? Bulkhead = Proposed Bulkhead.
= Opening above level.
= Opening below level.
BH
Dead
BH 1150 Stope
Return Air from 1100 Level
BG
BF Brattice Partition
76° 84° 2000 CFM 6/9/26
BE
Door Open
76° 84° 2000 CFM 6/9/26
76° 84° 6/9/26
BD
Door Closed
71° 82° 6/10/26
Belmont Shaft
74° 82° 6/7/26
75° 83° 6/9/26
BC
Filter Cloth Curtain
From 1100 Level
FS
To 900 Level
FR
From 1100 Level
FQ 69° 80° 6/10/26
BM
2000 CFM 6/9/26
To 1100 Level
Dead
Dead
Dead
West Favorite Stopes
Below Level
BR
BS
Dead
BT
BP
BO
Door Open
2000 C.F.M. 6/9/26
Saw
Mill



75° 76°
Bratice
? Bulkhead
Dead
Dead
West Favorite Stopes
Below Level
BR
BS
BT
Dead
BP
From 1100 Level
FS
To 900 Level
F.R
From 1100 Level
FQ 69° 80° 6/12/26
71°82° 6/9/26
3500 CFM
BF Brattice Partition
76° 84° 2000 CFM 6/9/26
BO
Door Open
58°66° 10300 CFM 6/10/26
BE
Door Open
76° 84° 2000 CFM 6/9/26
Saw
Mill
2000 C.F.M 6/9/26
BL
Doors Open
58°66° 11300 CFM 6/9/26
6400 CFM 6/6/26
00 CFM 6/7/26
BM
2000 CFM 6/9/26
To 1100 Level
76°84° 6/9/26
BD
Door Closed
71° 82° 6/10/26
Belmont Shaft
74° 82° 6/7/26
75° 83° 6/9/26
BC
Filter Cloth Curtain
To 1100 Level
Brattice
Tunnel
BJ
58°65° 8100 CFM
6/9/26
62° 66° 3900 CFM
6/9/26
To 1100 Level
BK
Curtain Closed
Rock Bulkhead
Curtain Closed
Dead
CM
79°84°
6/10/26
CK
Fan
71° 82°
6/10/26
Fan Intake
BW
Door Closed
Door Open
BX
60°70° 10000 CFM
6/10/26
CD
Door Closed
67° 80° 6/10/26
Dead
CJ
Curtain Ope
70° 80° 4100 CFM 6/10/26
CF


BP
BO
Door Open
58°66°10300 CFM 6/10/26
Saw
Mill
2000 C.F.M 6/9/26
BL
Doors Open
58°66°11300CFM 6/9/26
To 1100 Level
Brattice
Tunnel
BJ
58°65°8100 CFM
6/9/26
62°66° 3900CFM
6/9/26
To 1100 Level
Curtain Closed
Rock Bulkhead
Curtain Closed
BK
Dead
BM
2000 CFM 6/9/26
To 1100 Level
76°84° 6/9/26
BD
Door Closed
71° 82° 6/10/26
Belmont Shaft
74° 82° 6/7/26
75° 83° 6/9/26
BC
Filter Cloth Curtain
CM
79°84°
6/10/26
CK
Fan
71° 82°
6/10/26
Fan In
CJ
Curta
CD
Door Closed
67° 80° 6/10/26
Dead
70°80° 4100 CFM 6/10/26
CF
Curtain
Closed
BW
Door Closed
BX
Door Open
60°70° 10000 CFM
6/10/26
From 900 Level
BY
58°67°
6/10/26
CA
1000 C.F.M.
From 1100 Level
67°75° 6/10/26
CB
Door Closed
8400 CFM 6/9/26
To 1100 Level
CC
66°73° 6/10/26
4500 CFM
From 900 Level
thru Stopes
CE
67°78° 6/10/26
PLAN
UNDERGROUND
TONOPAH BELMO
TONO
SCALE 1"=80'
DATE JUNE 5 TO 12,



PLAN 1000 LEVEL

UNDERGROUND VENTILATION REPORT

TONOPAH BELMONT DEVELOPMENT CO.

TONOPAH NEVADA

SCALE 1" = 80'

DATE JUNE 5 TO 12, 1926.

BY B. O. PICKARD.
W. I. SMYTH.

an air course to fan CK which forces the air to working place CL, a caved stope that is being reworked. From here the air returns to the Belmont shaft, Door CB is closed to keep the hot air of the Rhyolite stopes from this air course.

Air measurements were:

June 10, 1926, BY, intake air from 900 level, 58° 67° 57%.

June 10, 1926, BX, open door, intake air, 60° 70° 55%, 440 x 3.5 x 6.6, 10,000 c.f.m.

June 10, 1926, CB, closed door to keep out hot air from Occidental vein, 67° 75° 66%.

June 10, 1926, CC, 1198 stope, air course to 1100 level, 66° 73° 69%, 8400 c.f.m.

June 10, 1926, CD, closed doors, one 5' wide for motor and other 20" wide for men, 67° 80° 50%, dead.

June 10, 1926, CE, starting stope over level, 67° 78° 56%, 4100 c.f.m.

June 10, 1926, CF, 70° 80° 61%, 120 x 5.0 x 6.8, 4100 cfm.

June 10, 1926, CK, fan, 71° 82° 58%,

June 10, 1926, CL, working place, receives air from fan CK, 76° 83° 83%

June 10, 1926, return air to shaft, 79° 84° 81%.

CH is a raise to the 900 level thru which air may

may be drawn when fan CQ on the 900 level is running.

Brattice cloth curtain CG and brattice cloth bulkhead CI are to keep air from the Rescue Eula Mine. CG should be repaired as it has been practically blasted out. The temperature at CI was 75° 85° 63%.

Main Ventilation System. Intake air is from the Desert Queen shaft and from the 900 level thru stopes BU. The amount of intake air varied from 15,400 to 24,000 c.f.m. This air splits, about 11,000 c.f.m. going thru the saw mill to the West Favorite stopes, BT, BS and BR. Raises BJ, BK and BM convey the balance of the intake air to the 1100 level. Curtain BJ and door BD keep the intake air from short circuiting to the shaft or the return air course. Air is being upcast from the 1100 level thru stopes FS and FQ, some of which goes up stope FR to upper levels and the balance forms the return air for this level, passing along one side of brattice cloth partition BF and past raises BK. Return air from the 1100 level joins with the return air from the 1000 level at BK. The combined return air from the two levels goes up raise BI to Mizpah Extension Workings where it splits part upcasting to the surface up the Mizpah Extension shaft and the remainder upcasting thru the Halifax shaft. A curtain is located in these workings which could be closed in case of fire to send all the foul air up the Mizpah Extension shaft. About 2000 c.f.m. of hot air from the Lily Belle stopes passes on the south side of brattice cloth partition BF and goes to the Belmont shaft. The air returning to the Belmont shaft splits at the shaft, part being upcast and part downcast.

Air measurement on the 1000 level were:

June 6, 1926, Desert Queen station, 55° 60° 63%, 300 x 5.6 x 8.0, 13400 c.f.m.

June 6, 1926, Total intake air for level, 55° 61° 59%, 335 x 7 x 7, 16,400 c.fm.

June 7, 1926, total intake air for level, 54° 62° 59%, 610 x 5.9 x 6.9, 24,000 c.f.m.

June 10, 1926, air from Desert Queen shaft, 58° 62° 79%, 580 x 5 x 6, 17,400 c.f.m.

June 9, 1926, BL, air to saw mill, 58° 66° 62%, 520 x 3.4 x 6.4, 11,300 c.f.m.

June 10, 1926, BO, air course to West Favorite stopes, 58° 66° 62%, 460 x 3.6 x 6.2, 10,300 c.f.m.

June 10, 1926, BR, raise from West Favorite Stopes, 55° 73° 27%, 3000 c.f.m.

June 9, 1925, BJ, brattice cloth tunnel air course to 1100 level, 58° 65° 66%, 400 x 3.5 x 5.8, 8100 c.f.m.

June 9, 1926, BE, air to 1100 level, 62° 66° 80%, 100 x 6.0 v 6.5, 3900 c.f.m.

June 9, 1926, BD, 76° 84° 70%, closed door near station.

June 9, 1926, Belmont station, 75° 83° 69%.

June 10, 1926, Belmont station, 71° 82° 58%.

June 7, 1926, Belmont station, 74° 82° 69%.

June 10, 1926, CM, curtain up, air from 900 level, 75° 85° 65%, 2000 c.f.m.

June 12, 1926, FQ, thru stope from 1100 level, 69° 80° 57%, about 4000 c.f.m., air goes on to 900 level.

June 9, 1926, BF, north side of partition, 71° 82° 58%, 210 x 2.8 x 6.0, 3500 c.f.m.

June 9, 1926, BF, south side of partition, 76° 84° 70%, 2000 c.f.m.

June 9, 1926, BE, open door north of Belmont station, 76° 84° 70%, 2000 c.f.m.

June 9, 1926, BG, working place 20 feet above level, 78° 82° 85%, no movement.

June 7, 1926, BI, return air, 75° 79° 75%, 150 x 5 x 7.5, 5600 c.f.m.

June 9, 1926, BI, return air, 76° 81° 79%, 150 x 5.6 x 8.5, 7000 c.f.m.

The 1000 level is equipped with electric haulage and is the principal haulage level in the mine. All ore mined on the upper levels is drawn from chutes on this level and trammed with an electric storage battery motor to ore passes near the Belmont shaft.

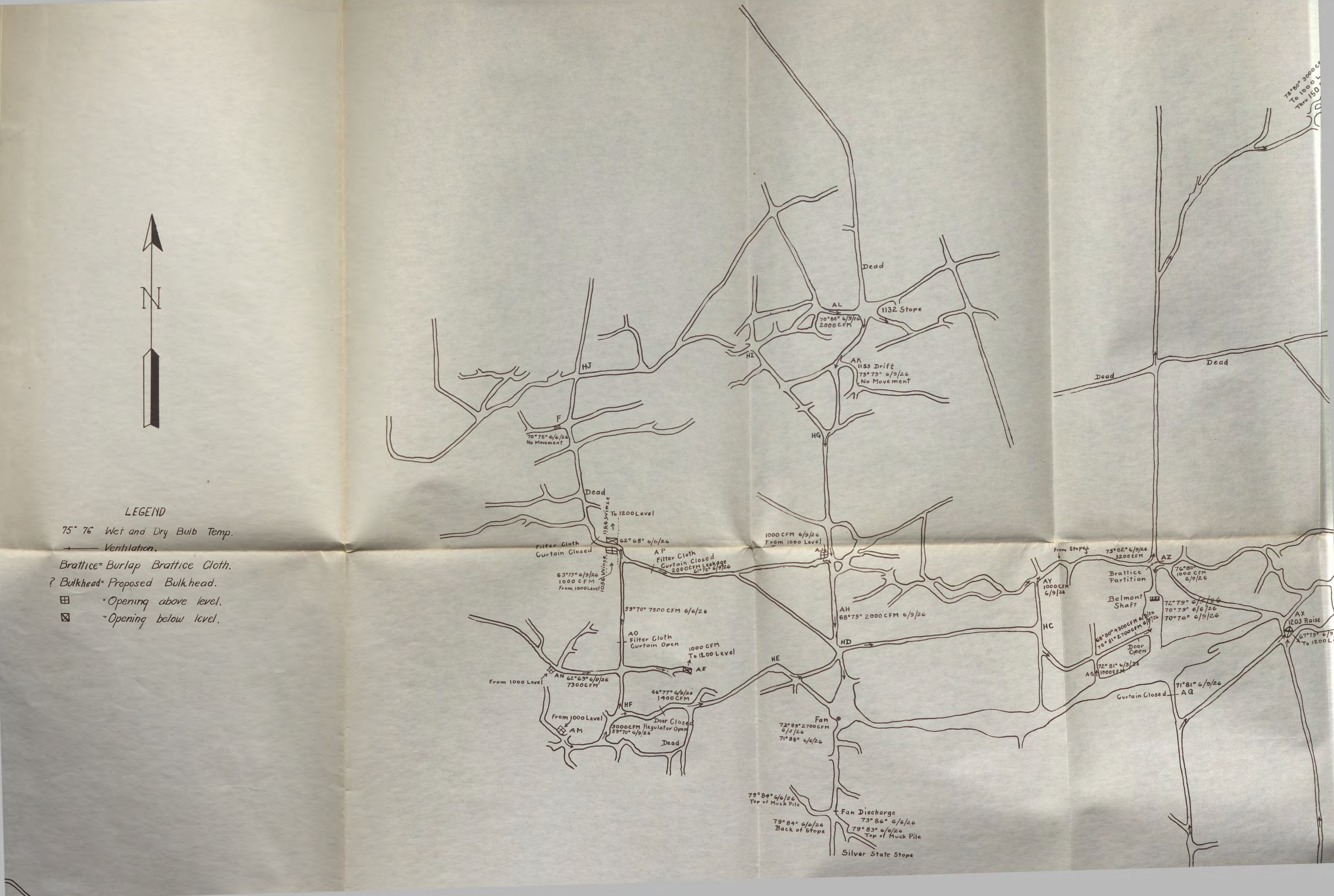
1100 LEVEL.

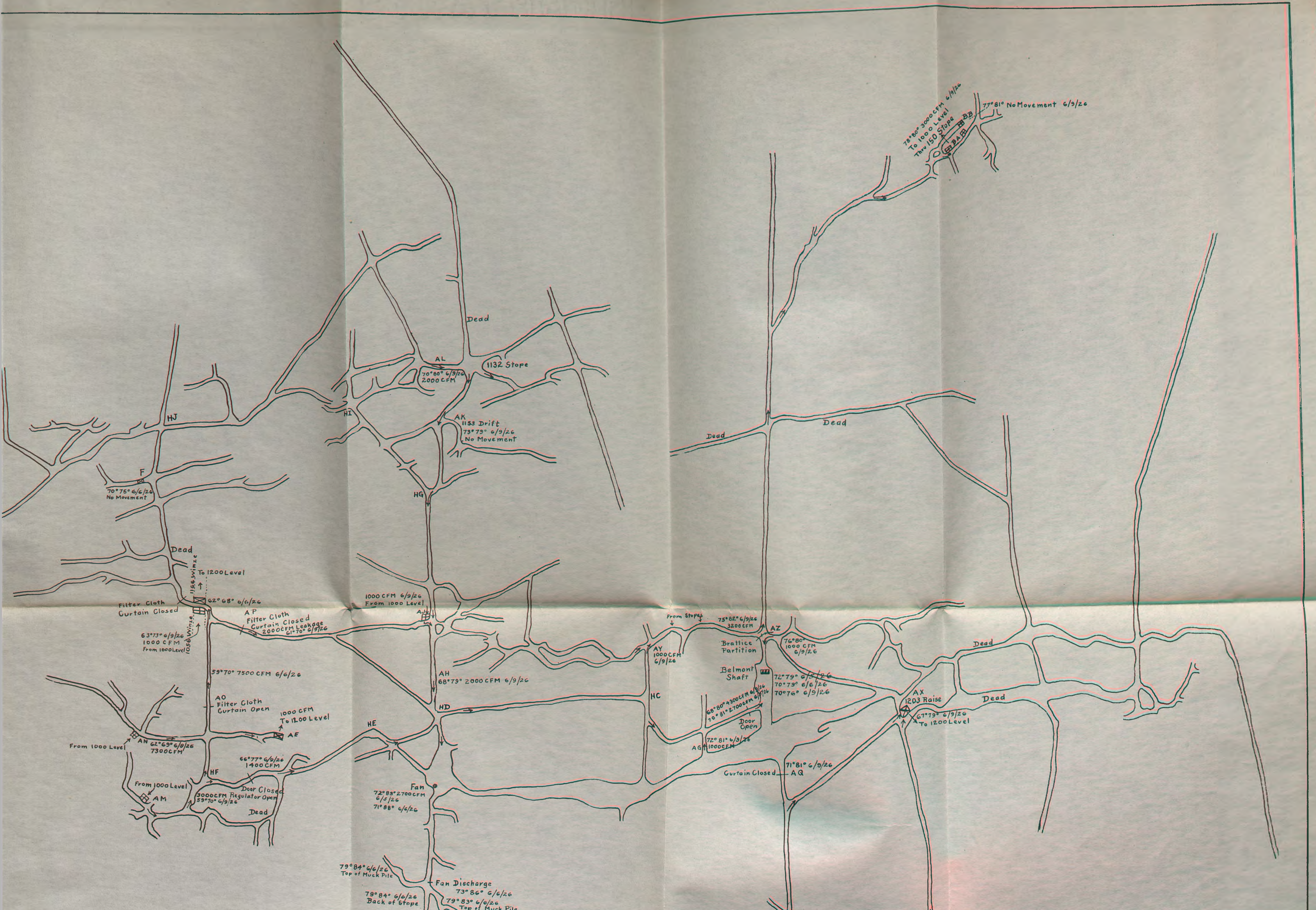
Southern Ventilation System. The intake air for this level is from the 1000 level thru raise AV, corresponding to raise CC on the 1000 level map. The air, 8400∅ c.f.m., follows an air course to junction with a cross cut due south from the Belmont shaft. Here the air splits following two courses to the 1203 raise where they meet again. Part of the air goes down thru the raise to the 1200 level and the remainder works its way up the Belmont vein stopes to the 900 level where it is returned to the Belmont shaft. There is no need for two air courses to the 1203 raise and the longer should be stopped. Door AW shuts off the Rescue Eula Mine.

The only working place ventilated by this system on this level is a stope off 1203 raise in which a man was timbering. The temperature in the stope was 67° 79° 53% and the air movement good.

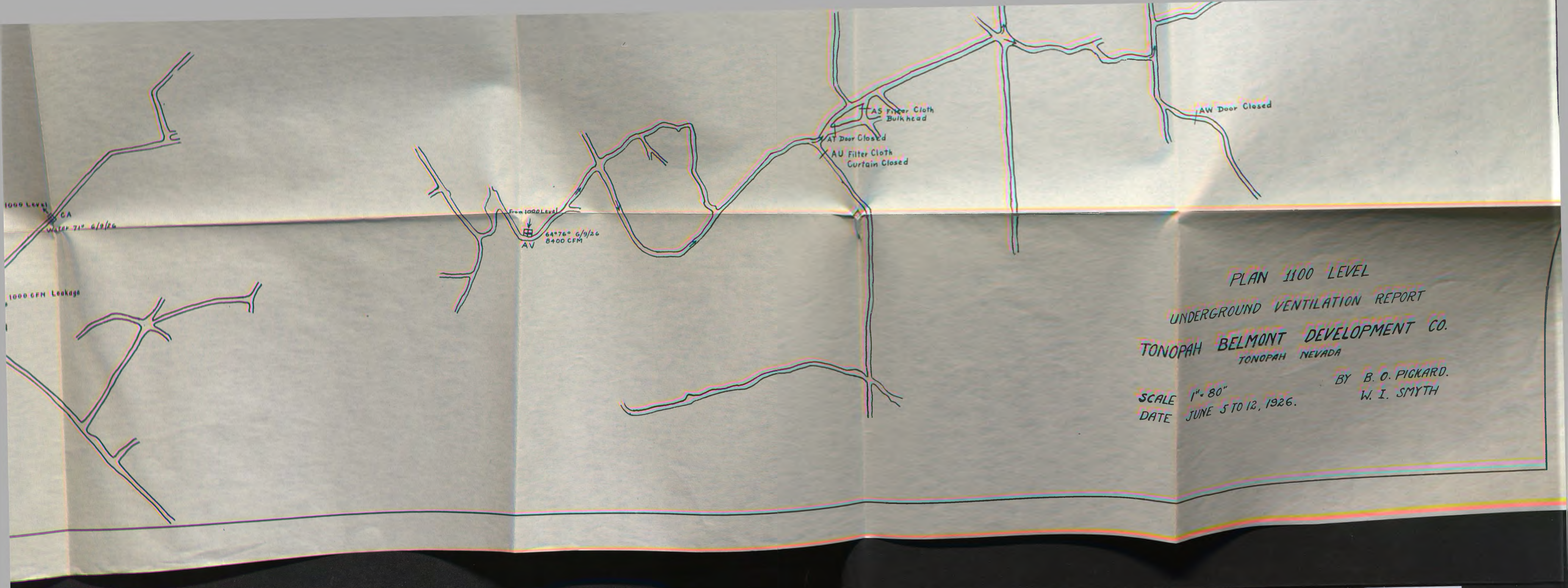
Other air measurements were:

June 9, 1926, AV, intake air from 1000 level, 64° 76° 45%,


N
LEGEND
75° 76° Wet and Dry Bulb Temp.
Ventilation.
Brattice = Burlap Brattice Cloth.
? Bulkhead = Proposed Bulkhead.
= Opening above level.
= Opening below level.
Dead
AL
70°80° 6/9/26
2000 CFM
1132 Stope
HI
HJ
AK
1153 Drift
73°79° 6/9/26
No Movement
F
70°75° 6/6/26
No Movement
HG
Dead
Dead
Dead
1156 Winze
To 1200 Level
62° 68° 6/6/26
Filter Cloth
Curtain Closed
63°73° 6/9/26
1000 CFM
From 1000 Level
1056 Winze
AP
Filter Cloth
Curtain Closed
2000 CFM Leakage
61°70° 6/9/26
1000 CFM 6/9/26
From 1000 Level
AJ
59°70° 7500 CFM 6/6/26
AO
Filter Cloth
Curtain Open
1000 CFM
To 1200 Level
AE
AN 62°69° 6/9/26
7300 CFM
From 1000 Level
HF
66°77° 6/9/26
1400 CFM
From 1000 Level
AM
Door Closed
3000 CFM Regulator Open
59°70° 6/9/26
Dead
AH
68°79° 2000 CFM 6/9/26
HD
HE
Fan
72°83° 2700 CFM
6/5/26
71°88° 6/6/26
79°84° 6/6/26
Top of Muck Pile
Fan Discharge
73°86° 6/6/26
79°84° 6/6/26
Back of Stope
79°83° 6/6/26
Top of Muck Pile
Silver State Stope
From Stopes
75°82° 6/9/26
3200 CFM
AZ
AY
1000 CFM
6/9/26
Brattice
Partition
76°80°
1000 CFM
6/9/26
Belmont
Shaft
72°79° 6/5/26
70°79° 6/6/26
70°76° 6/9/26
HC
68°80° 4300 CFM 6/9/26
70°81° 2700 CFM 6/5/26
Door
Open
72°81° 6/9/26
AG 1000 CFM
AX
1203 Raise
67°79° 6/9/
To 1200 Le
71°81° 6/9/26
Curtain Closed
AQ
78°80° 3000 C
To 1000 L
Thru 150


78°80° 3000 CFM 6/9/26
To 1000 Level
Thru 150 Stope
BB
BA
77°81° No Movement 6/9/26
Dead
AL
70°80° 6/9/26
2000 CFM
1132 Stope
HJ
HI
AK
1153 Drift
73°79° 6/9/26
No Movement
Dead
Dead
F
70°75° 6/6/26
No Movement
HG
Dead
1156 Winze
To 1200 Level
62°68° 6/6/26
Filter Cloth
Curtain Closed
1000 CFM 6/9/26
From 1000 Level
AJ
AP
Filter Cloth
Curtain Closed
2000 CFM Leakage
61°70° 6/9/26
63°73° 6/9/26
1000 CFM
From 1000 Level
1056 Winze
From Stopes
75°82° 6/9/26
3200 CFM
AZ
AY
1000 CFM
6/9/26
Brattice
Partition
76°80°
1000 CFM
6/9/26
Dead
59°70° 7500 CFM 6/6/26
AH
68°79° 2000 CFM 6/9/26
Belmont
Shaft
72°79° 6/5/26
70°79° 6/6/26
70°76° 6/9/26
AO
Filter Cloth
Curtain Open
HD
HC
68°80° 4300 CFM 6/5/26
70°81° 2700 CFM 6/5/26
AX
1203 Raise
Dead
1000 CFM
To 1200 Level
Door
Open
67°79° 6/9/26
To 1200 Level
HE
AE
AN
62°69° 6/9/26
7300 CFM
From 1000 Level
AG
72°81° 6/9/26
1000 CFM
66°77° 6/9/26
1400 CFM
71°81° 6/9/26
Curtain Closed
AQ
HF
From 1000 Level
Door Closed
Fan
72°83° 2700 CFM
6/5/26
71°88° 6/6/26
AM
3000 CFM Regulator Open
59°70° 6/9/26
Dead
79°84° 6/6/26
Top of Muck Pile
Fan Discharge
73°86° 6/6/26
79°84° 6/6/26
Back of Stope
79°83° 6/6/26
Top of Muck Pile


To 1000 Level
CA
BZ
Door and
Curtain Closed
Dead
Silver State Stope
From 1000 Level
AV
64°76° 6/9/26
8400 CFM
AT Door Closed
AU Filter Cloth
Curtain Closed
AS Filter Cloth
Bulkhead
AR
Door Open
63°77° 4100 CFM 6/9/26
UNDERGRO
TONOPAH BEL
SCALE 1"=80'
DATE JUNE 5 TO


1000 Level
CA
Water 71° 6/9/26
1000 CFM Leakage
From 1000 Level
AV
64°76° 6/9/26
8400 CFM
AS Filter Cloth
Bulkhead
AT Door Closed
AU Filter Cloth
Curtain Closed
AW Door Closed
PLAN 1100 LEVEL
UNDERGROUND VENTILATION REPORT
TONOPAH BELMONT DEVELOPMENT CO.
TONOPAH NEVADA
SCALE 1" = 80'
DATE JUNE 5 TO 12, 1926.
BY B. O. PICKARD.
W. I. SMYTH

260 x 5.0 x 6.5, 8400 c.f.m.

June 9, 1926, AR, open door, 69° 77° 67%, 170 x 4.0 x 6.0, 4100 c.f.m.

June 9, 1926, AL, 1203 stope, 67° 79° 53%.

Main Ventilation System. This level receives intake air from the 1000 level thru raises AM, AN, and AJ, corresponding to raises BK, BJ and BM, respectively, on the 1000 level map. Air is also received from the 1000 level thru the West Favorite stopes, about 2000 c.f.m. of it being mapped near the 1132 stopes. The 10,000 c.f.m. of air to the West Favorite stopes from the 1000 level does not, after leaving these stopes, form definite air courses, but seeps thru a large stoped area forming part of the return air on the 900, 1000 and 1100 levels.

Most of the intake air on this level goes to the 1200 level thru 1166 winze and raise AE. The balance; that is air from raise AJ, seepage thru curtain AP, 1400 c.f.m. thru an open regulator in a closed door and a small amount of air from the 1132 stope country, works its way thru poorly defined air courses to either the Belmont shaft or the return air course thru the 150 stopes to the 1000 level. A fan draws 2700 c.f.m. of air to ventilate the Silver State stope.

A curtain AQ south of the Belmont shaft separates

260 x 5.0 x 6.5, 8400 c.f.m.

June 9, 1926, AR, open door, 69° 77° 67%, 170 x 4.0 x 6.0, 4100 c.f.m.

June 9, 1926, AX, 1203 stope, 67° 79° 53%.

Main Ventilation System. This level receives intake air from the 1000 level thru raises AM, AN, and AJ, corresponding to raises BK, BJ and BM, respectively, on the 1000 level map. Air is also received from the 1000 level thru the West Favorite stopes, about 2000 c.f.m. of it being mapped near the 1132 stopes. The 10,000 c.f.m. of air to the West Favorite stopes from the 1000 level does not, after leaving these stopes, form definite air courses, but seeps thru a large stoped area forming part of the return air on the 900, 1000 and 1100 levels.

Most of the intake air on this level goes to the 1200 level thru 1166 winze and raise AE. The balance; that is air from raise AJ, seepage thru curtain AP, 1400 c.f.m. thru an open regulator in a closed door and a small amount of air from the 1132 stope country, works its way thru poorly defined air courses to either the Belmont shaft or the return air course thru the 150 stopes to the 1000 level. A fan draws 2700 c.f.m. of air to ventilate the Silver State stope.

A curtain AQ south of the Belmont shaft separates the main and southern ventilation systems.

A curtain and a door have been placed in the cross cut from the Desert Queen shaft to prevent air from the shaft going to the southern ventilation system. There is about 1000 c.f.m. of air leakage thru this barrier, however, which goes up raise CA to the 1000 level. The temperature of standing water on the 1100 level Desert Queen at the foot of raise CA was 71° F.

Air measurements were as follows:

June 9, 1926, AM, intake air, 59° 70° 51%, 3000 c.f.m.

June 9, 1926, AN, intake air, 62° 69° 68%, 250 x 4.5 x 6.5, 7300 c.f.m.

June 8, 1926, door with open regulator, 62° 73° 53%.

June 9, 1926, door with open regulator, 66° 77° 55%, 40 x 5 x 7, 1400 c.f.m.

June 6, 1926, filter cloth curtain up, main air course to lower levels, 59° 70° 51%, 270 x 4.6 x 6.0, 7500 cfm.

June 6, 1926, collar 1166 winze, 62° 68° 71%.

June 9, 1926, air from 1056 raise, 63° 73° 57%, 1000 c.f.m.

June 6, 1926, underhand stope F, 70° 75° 78%, dead.

June 9, 1926, AP, filter cloth curtain in bad order, 61° 70° 59%, 2000 c.f.m. leakage.

June 9, 1926, AL, to 1122 stope, 70° 80° 61%, 2000 c.f.m.

June 9, 1926, AK, 1152 drift, 73° 79° 75%, no movement.

June 9, 1926, AH, 68° 76° 66%, 2000 c.f.m.

June 5, 1926, at fan Silver State stope, 72° 83° 58%, 2700 c.f.m.

June 6, 1926, at fan Silver State stope, 71° 88° 43%.

June 6, 1926, east side Silver State stope, 79° 84° 81%.

June 6, 1926, back Silver State stope, 79° 84° 81%.

June 6, 1926, west side Silver State stope, 79° 83° 84%.

June 9, 1926, curtain AQ south of Belmont shaft, 71° 81° 61%, no movement.

June 5, 1926, door Belmont station, 70° 81° 57%, 140 x 5.6 x 5.6, 2900 c.f.m.

June 9, 1926, door Belmont station, 68° 80° 54%, 190 x 5.8 x 6.0, 4500 c.f.m.

June 9, 1926, AG, air from Belmont vein stopes, 72° 81° 64%, 1000 c.f.m.

June 5, 1926, Belmont station, 72° 79° 72%.

June 6, 1926, Belmont station, 70° 79° 64%.

June 9, 1926, Belmont station, 70 ° 76° 74%.

June 9, 1926, AM, south of partition, air to Belmont shaft, 70° 80° 63%. 1000 c.f.m.

June 9, 1926, AL, north of partition, air to 150 stope, 75° 82° 72%, 100 x 5.0 x 6.5, 3200 c.f.m.

June 9, 1926, return air, BA, 78° 80° 91%, 3000 c.f.m., air passes thru working place, 150 stope to 1000 level.

June 9, 1926, stope BB, working place, 77° 81° 82%, no movement, dusty.

June 10, 1926, BE, cross cut from Desert Queen shaft, 61° 74° 46%, 1000 c.f.m. leakage.

1166 LEVEL.

The 1166 level was not mapped in detail. There are two working places on this level. An Ingersoll-Rand drifter machine was prospecting for ore at G1. Four men were working in the Western vein stope at H.

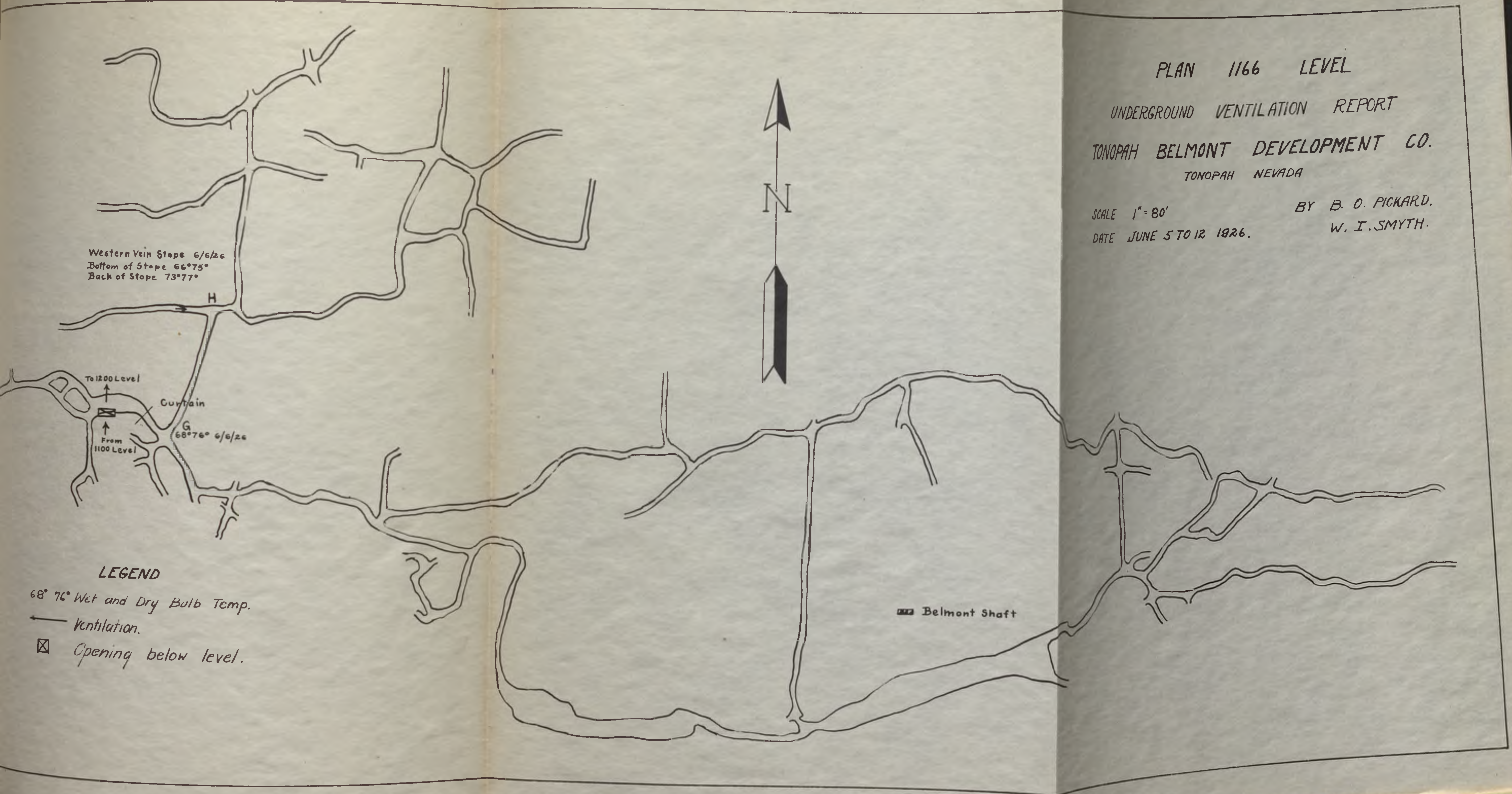
Air measurements were:

June 6, 1926, G-1, drill station, 68° 76° 86%, very muddy along drift.

June 6, 1926, H, bottom Western vein stope, 66°75° 62%.

June 6, 1926, H, back Western vein stope, 73° 77° 82%.

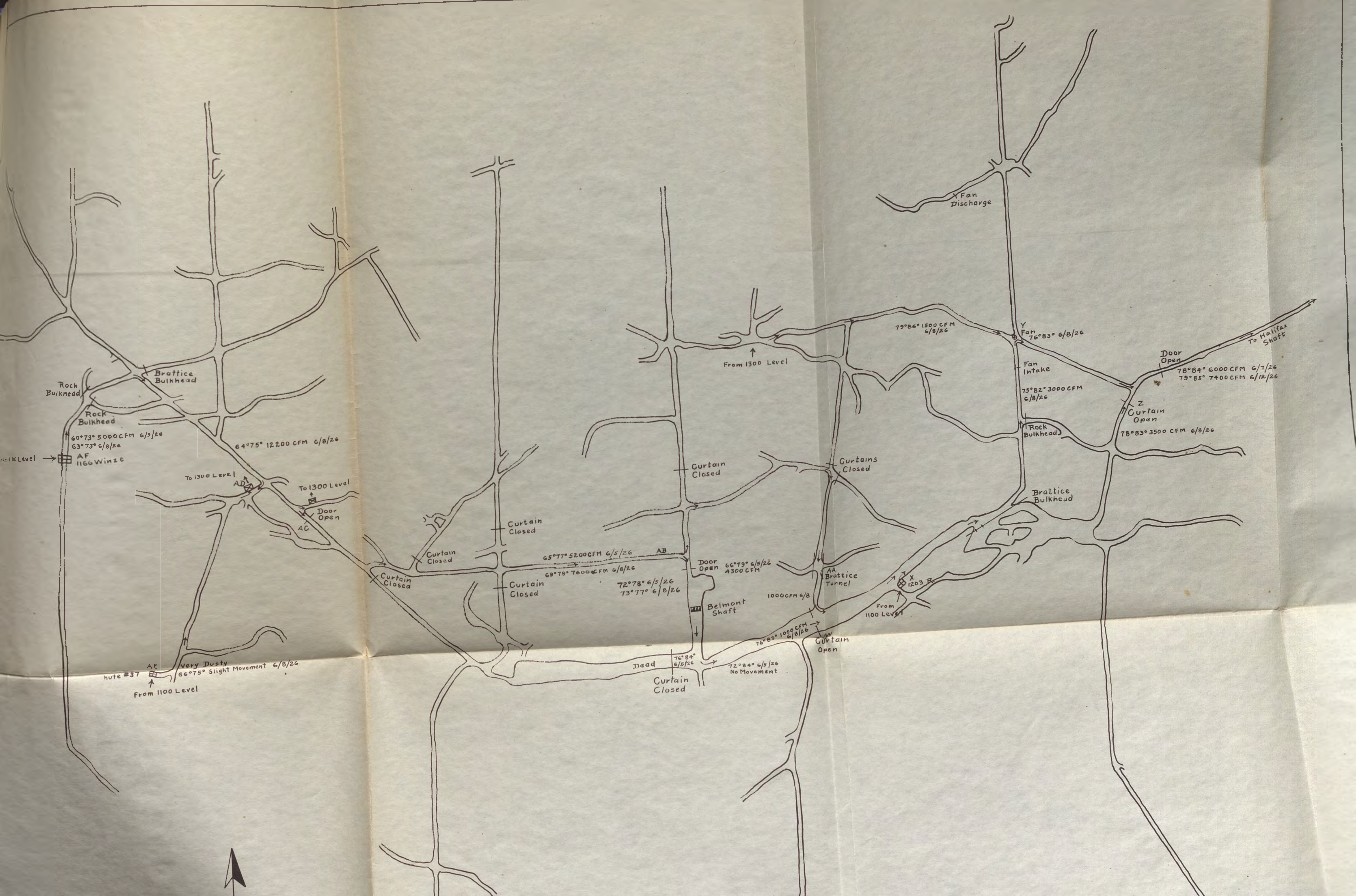
A fire occurred on this level at the 1166 winze on Feb. 23, 1911 in which 17 men lost their lives. Results of the fire are still evident. Timber in the vicinity of the winze is badly charred, the walls and top of drifts for a long distance are black from smoke, and the odor of creosote is still strong.

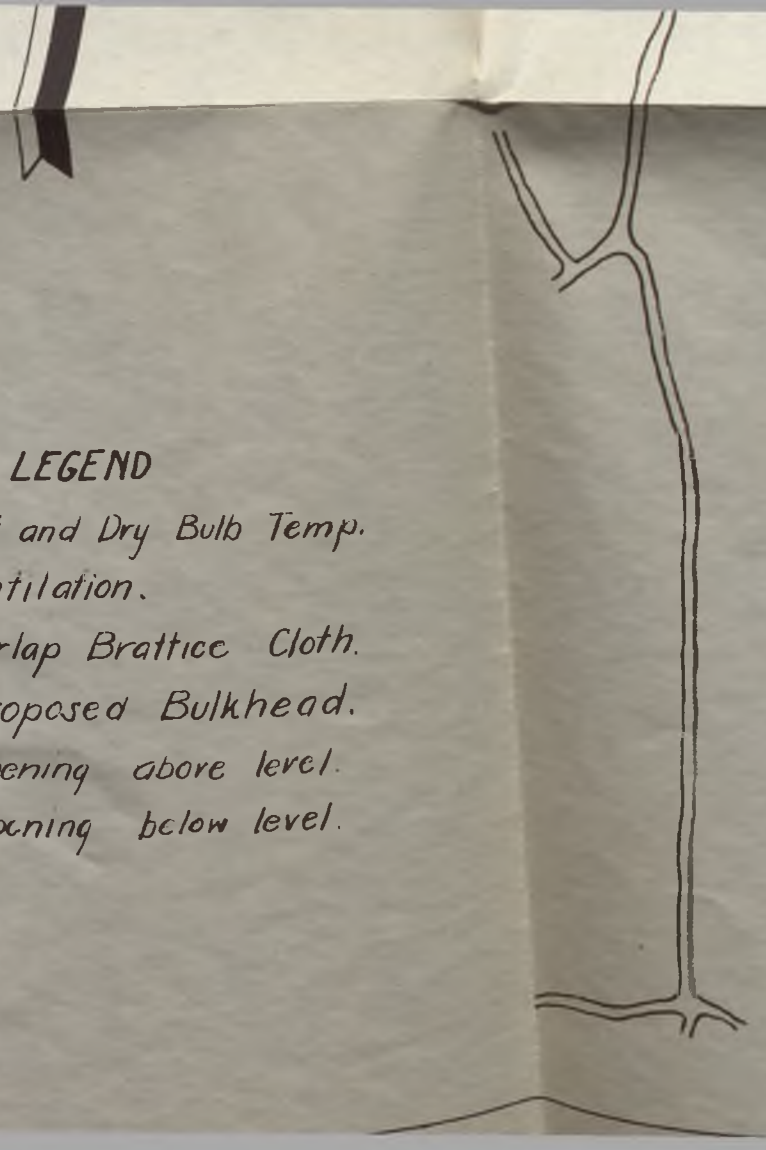

PLAN 1166 LEVEL
UNDERGROUND VENTILATION REPORT
TONOPAH BELMONT DEVELOPMENT CO.
TONOPAH NEVADA
SCALE 1" = 80'
DATE JUNE 5 TO 12 1926.
BY B. O. PICKARD.
W. I. SMYTH.
N
Western Vein Stope 6/6/26
Bottom of Stope 66° 75°
Back of Stope 73° 77°
H
To 1200 Level
Curtain
G
68° 76° 6/6/26
From 1100 Level
Belmont Shaft
LEGEND
68° 76° Wet and Dry Bulb Temp.
Ventilation.
Opening below level.

1200 LEVEL.

Intake air for this level is received from the 1100 level thru the 1166 winze and raise AE. Raise AE is also used for an ore passage and the amount of air coming down it varies with the amount of ore it is holding. At the time of our investigation, the ore had not been sprinkled, and consequently, great clouds of dust would roll along the drift when ore was drawn from the chute. Dust several inches deep had settled along the drift for a hundred or more feet from the chute. The finer portions of the dust would be carried in suspension for long distances along the air course. Several times during the eight days dust from this raise was noted at the Belmont station.

The total amount of intake air varied from 5000 c.f.m. to 12,000 c.f.m. This variation was probably due to curtains on the 1000 and 1100 levels being open when they should be closed. Part of the intake air goes to the 1300 level thru raise AD and AC. The balance follows an air course to the cross cut north from the Belmont shaft. Here the current splits, part going to the shaft, and the balance taking a crooked course controlled by burlap stoppages to fan Y. 1500 c.f.m. of


Rock Bulkhead
Brattice Bulkhead
Rock Bulkhead
60°73° 5000 CFM 6/5/26
63°73° 6/8/26
AF
1166 Winze
64°75° 12200 CFM 6/8/26
To 1300 Level
AD
To 1300 Level
Door Open
AC
Curtain Closed
Curtain Closed
Curtain Closed
Curtain Closed
Curtain Closed
65°77° 5200 CFM 6/5/26
AB
69°79° 7600 CFM 6/8/26
72°78° 6/5/26
73°77° 6/8/26
Door Open
66°79° 6/5/26
4300 CFM
Belmont Shaft
From 1300 Level
Curtains Closed
AA
Brattice Tunnel
1000 CFM 6/8
76°83° 1000 CFM 6/8/26
W
Curtain Open
76°84° 6/5/26
Dead
Curtain Closed
72°84° 6/5/26
No Movement
AE
Very Dusty
66°75° Slight Movement 6/8/26
hute #37
From 1100 Level
X
1203 R.
From 1100 Level
Brattice Bulkhead
Rock Bulkhead
75°82° 3000 CFM 6/8/26
Fan Intake
Y
Fan 76°83° 6/8/26
79°86° 1500 CFM 6/8/26
Fan Discharge
Door Open
78°84° 6000 CFM 6/7/26
79°85° 7400 CFM 6/12/26
To Halifax Shaft
Z
Curtain Open
78°83° 3500 CFM 6/8/26



LEGEND

72° 78°	Wet and Dry Bulb Temp.
←——	= Ventilation.
Brattice	= Burlap Brattice Cloth.
? Bulkhead	= Proposed Bulkhead.
⊞	= Opening above level.
⊠	= Opening below level.

PLAN 1200 LEVEL

UNDERGROUND VENTILATION REPORT

TONOPAH BELMONT DEVELOPMENT CO.

TONOPAH NEVADA

SCALE 1" = 80'

DATE JUNE 5 TO 12 1926.

BY B. O. PICKARD.

W. I. SMYTH.

air from the 1300 level also passes fan Y coming along the drift from the west..

Thru curtain Z, 3500 c.f.m. of air from the southern ventilation system joins the return air to the Halifax shaft.

The main pumps of the mine are located on this level at the Belmont station. Smaller pumps on the 1400 level pump water to this level.

Air measurements were:

June 8, 1926, AE, Air course and ore passage from 1100 level, 66° 75° 62%, slight movement, very dusty.

June 6, 1926, AF, 1166 winze, intake air, 60° 73° 46%, 180 x 4 x 7, 5000 c.f.m.

June 8, 1926, AF, 1166 winze intake air, 63° 73° 57%.

June 8, 1926, total intake air, 64° 75° 54%, 350 x 5 x 7, 12,200 c.f.m.

June 5, 1926, AB, air course northwest of Belmont station, 65° 77° 49%, 140 x 5.0 x 7.5, 5200 c.f.m.

June 8, 1926, AB, 69° 79° 60%, 180 x 5.7 x 7.4, 7600 c.f.m.

June 5, 1926, door north of station, 66° 79° 50%, 200 x 3.8 x 6.0, 4500 c.f.m.

June 5, 1926, Belmont station, 72° 78° 75%.

June 8, 1926, Belmont station, 75° 77° 81%.

June 5, 1926, at curtain in stope southwest of station, 76° 84° 68%, no movement.

June 5, 1926, air going southeast from shaft, 72° 84° 56%, slight movement.

June 8, 1926, W, curtain up in stope south east of station, 76° 83° 73%, 1000 c.f.m.

June 8, 1926, at intake fan Y, 75° 82° 73%, 90 x 4.5 x 7.5, 3000 c.f.m.

June 8, 1926, fan Y, 76° 83° 73%.

June 8, 1926, air from drift west of fan Y, 79° 86° 73%, 1500 c.f.m.

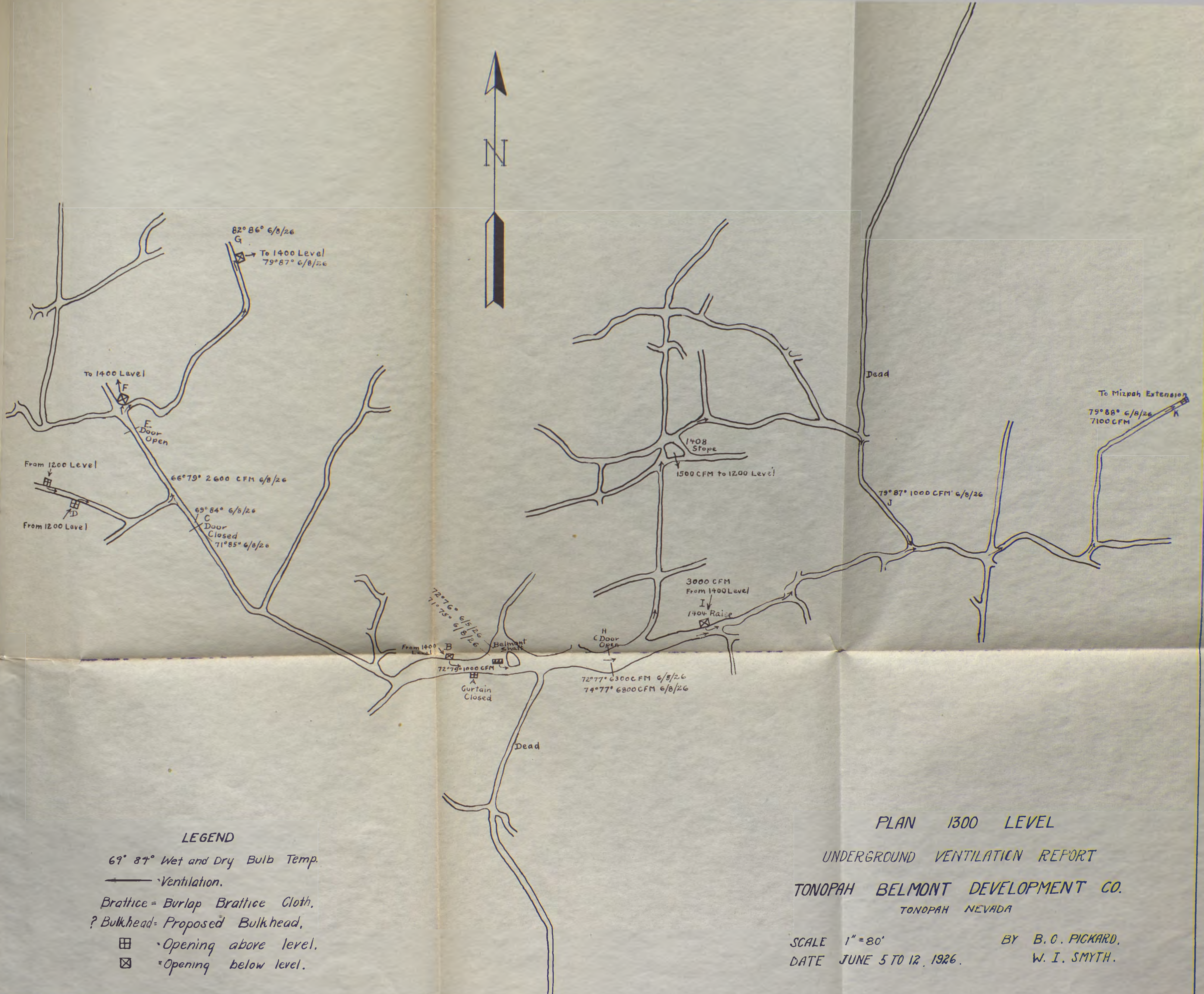
June 8, 1926, E, curtain up, air probably from southern ventilation system, 78° 83° 80%, 210 x 3.3 x 5.0, 3500 c.f.m.

June 7, 1926, return air to Halifax shaft, 75° 84° 77%, 250 x 3.7 x 6.5, 6000 c.f.m.

June 12, 1926, return air to Halifax shaft, 79° 85° 77%, 320 x 3.6 x 6.4, 7400 c.f.m.

1300 LEVEL.

Air is received on this level from the 1200 level thru two raises connecting with drift D, corresponding with raises AC and AD on the 1200 level map. By keeping



LEGEND

69° 84° Wet and Dry Bulb Temp.

⟵ Ventilation.

Brattice = Burlap Brattice Cloth.

? Bulkhead = Proposed Bulkhead.

⊞ = Opening above level.

⊠ = Opening below level.

PLAN 1300 LEVEL

UNDERGROUND VENTILATION REPORT

TONOPAH BELMONT DEVELOPMENT CO.

TONOPAH NEVADA

SCALE 1" = 80'

DATE JUNE 5 TO 12, 1926.

BY B. O. PICKARD.
W. I. SMYTH.

door C closed, this air is forced to the 1400 level thru raised F and G2. The amount of air was 2600 c.f.m. on June 8, 1926. The only work being done on the level was at G2 where a crew was prospecting with an Ingersoll-Rand drifter machine.

Air was also received on this level from the Belmont shaft, which is downcast in the lower levels of the mine. The amount of air from the shaft varied from 5000 to 6000 c.f.m. More air is received from the 1400 level thru raises B and 1404. 1408 stope takes air from both the 1400 level and the 1300 level up to the 1200 level. 7100 c.f.m of return air to the Halifax shaft was measured on June 8th.

Air measurements on the 1300 level were:

June 8, 1926, intake air thru raises D, 66° 74° 49%. 75 x 5 x 7, 2600 c.f.m.

June 8, 1926, G2, breast of drift, 82° 86° 84%, no movement.

June 8, 1926, G2, air to 1400 level, 79° 87° 69%.

June 8, 1926, west side door C, 69° 84° 46%.

June 8, 1926, east side door C, 71° 85° 50%.

June 8, 1926, air from raise B, 72° 79° 72%, 1000 c.f.m.

June 5, 1926, Belmont station, 72° 76° 82%.

June 8, 1926, Belmont station, 71° 75° 82%.

June 8, 1926, H, open door, 72° 77° 78%, 320 x 3.6 x 5.5, 6300 c.f.m.

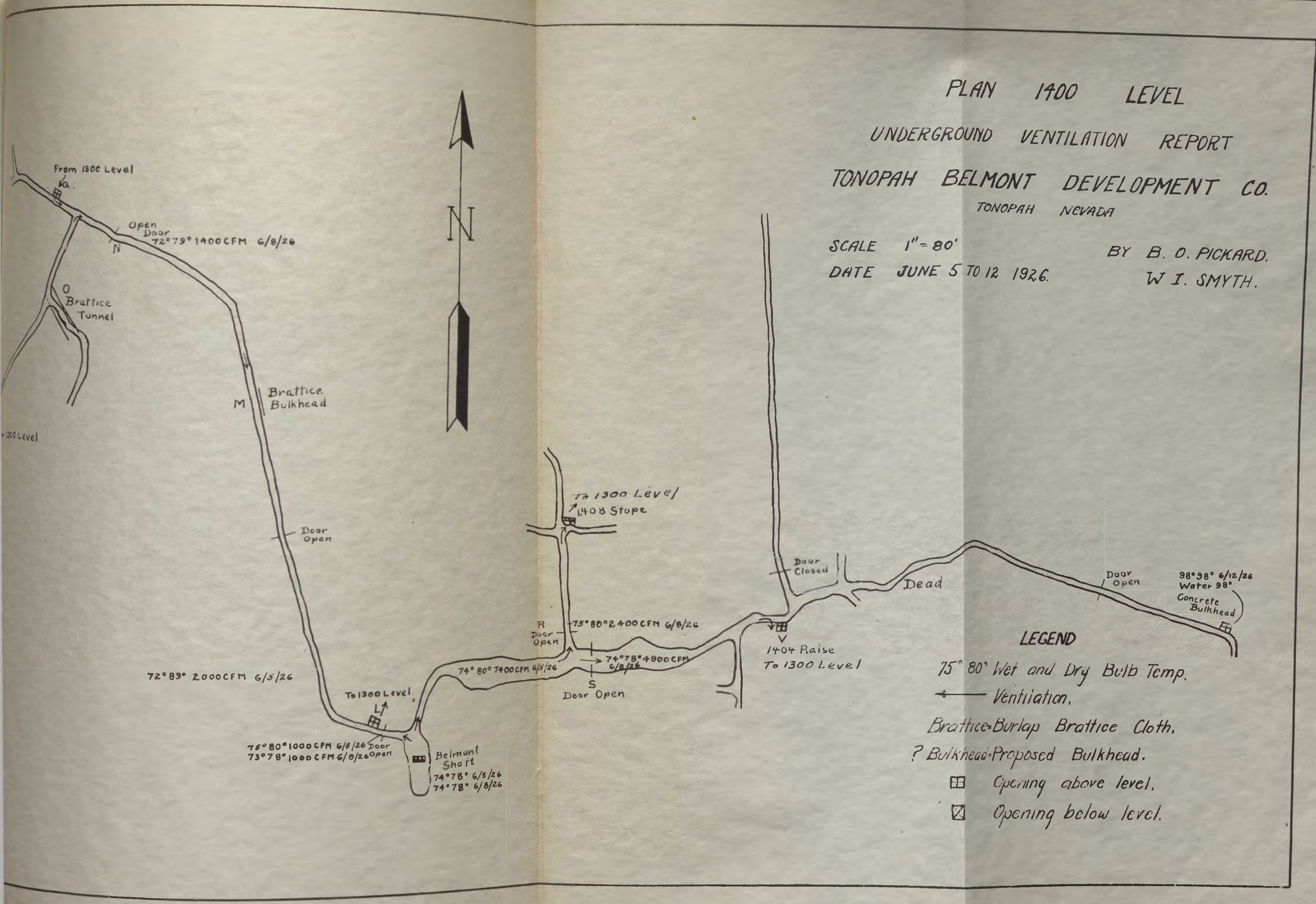
June 8, 1926, H, open door, 74° 77° 80%, 330 x 3.7 x 5.6, 6800 c.f.m.

June 8, 1926, cross cut J, 79° 87° 70%, 1000 c.f.m.

June 8, 1926, return air to Halifax shaft, 79° 85° 67%, 190 x 5.0 x 7.5, 7100 c.f.m.

1400 LEVEL.

Air is received on this level from the 1500 level thru raises Pand O, corresponding to raises F and G2 on the 1300 level map. The quantity of air measured at open door N was only 1400 c.f.m. on June 8th. This door was installed when the 1500 level was being worked to force air thru the brattice cloth tunnel O and down a raise to the 1500 level. This level has since been abandoned and allowed to fill with water. Consequently, door N is now kept open. More air is received from the Belmont shaft. Stope 1408 and raises 1404 and L (raise L corresponding to raise B on the 1500 level map) carry all this air to the 1300 level. No work was being done on the 1400 level.


PLAN 1400 LEVEL
UNDERGROUND VENTILATION REPORT
TONOPAH BELMONT DEVELOPMENT CO.
TONOPAH NEVADA
SCALE 1" = 80'
DATE JUNE 5 TO 12 1926.
BY B. O. PICKARD.
W. I. SMYTH.
N
From 1300 Level
Ka
Open Door
N
72° 79° 1400 CFM 6/8/26
O
Brattice Tunnel
M
Brattice Bulkhead
1300 Level
Door Open
72° 89° 2000 CFM 6/5/26
To 1300 Level
L
75° 80° 1000 CFM 6/8/26
73° 78° 1000 CFM 6/8/26
Door Open
Belmont Shaft
74° 78° 6/5/26
74° 78° 6/8/26
74° 80° 7400 CFM 6/5/26
To 1300 Level
1408 Stope
R
Door Open
75° 80° 2400 CFM 6/8/26
74° 78° 4800 CFM 6/8/26
S
Door Open
Door Closed
Dead
V
1404 Raise
To 1300 Level
Door Open
98° 98° 6/12/26
Water 98°
Concrete Bulkhead
LEGEND
75° 80° Wet and Dry Bulb Temp.
Ventilation.
Brattice-Burlap Brattice Cloth.
? Bulkhead-Proposed Bulkhead.
Opening above level.
Opening below level.

At the extreme east of this level, a concrete bulkhead has been constructed in a connection with the Halifax shaft. Thru this bulkhead a pipe line extends to the sump of the Halifax shaft. Pumps at the 1400 station pump water thru this pipe line to the 1200 station Belmont from where larger pumps pump the water to the surface.

The temperature under the concrete bulkhead at the Halifax connection was 98° 98°, humidity 100%. The rock temperature determined by the temperature of standing water was also 98°. A gas sample taken here showed a CO_2 content of 0.39%.

Air measurements on the 1400 level were:

June 8, 1926, N, open door, 72° 79° 72%, 80 x 3.0 x 6.0, 1400 c.f.m.

June 5, 1926, intake air from 1300 level, 72° 89° 44%, 2000 c.f.m.

June 5, 1926, air west from shaft, 75° 80° 79%, 1000 cfm.

June 8, 1926, air west from shaft to raise L, 75° 78° 79%, 1000 c.f.m.

June 5, 1926, Belmont shaft, 74° 78° 83%.

June 8, 1926, Belmont station, 74° 78° 83%.

June 5, 1926, air east from shaft, 74° 80° 75%, 265 x 4 x 7, 7400 c.f.m.

June 8, 1926, R, air to 1400 stope, 75° 80° 90%, 100 x 3.7 x 6.5, 2400 c.f.m.

June 8, 1926, S, open door, 74° 78° 83%, 240 x 4.0 x 6.0, 4900 c.f.m.

June 12, 1926, under concrete bulkhead at Halifax connection, 98° 98° 100%, no movement, standing water 98°.

ANALYSIS AND DISCUSSION OF RESULTS.

TEMPERATURES AND HUMIDITIES.

General. The principal factors that influence the dry-bulb temperature of mine air are as follows:

1. Temperature of outside air.
2. Rock and water temperature.
3. Oxidation.
   - Ore.
   - Timber.
   - Fires.
   - Explosives.
4. Friction of air.
5. Quantity of air.
6. Air from other mines.

The rock temperature is the most important of these factors because, normally, the air temperature will approach that of the rock at the rate of 1 degree per 100 feet of travel until the two equalize. Large quantities of cool air will have the effect of slowly lowering rock temperatures until eventually the rock will be cool enough to help keep down high temperatures in the air currents.

A great deal of heat may be generated in old stopes by the oxidation and decay of timber. In the region of such stopes, the air temperature may be considerably above that of the rocks.

The wet-bulb reading is the more important temperature underground because it is one of the factors that determine the cooling power of the air. The dry-bulb temperature may be as high or higher than the body temperature of a miner but, if the wet-bulb temperature is low, the air will evaporate the sweat on the miner, cooling him and allowing him to work at maximum capacity. Consequently, low wet-bulb temperatures and low relative humidities are desired underground.

The principal factors affecting the relative humidity of mine air are as follows:

1. Relative humidity of surface air.
2. Moisture content of workings.
3. Water used in mining operations.
4. Temperature and velocity of air.

As a rule, air traveling thru a mine takes up water vapor from underground water and from water used for sprinkling, drilling, etc., raising both the wet-bulb temperature and the relative humidity. In cases where the dry-bulb temperature raises without without a corresponding raise in the wet-bulb temperature, as when air is forced thru a ventilatinn pipe by a booster fan, the relative humidity of the air is lowered.

A thorough discussion of temperatures and humidities will be found in Daniel Harrington's reporton "Ventilation in Metal Mines", Technical Paper 251, U. S. Bureau of Mines, and in Bullitin 204, U. S. Bureau of Mines, "Ventilation at Butte" by the same author.

Temperature and Humidity Tables.

Intake air from Tonopah Mining Co.

Date 1926	Level	Wet-Bulb	Dry-bulb	Humidity
June 7	600	51°	59°	57%
June 7	700	53°	61°	59%
June 12	700	55°	61°	68%
June 11	800	57°	62°	74%
June 6	1000	53°	60°	63%
June 10	1000	58°	62°	79%
Average		55°	61°	66%

Intake air from Stone Cabin Mine.

Date 1926	Level	Wet-bulb	Dry-bulb	Humidity
June 12	800	54°	64°	54%
June 12	800	59°	69°	54%
June 10	900	58°	67°	57%
Average		57°	67°	55%

Return air Belmont Shaft.

Date 1926	Level	Wet-bulb	Dry-bulb	Humidity	
June 7	700	72°	77°	78%	
June 11	700	71°	76°	78%	
June 7	900	76°	82°	83%	N. X cut
June 6	900	80°	88°	71%	S. X cut
June 7	900	79°	87°	71%	S. X cut
June 10	900	78°	86°	70%	S. X cut
June 9	1000	76°	84°	70%	N. X cut
June 10	1000	79°	84°	81%	S. X cut
Average		76°	83°	75%	

Return air Mizpah Extension and Halifax Shafts.

Date 1926	Level	Wet-bulb	Dry-bulb	Humidity
June 7	1000	73°	79°	75%
June 9	1000	76°	81°	79%
June 7	1200	78°	84°	77%
June 12	1200	79°	85°	77%
June 8	1300	79°	88°	67%
Average		77°	83°	75%

AVERAGE TEMPERATURES AND HUMIDITIES TONOPAH-BELMONT MINE.

Level	Western Portion				Central Portion				Eastern Portion				Average for Level			
	Number Readings	Temperatures & Humidities			Number Readings	Temperature & Humidity			Number Readings	Temperature & Humidity			Number Readings	Temperature & Humidity		
600	1	51	59	57%	1	75	76	96%					2	63	67	76%
700	4	54	60	65%	5	74	77	85%	2	71	76	76%	11	66	71	76%
800	7	58	66	62%	7	71	79	74%					14	65	72	68%
900	11	60	69	63%	5	70	80	60%	16	79	85	78%	32	71	79	70%
1000	13	59	67	62%	9	70	80	62%	12	74	82	70%	34	67	76	65%
1100	1	61	67	62%	23	68	78	62%	10	72	79	72%	34	69	78	64%
1166					3	69	76	70%					3	69	76	70%
1200					9	67	77	58%	11	75	82	72%	20	71	80	65%
1300					6	73	83	62%	6	74	80	77%	12	74	82	70%
1400					5	72	83	74%	6	79	82	84%	11	76	84	79%
Average	37	58	66	62%	73	70	79	66%	63	76	82	75%	173	70	77	68%

Summary of 1921 Temperature and Humidity Readings.

	Number Readings	Wet-bulb	Dry-bulb	Humidity
Average drifts and cross cuts	54	71°	77°	75%
Average stopes	20	74°	77°	83%
Average all readings	74	73°	78°	79%

Water Temperatures.

1100 level Desert Queen, standing water .... 71°F
1400 level, bulkhead at Halifax shaft, standing water ... 98°F

The charts on pages 62 and 63 show the temperature of the intake air to average 63°F. and the humidity 62%. While passing thru the mine, the air increases in temperature 20 degrees and in humidity 13 percent, the average readings at the upcast shafts being 83° F. and 75% humidity. Assuming a volume of 50,000 c.f.m. of air for the mine, the amount of moisture taken up and removed from the underground workings by the air currents is 33.5 pounds per minute or about one ton per hour. This is sufficient to keep practically all portions of the mine dry.

The chart on page 64 showsthe average wet-bulb and dry-bulb temperatures and relative humidities of all readings taken underground, arranged vertically according to levels and horizontally according to western, central or eastern portion of mine. The western portion includes all workings from the Desert Queen shaft to a north and south line midway between the two shafts. The central portion includes all workings from this line to, but not including, the Belmont shaft. The eastern portion includes all workings east of the Belmont shaft.

Excluding the 900 level, the chart clearly shows a gradual increase in both wet-bulb and dry-bulb temperatures with depth and also from the western to the eastern part of the mine. Rock temperatures play the most important part in this increase in air temperatures. The rock in the lower levels near the Halifax line are much hotter than in the Desert Queen workings. The difference in rock temperatures is partially due to the cooling effect of the intake air on the rocks over a period of many years.

In the regions of extensive stoping and timbering, the oxidation and decay of old timber has an important effect by raising air temperatures. This source of heat from the old abandoned stopes of the 900 level causes this level to be much hotter than the neighboring levels.

A study of the above charts and , also, detailed temperature readings listed under "Details of Study Data" is interesting from the standpoint of wet-bulb temperatures and relative humidities. Less than 5% of the relative humidity readings are over 90% and only 17% are over 80%. All the places of higher humidities are in dead ends or stopes with poor air circulation. An average mine air of 70° 77° 68% is much better than is found in most mines as large as the Tonopah-Belmont.

VELOCITY AND VOLUME TABLE.

LEVEL	LOCATION	CROSS SECTION FEET	VELOCITY FT PER MIN	VOLUME CU FT PER MIN	DATE
600	Desert Queen - Intake from Tonopah Mining Co.	3.7 x 6.2	700	16,000	6/7/26
700	Desert Queen - Intake from Tonopah Mining Co.	5.2 x 7.4	210	8,100	6/7/26
700	" " " " " " " " " " "	3.4 x 5.8	280	5,500	6/12/26
700	Belmont return air	3.3 x 6.5	330	7,100	6/7/26
700	" " "	3.3 x 6.5	340	7,300	6/11/26
800	Intake from Stone Cabin (FL)	5 x 7	100	3,500	6/12/26
800	Air to 900 level thru FG	3 x 7.3	180	3,900	6/11/26
800	Air passing door at EV	3.3 x 6.0	245	4,900	6/7/26
800	" " " " "	3.4 x 6.0	260	5,300	6/11/26
900	Air passing EE	4.0 x 6.3	230	6,000	6/11/26
900	Intake at DI	5 x 7	140	5,300	6/11/26
900	Air passing DE	3.5 x 3.0	200	2,100	6/11/26
900	Air passing DG	4 x 5	160	3,200	6/11/26
900	Air passing EC			5,000	6/7/26
900	" " "			4,000	6/11/26
900	Air passing to Belmont stopes			4,000	6/11/26
1000	Air from Desert Queen shaft at BV	5.0 x 6.0	580	17,400	6/10/26
1000	Air passing BL	3.4 x 6.4	520	11,300	6/9/26
1000	Air passing BO	3.6 x 6.2	460	10,300	6/10/26
1000	Air passing BJ	3.5 x 5.8	400	8,100	6/9/26
1000	Air passing BK	6.0 x 6.5	100	3,900	6/9/26
1000	Air passing north side BF	2.8 x 6.0	210	3,500	6/9/26
1000	Air passing south side BF			2,000	6/9/26
1000	Air returning at BI	5 x 7.5	150	5,000	6/7/26
1000	" " " "	5.6 x 8.5	160	7,600	6/9/26
1000	Intake at Desert Queen station	5.6 x 8.0	300	13,400	6/6/26
1000	Total Intake	5.9 x 6.9	610	24,000	6/7/26

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VELOCITY AND VOLUME TABLE.

LEVEL	LOCATION	CROSS SECTION FEET	VELOCITY FT PER MIN	VOLUME CU FT PER MIN	DATE
1100	Intake air at AV	5.0 x 6.5	260	8,400	6/9/26
1100	Air passing AR	4 x 6	170	4,100	6/9/26
1100	Door Belmont station	3.6 x 5.6	142	2,900	6/5/26
1100	Door Belmont station	3.8 x 6.0	190	4,300	6/9/26
1100	South of partition AZ			1,000	6/9/26
1100	North of partition AZ	5.0 x 6.5	100	3,200	6/9/26
1100	Intake at AN	4.5 x 6.5	250	7,300	6/9/26
1100	Door with regulator	5 x 7	40	1,400	6/9/26
1100	Air passing AD	4.6 x 6.0	270	7,500	6/6/26
1200	1166 winze intake air	4 x 7	180	5,000	6/5/26
1200	Total intake air	5 x 7	350	12,200	6/8/26
1200	Air passing AB	5.0 x 7.5	140	5,200	6/5/26
1200	" " "	5.7 x 7.4	180	7,600	6/8/26
1200	Door north of Belmont station	3.6 x 6.0	200	4,300	6/5/26
1200	Intake at fan Y	4.5 x 7.5	90	3,000	6/8/26
1200	Air passing Z	3.3 x 5.0	210	3,500	6/8/26
1200	Return air to Halifax shaft	3.7 x 6.5	250	6,000	6/7/26
1200	" " " " "	3.6 x 6.4	320	7,400	6/12/26
1300	Intake air through raises at D	5 x 7	75	2,600	6/8/26
1300	Air at H	3.6 x 5.5	320	6,300,	6/5/26
1300	" " "	3.7 x 5.6	330	6,800	6/8/26
1300	Return air to Halifax at K	5.0 x 7.5	190	7,100	6/8/26
1400	Air passing S	4 x 6	240	4,900	6/8/26
1400	Air passing N	3 x 6	80	1,400	6/8/26
1400	Air from Belmont shaft	4 x 7	265	7,400	6/5/26

INTAKE AIR.

Main Ventilation System

800 level, passing EV	5300 c.f.m	
900 level, passing DA	2500 c.f.m.	
900 level, passing DN	2000 c.f.m.	
1000 level	24000 c.f.m.	
	33800 c.f.m.	33800 c.f.m.

Southern Ventilation System

700 level, from Stone Cabin	3000 c.f.m.	
800 level, from Stone Cabin	3500 c.f.m.	
900 level, from Stone Cabin	9000 c.f.m.	
1100 level, from Desert Queen	1000 c.f.m.	
	16500 c.f.m.	16500 c.f.m.
Allowance for compressed air		2000 c.f.m.
Allowance for expansion, 4.7%		2400 c.f.m.
Total amount of intake air		54700 c.f.m.

RETURN AIR.

To Belmont Shaft

700 level, passing EI	7300 c.f.m.
900 level, from south	11100 c.f.m.
900 level from north	5000 c.f.m.
1000 level, from raise CM	2000 c.f.m.
1000 level, from fan CK	4100 c.f.m.
1000 level, passing BE	2000 c.f.m.
1100 level, from south	4300 c.f.m.
1100 level, from north	1000 c.f.m.
1200 level, from north	6600 c.f.m.
1300 level, from west drift	1000 c.f.m.
Total air to Belmont shaft	44400 c.f.m.

Total air to Belmont Shaft	44400 c.f.m.	
Leaving Belmont Shaft		
1200 level, to south X cut	1000 c.f.m.	
1300 level, to east drift	6800 c.f.m.	
1400 level, to west drift	1000 c.f.m.	
1400 level, to east drift	4900 c.f.m.	
Total	13700 c.f.m.	
Returned to surface by Belmont Shaft	30700 c.f.m.	30700 c.f.m.
Return air to Mizpah Extension and Halifax Shafts		
1000 level	7600 c.f.m.	
1200 level	7400 c.f.m.	
1300 level	7100 c.f.m.	
	22100 c.f.m.	22100 c.f.m.
Short circuit to Stone Cabin Mine		1500 c.f.m.
Total amount of return air		54300 c.f.m.

In calculating the intake and return air volumes, the readings taken during the last five days of the examination were used rather than the earlier readings because on the third day an important door in the ventilation scheme on the 600 level was opened, increasing the amount of intaking air down the Desert Queen shaft and changing volume readings throughout the mine.

The intake air volumes in the main ventilation system were taken along the main air courses from the Desert Queen workings to the Belmont workings. There was too much short circuiting of air thru the old Desert Queen stopes to obtain reliable volume readings near the points of intake.

The figure, 4.7%, for expansion allowance was obtained by comparing the specific gravity of the average intake air with that of the hotter and more humid average return air. See temperature and humidity tables of intake and return air, pages 62 and 63.

Disregarding the allowances for compressed air and expansion, the volume of air in the present ventilation system is about 50,000 c.f.m. The volumes of intake and return air check surprisingly close when one considers that the quantity of air intaking varies in a natural ventilated mine with changes of surface temperature and that conditions within the mine changed from time to time because workmen would not always close curtains and doors as instructed.

Mr. Gardner in November, 1921, found the volume of intake air to be apporximately 40,000 c.f.m. or 20% less than we found in our investigation of June, 1926. Natural ventilation should be poorer in summer than in winter. The conflicting results can only be explained by less mine resistance now for the air c currents and more openings thru which they can travel than there were in 1921.

The 900 level does not receive enough air to satisfy its ventilation requirements. It has more working places than any other level but receives a smaller amount of intake air than any of the main levels. It will also be remembered that it is one of the hottest levels in the mine and, therefore, its share of fresh air should be greater instead of less.

The other levels of the mine are receiving plenty of air for their ventilation requirements if the air were properly circulated thru the stopes.

WORKING PLACES.

General. The U. S. Bureau of Mines standard for metal-mine ventilation has been expressed by Mr. Harrington[5] as follows:

> Efficient ventilation of metal mines consists in supplying at all times such volumes of circulating air at all working places as will enable the miner to work in comfort at maximum physical capacity without endangering his health. Most of the better practice in present-day metal-mine ventilation consists in supplying air through the drifts and a few manways, with little or no attempt to conduct moving or fresh air to the faces or breasts where men work.

The reasons why fresh moving air is necessary at working faces may be summarized as follows:

1. Replacement of hot air with cooler air.
2. Replacement of humid air with air of lower relative humidity.
3. Cooling effect of air of low humidity upon workmen.
4. Cooling effect of moving air upon workmen.
5. Dilution and removal of inert and poisonous gases.
6. Removal of dust.

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5. Ventilation of Metal Mines, U. S. Bureau of Mines Technical Paper 251, page 35.

In order to get cool air and air of low humidity to a working place it is necessary that it reach that place before it is heated to rock temperature, if the rock temperature is high, and before it can evaporate enough water to become saturated. Hence, it is necessary that air reaches the stope by the shortest and quickest route possible. By so doing, it will not only be cooler and of lower humidity, but will contain less dust, decay spores and other impurities.

In discussing the physiological effects of air movement in the publication quoted above, Mr. Harrington states:

> Until dry-bulb temperature approaches 75° F., a relative humidity practically up to saturation causes little or no discomfort, even though the air is still, unless the air is depleted of oxygen or is charged with comparatively large quantities of CO, CO_2, or other noxious gases. When such air is given a velocity of 25 linear feet or more, work can be done normally. With the relative humidity 85% or more and the temperature 75° to 85°, stagnant air, even when pure, is oppressive, and its oppressiveness is greatly intensified with even a small decrease in oxygen supply or increase of CO_2. However, where comparatively pure air of the above sort is given a velocity of 100 linear feet a minute, a miner feels no appreciable discomfort even when working fairly hard. Similarly, stagnant air, regardless of purity and humidity, is oppressive at temperatures of 90° to 95° F., and the oppressiveness increases as the air approaches saturation.

With a velocity of 400 linear feet or more a minute, such air is not particularly oppressive and with velocities of 1,000 or more linear feet a minute the effect is pleasant, particularly if the relative humidity is not more than 95%. It is the authors opinion that 25 feet a minute should be the minimum allowable air velocity in any working place underground.

Working conditions in the Belmont Mine will be compared with the standard established by the Bureau of Mines. The table on page 77 is a tabulation of data taken in the working places of the Belmont Mine. Below is a summary of conditions grouping the working places into groups according to the velocity of air thru the place.

SUMMARY OF CONDITIONS IN WORKING PLACES.

		Average Readings			
Air Movement	Number Places	Wet-bulb	Dry-bulb	Humidity	Wet-bulb Depression
None	11	78°	82°	84%	4°
Less than Bureau of Mines Standard of 25 feet per Min.	8	69°	76°	72%	7°
More than Bureau of Mines standard of 25 ft per min	5	69°	79°	62%	10°
Average of all working places	24	74°	80°	75%	6°

WORKING PLACES.

DATE 1926	WORKING PLACE	LEVEL	TEMPERATURE AND HUMIDITY			CROSS SECTION	VELOCITY	QUANTITY OF MOVING AIR	NUMBER MEN
6/12	6000 stope	600	75	76	96%	5 x 30	0	0	2
6/12	FP West stope 6	800	87	90	89	5 x 10	0	0	2
6/11	EQ	800	70	80	61	5 x 8	50	2,000	2
6/11	ES	800	69	77	67	10 x 30	10	3,000	2
6/11	ET	800	69	77	67	6 x 8	20	1,000	1
6/12	FO	800	65	70	77	8 x 10	25	2,000	2
6/11	DM	900	62	68	71	6 x 8	20	1,000	2
6/11	DY fan not running	900	80	82	91	6 x 7	0	0	0
6/10	CN " " "	900	80	89	68	?	0	0	0
6/10	CR	900	83	85	92	5 x 25	0	0	1
6/10	CQ fan not running	900	83	85	92	6 x 30	0	0	0
6/10	CZ air from fan	900	68	79	56	6 x 8	20	1,000	1
6/10	CE	1000	67	78	56	6 x 9	70	4,000	1
6/10	CL air from fan	1000	76	83	73	7 x 10	40	2,800	3
6/9	BG	1000	78	82	83	6 x 12	0	0	2
6/9	AX 1203 raise	1100	67	79	53	8 x 10	100	8,000	1
6/10	West Favorite stope	1100	58	66	62	7 x 150	10	10,000	3
6/6	Silver State stope	1100	79	84	81	5 x 40	14	2,800	4
6/6	F	1100	70	75	78	5 x 10	0	0	1
6/9	AH 1153 drift	1100	73	79	75	5 x 7	0	0	1
6/9	BB	1100	77	81	83	6 x 8	0	0	1
6/9	BA 150 stope	1100	78	80	91	8 x 25	15	3,000	3
6/6	Western Vein stope	1166	73	77	82	5 x 25	8	1,000	4
6/6	G1 prospect drill	1166	68	76	66	6 x 7	25	1,000	2
6/8	Y fan not running	1200	76	83	73	5 x 7	0	0	0
6/8	G2 prospect drill	1300	82	86	84	5 x 7	0	0	2

A study of the above charts show that less than 25% of the working faces receive air at a velocity up to the minimum standard recommended by the Bureau of Mines engineers. However, the Belmont Mine is far ahead of the average metal mine of its size in the ventilation of its stopes and the management is to be commended for the working conditions they have been able to maintain with natural ventilation. The Belmont Mine for many years had the reputation among miners of being one of the hottest, dustiest, and poorest ventilated mines in the west in which to work. The ventilation scheme worked out by Mr. Robbins distributes air thru all portions of the mine and has changed the Belmont from one of the poorest to one of the best ventilated mines in the country.

The chart on page 77 shows conditions worse than they are because four of the stopes showing no air circulation are equipped with fans to supply air when miners are working in them. Thus stopes CM, CQ, DY and Y should receive from 1000 to 2000 c.f.m. of air each. Stope CR could likewise receive air if the Mexican miner working there would take a few minutes to connect to fan CQ a ventilation pipe line that is already strung from the fan to the stope. These five stopes would then show lower temperatures and humidities, some air movement, and be fairly comfortable working places.

The schemes for ventilating stopes 6000 and FP, however, fail because the resistance of the circuitous route the air must follow is too great to be overcome by natural ventilation. A scheme including booster fans would help these stopes.

Another reason why stopes 6000 and FP receive no air is because the heated air from the stopes would have to travel downward distances of 200 and 100 feet respectively. The natural tendency of heated air is to rise due to its lower specific gravity than that of surrounding air and it would require considerable pressure behind the air circuit to force this heated air to its exit on the lower level. Several other working places in the mine require the used air to travel downward instead of upward to leave the stope.

An outstanding feature in the Belmont Mine is the fairly comfortable working conditions that prevail due to low relative humidity. The temperature of the air in most of the stopes is above the limit at which a man can work at maximum efficiency and would make the stopes quite oppressive were it not for the low humidity.

The air that is furnished the working places is not a s fresh as could be desired. It first comes adjoining mines and then thru old, and in most cases abandoned Desert Queen workings. In many cases the air is diluted with used air from other stopes. A scheme supplying all working places with fresh moving air should be worked out.

About one-third of the intake air is returned to the surface without being used at any working face.

Working conditions have improved since Mr. Gardner's examination in 1921. There is still room for much improvement, however.

COMPOSITION OF MINE AIR.

General. The normal composition of surface air[6], omitting water vapor, is 20.94% oxygen by volume, 79.03% nitrogen (including argon and other inert gases) and 0.03% carbon dioxide. The composition of mine air may be changed from that of surface air by a depletion of oxygen or an addition of other gases.

The main factors that influence the composition of mine air are:

1. Gaseous emanations.
2. Gases from explosives.
3. Gases from mine fires.
4. Timber decay.
5. Breathing of men and animals.

Mine air should contain not less than 20% oxygen and not over 0.25% carbon dioxide.

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6. "Permissible Limits of Toxic and Noxious Gases in Mine and Tunnel Ventilation," by R. R. Sayers, American Institute of Mining and Metallurgical Engineers, February, 1926.

Gas Samples Tonopah-Belmont Mine.

Discription	CO_2	O_2	CO	CH_4	H_2	N_2
Normal surface air	0.03%	20.94%	0	0	0	79.03%
Intake air from Tonopah Mining Co., 700 level, 11/2/21, 55° 60° 74%, velocity 270 ft/min.	0.05	20.95	0	0	0	79.00
Return air, 900 level sta., 6/12/26, 1:20 PM, 77° 83° 76%, 100 x 15 x 10, 15,000 c.f.m.	0.12	20.70	0	0	0	79.18
Return air to Halifax shaft, 1200 level, 6/12/26 10:40AM, 79° 85° 77%, 3.6 x 6.4 x 320, 7400 c.f.m.	0.10	20.74	0	0	0	79.16
Stope 6000, 600 level, 6/12/26, 12:50 PM, 75° 76° 96%, no air movement	0.27	20.43	0	0	0	79.30
Under Halifax bulkhead, 1400 level, 6/12/26, 10:10 AM, no air movement, 98° 98° 100%.	0.39	19.22	0	0	0	80.39

With the exception of the intake air from the Tonopah Mining Co., the above samples were taken at places where abnormal conditions were thought to exist. They do not fepresent average conditions in the mine or in the stopes, but are the worst air conditions that could be found in the mine.

The stagnant air under the Halifax bulkhead is the only sample with less than 20% oxygen or with a CO_2 content appreciably over 0.25%. This is not a place where men are working or passing but is a hot dead end.

The two samples of return air show an average decrease in oxygen of 0.22% and an average increase in carbon dioxide of 0.08%. The increase in carbon dioxide should equal the loss in oxygen if all of the oxygen depletion was to CO_2. It is evident that some oxygen is being removed from the mine air. As there ~~is~~ are but little sulphides in the mine ~~but~~ and a large amount of old timber, the depletion of oxygen is due in the most part to the decaying of timber.

Nitrogen emanations from the rocks have been found in some of the Tonopah mines but none were detected in the Belmont Mine.

The composition of the air in the drifts and stopes of the Belmont Mine is very close to that of normal surface air and is free from harmful gases.

VENTILATION CONTROL.

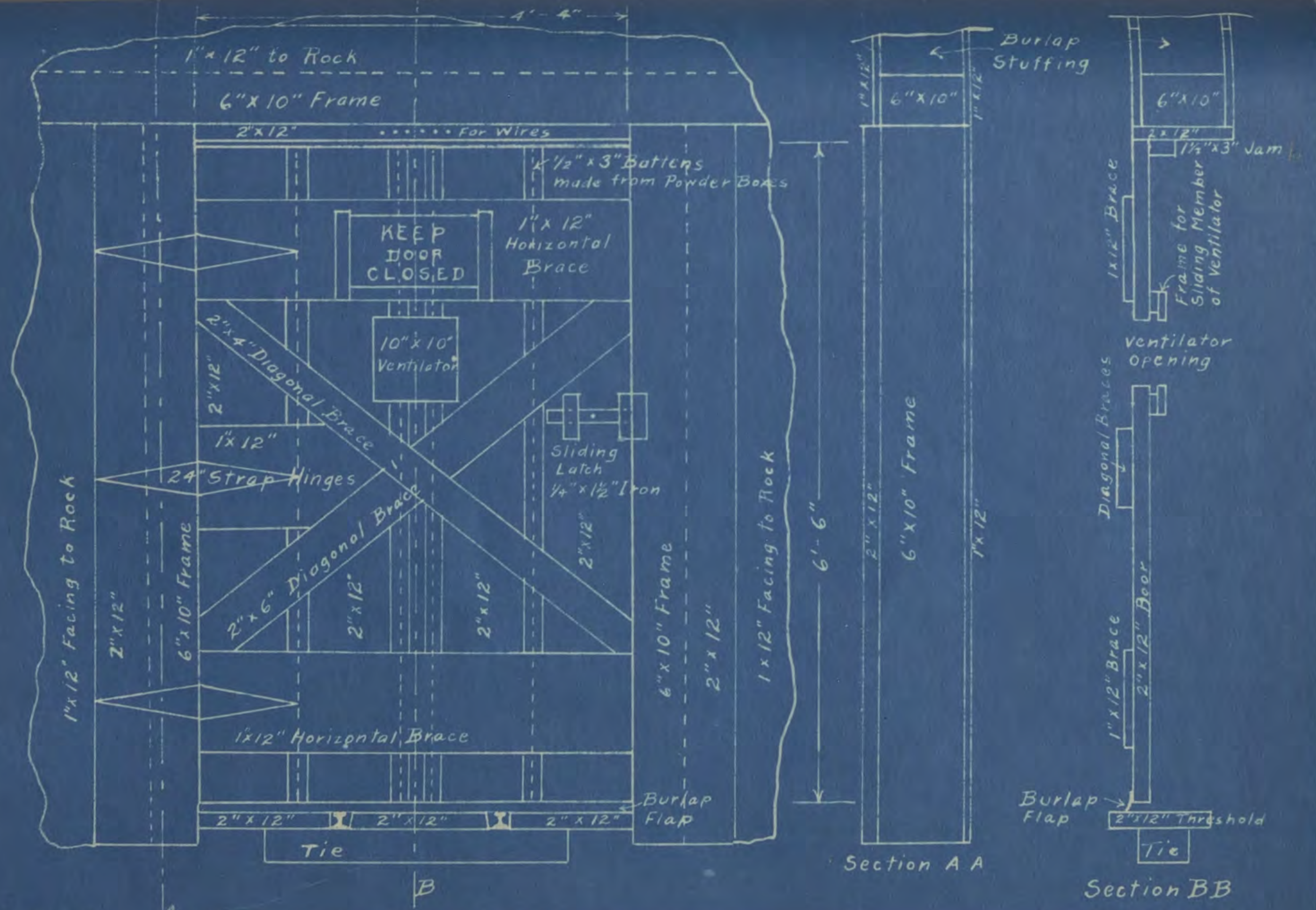
Natural Ventilation Pressure.

An outstanding feature of the ventilation scheme of the Tonopah-Belmont Mine is the methods used to control air currents induced by natural ventilation. Before discussing these control measures, some idea of the magnitude of the force moving air thru the mine should be understood.

The natural ventilation pressure may roughly be determined by calculating the difference in the weights of a vertical column of air 1000 feet high and 1 square foot in cross section extending from the surface to the 1000 foot level of the Desert Queen shaft and a similar column of air from the surface to the 1000 foot level of the Belmont shaft. It will be remembered that on this level the air at the Belmont station is in equilibrium, part of it upcasting and the remainder downcasting and rising again to the surface later thru the Halifax or Mizpah Extension shafts. We will assume that the weight of a vertical column of intake air 1000 feet high coming from the Mizpah open stopes or from the Stone Cabin shaft is the same as that in the Desert Queen shaft. We will also assume that the average temperature readings taken at the various stations of each shaft above the 1000 level is the mean temperature for each shaft, respectively.

Level	Desert Queen shaft	Belmont shaft
600	51° 59°	71° 76°
700	53° 59°	71° 76°
800	53° 60°	
900	53° 61°	78° 84°
1000	53° 60°	74° 82°
Average	53° 60°	74° 81°
Weight 1 cu ft mean air	.06086 lbs	.05806 lbs
Weight 1000 ft column of air	60.87 lbs	58.06 lbs
Natural ventilation pressure		2.81 lbs/sq ft
Water gauge pressure		0.54 in.

The data for the above calculations was taken in the early summer time. In winter the pressure may be greater due to the surface air being colder. But the air intaking at the Desert Queen shaft and the Mizpah open stopes travel slowly for the first



3/4" = 1'   VENTILATION DOOR   TONOPAH-BELMONT DEVELOPMENT CO.   June 1926

The first doors installed in the mine were made of one inch lumber, were of light construction, and conformed to no standard pattern. Such frail doors gave unsatisfactory results and a standard door of sturdier design was adapted. These doors have replaced most of the old doors and are used in all new work. See page 87 for a sketch of the Belmont standard ventilation door.

The door is made of 2" x 12" lumber running vertically and held together with 1" x 12" boards placed near the top and bottom of the door. The bracing is a 2" x 6" piece and a 2" x 4" piece nailed diagonally across the door and crossing each other. The cracks are covered on each side of the door with battens from powder boxes. A sliding ventilator will make a 10" x 10" opening thru the door. A frame is made on each side of the door to hold a standard sign, one side of the sign reading "Keep Door Closed" and when reversed reading "Keep Door Open". The door swings on three 24 inch strap hinges. It fits inside of the frame hitting against a jam the same as a house door closes in its frame. The latch consists of a sliding piece of ¼" x 1½" strap iron.

A handle projects thru the latch to each side of the door. When the door is closed, the latch will slide into an opening on the frame made also of ¼" x 1½" strap iron securely fastening the door.

The frame is made of 6" x 10" timber. One inch boards extend from both the front and the back of the frame to the sides and top of the drift. The space between the one inch boards is packed with burlap so no air can escape between the rock walls and the frame. The space on each side and between the rails is filled with a 2" x 12" threshold, leaving just enough space for the flanges of the car wheels. A burlap flap nailed to the bottom of the door closes the gap between the threshold and the bottom of the door.

Below is a list of material for a 4'-4" x 6'-6" door.

3 pieces 6 x 10 x 7 ft.
5 pieces 1 x 12 x 7 ft.
3 pieces 1 x 12 x 6 ft.
6 pieces 2 x 12 x 7 ft.
1 piece 2 x 12 x 16 ft for threshold and bracing.
1 piece 2 x 4 x 10 for bracing.
3 pieces 1½ x 3 x 6 ft.
3 strap hinges 24 inch.
1 latch.
Labor, 2 shifts each for timberman and helper.

The cost of the door installed is about $45.00

This type of door is very satisfactory and one the company may justly feel proud of having designed. It is open to criticism in two respects however. The first is the method in which the door closes. It fits inside the frame striking against a jamb. We found several doors in the mine that would not close all the way because they were near running water from the large prospecting machines and had swollen too much to fit inside the frame. Other doors would close but only with considerable effort. A door stuck fast inside its frame due to swelling of the door or to rock movement twisting the frame might be the cause of fatalities in case of a mine fire. For safety it would be better to have a door strike against the frame instead of fitting inside the frame.

It is very essential that a door be latched. A pressure of one-half inch water gauge on a 4'-4" by 6'-6" door is 73 pounds, enough to swing any door. A door that normally presses against its jam might by reversal of air currents in case of fire receive the pressure on the opposite side opening the door unless it be latched. It is easy to imagine a person after going thru a doorway, to close the door but to neglect to slide the latch. In fact, several closed doors were found unlatched in our examination. A positive latch similar to those used on garage doors is preferable to the sliding latch.

BRATTICE CLOTH STOPPAGES.

In order to maintain air courses thru its intricate network of underground workings, the Belmont Mine has resorted freely to the use of Brattice cloth. So much brattice cloth underground reminds one of coal mine practice and favorably reflects on the earlier mining experience of Mr. Robbins in the coal mines of England. The cloth is a heavy closely woven burlap treated with ammonium phosphate to make it non-inflamable. The trade-name, "fireproof brattice cloth", is a misnomer because a carbide light will char the cloth and in time burn a hole thru it but the cloth will not burn with a flame.

The various types of brattice cloth stoppages used in the Belmont Mine are:

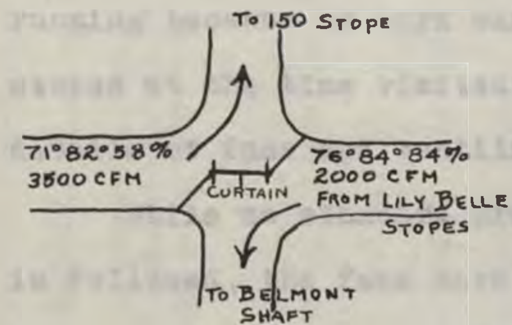
1. Curtains.
2. Bulkheads.
3. Tunnels.
4. Partitions.

Curtains. Curtains are used instead of doors for stoppages in drifts and cross cuts when the nature of the work does not justify the expense of a door. These curtains are two thicknesses of brattice cloth hung from a light wooden framework and weighted across the bottom with a piece of 3/16" by 2" strap iron, which holds the curtain in place. When an air course thru the drift is desired, the curtain may be rolled up and tied back out of the way. No signs are used with the curtains to indicate whether they are to remain up or down.

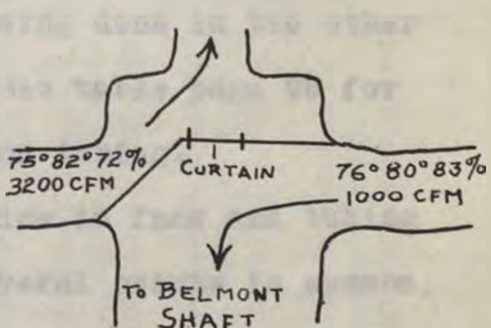
Bulkheads. Many drifts, cross cuts, raises and stopes are bulkheaded by nailing double thicknesses of brattice cloth across the opening. These stoppages make effective barriers to air cufrents when carefully installed with tight joints with the rock walls.

Tunnels. In several places in the mine, double-thickness brattice cloth has been fastened to the posts and caps of tunnel sets making a smooth brattice cloth lined tunnel for considerable distances, some as long as 100 feet. Usually these tunnels run thru stoped areas that would be hard to satisfactorily bulkhead by other means. In addition, they are very effective in cutting down friction. The tunnel at O on the 1400 level was installed to lessen the friction on a sharp bend in the former air course to the 1500 level. Likewise, tunnel BJ on the 1000 level reduces friction on a sharp turn in the main air course to the lower levels.

Partitions. When it is desired to prevent the mixing of air of two different currents at drift crossings, partitions of brattice cloth are used. There are two such cases in the Belmont Mine. On the 1000



Partition BF 1000 Level.



Partition AZ 1100 Level.

Level, partition BF prevents mixing of return air from the Lily Belle stopes with the fresher air for the 150 stope. This partition extends about 20 feet vertically dividing a small stope atthe junction of the drifts. A curtain in the partition allows tramming to the shaft. A similar partition is on the 1100 level just north of the Belmont shaft. Here the two air currents are so nearly the same temperature, it appears as if the partition is no longer of importance.

Booster Fans.

Fans have been installed at several places in the mine to supply dead-ends with air. This is a commendable practice and should be followed in all working places where there is a deficiency of air. There are seven fans in all but only three were running because no work was being done in the other stopes at the time visited. See table page 95 for details of fans and ventilation tubing.

While no standard practice in fans and tubing is followed, the fans have several points in common; as, direct connection with motor, alternating current at 440 volts, speed at full load 1700 revolutions per minute, and timber foundations.

Both galvanized sheet iron ventilation pipe and canvas ventilation tubing are used for the discharge lines from the fans. Because of the ease of transportation and installation, and the lower

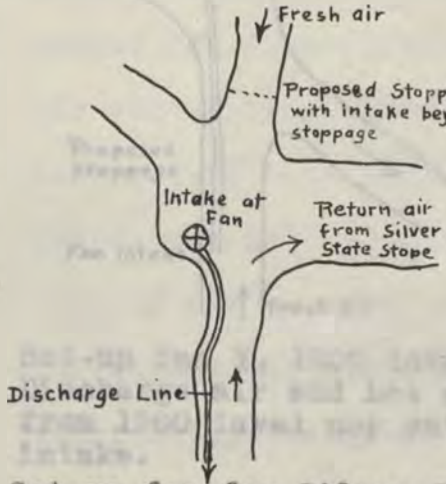
BOOSTER FANS   TONOPAH-BELMONT MINE.

LEVEL	LOCATION	DISCRIPTION	INTAKE	DISCHARGE
900	CN	NO. 2½ Sturdevant blower, direct connected with 7½ HP motor, 440 volts, 1700 RPM	5' of 15" galv vent pipe	40' Of 12" galv, vent pipe 150' of 10" galv vent pipe 25' of 10" canvas tubing
900	CZ	No. 2 Sirocco Blower direct connected with 5 HP motor, 440 volts, 1700 RPM	at fan	225' of 10" canvas tubing
900	CQ	No. 2½ Sirocco blower, direct connected with 7½ HP motor, 440 volts, 1700 RPM	25' of 15" galv vent pipe	300 ft of 12" canvas tubing
900	DY	No. 2½ Sturdevant blower, direct connected with 7½ HP motor, 440 volts, 1700 RPM	35' of 15" galv vent pipe	200' of 12" canvas tubing
1000	CK	No. 2 Sturdevant blower, direct connected with 5½HP motor, 440 volts, 1700 RPM	50' of 12" galv vent pipe	150' of 10" galv vent pipe 30' of 12" canvas tubing
1100	Silver State stope	No. 2½ Sturdevant blower, direct connected with 7½ HP motor, 440 volts, 1700 RPM	at fan	175' of 12" galv vent pipe
1200	Y	No. 2½ Sirocco Blower, direct connected with 7½ HP motor, 440 volts, 1700 RPM	45' of 12" galv vent pipe	250' of 15" canvas tubing 75' of 12" canvas tubing

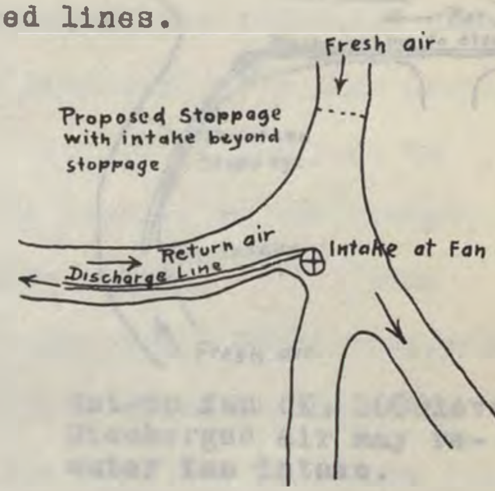
leakage loss, the company is favoring the use of canvas tubing over the sheet iron tubing.

Canvas ventilation tubing is made from 8 to 10 ounce duck specially treated with some coal tar derivative to prevent decay. At the seam is sewed eyelets thru which wire loops are attached. The tubing can then be ~~strung along a drift~~ hung by the loops from a heavy wire which has been stretched along a drift and is suspended from timber or from plugs driven into the roof. The chief objection to canvas tubing is its short life due to decay. The Belmont Mine is fortunate in this respect as it is a dry mine and decay is not excessive. The tubing comes in lengths of 50 and 100 feet. Tight joints are made by the use of patented slip ring connections.

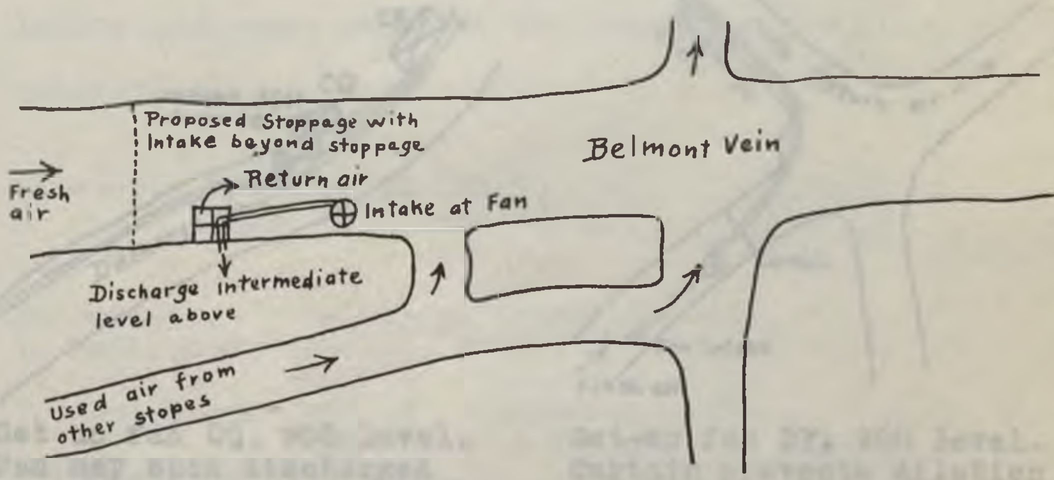
The fans in the Belmont were set up with very little attention to the purity of the intake air. The following sketches will show that in all cases, except fan DY on the 900 level, no provision has been made to prevent discharged air, which has become heated, contaminated with gases from explosives, and dust-laden, from diluting the intake air and being used again in the working place. Proposed stoppages to prevent this error in the set-up of the fans are shown as dotted lines.



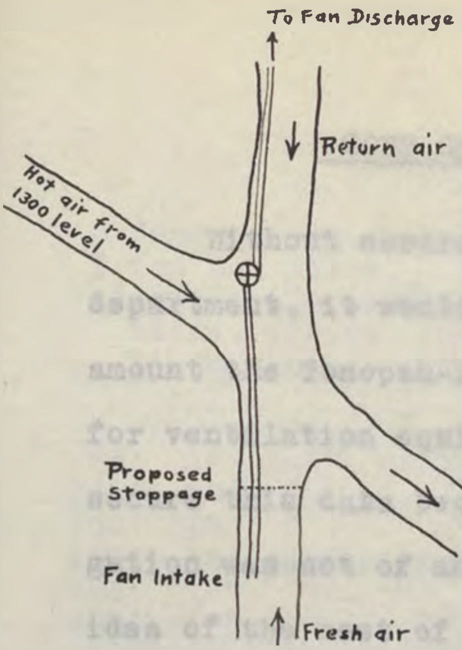
Set-up fan for Silver State stope, 1100 level. Return air passes fan intake



Set-up fan CZ, 900 level. Return air passes fan intake.

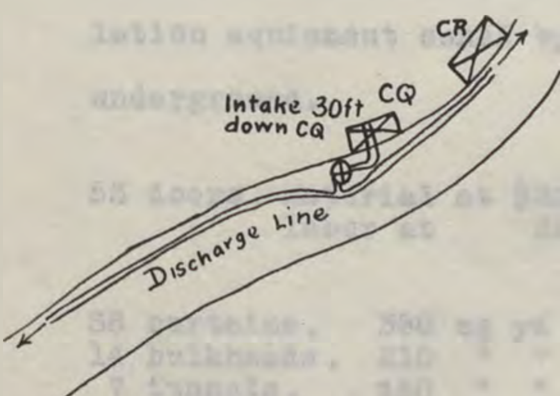


Set-up fan CN, 900 level. Discharged air and used air from other stopes pass fan intake

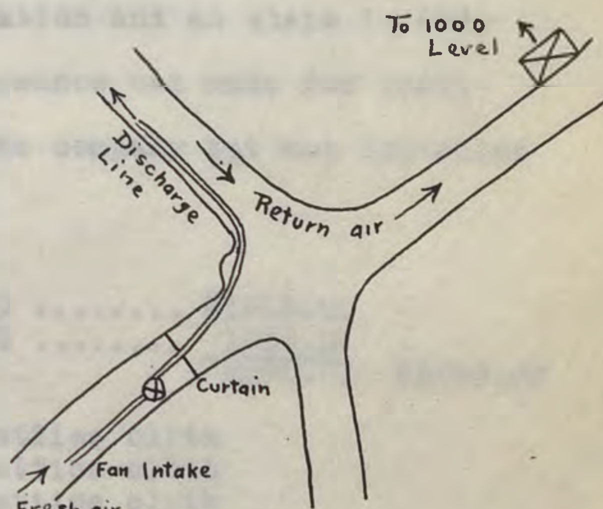


Set-up fan Y, 1200 level. Discharge air and hot air from 1300 level may enter intake.

Set-up fan CK, 1000level. Discharged air may re-enter fan intake.



Set-up fan CQ, 900 level. Fan may suck discharged air back to intake. This may be prevented by stoppage over top of raise CQ.



Set-up fan DY, 900 level. Curtain prevents dilution of intake air.

COST OF VENTILATION EQUIPMENT.

Without accurate cost data from the auditing department, it would be impossible to determine the amount the Tonopah-Belmont Development Co. has spent for ventilation equipment. No effort was made to secure this data because the purpose of the investigation was not of an economic nature. Still some idea of the cost of ventilation equipment is desirable for comparison later with the cost of mechanically ventilating the mine. At the best the cost data that follows is a rough approximation and no claim is made for close accuracy. No allowance was made for ventilation equipment owned by the company but not installed underground.

53 doors, material at $23.00	....	$1219.00	
labor at 22.00	....	1166.00	
		2385.00	$2385.00

38 curtains,	380 sq yd brattice cloth			
14 bulkheads,	210 " " brattice cloth			
7 tunnels,	460 " " brattice cloth			
2 partitions,	200 " " brattice cloth			
	1250 " " at $0.17½		218.75	
Allowance for freight		....	100.00	
Allowance for wooden framework and installation		....	200.00	
			518.75	518.75

Carried forward 2903.75

Brought forward			2903.75
6 fans and motors, 7½ HP at	$375.00	$2250.00	
1 fan and motor, 5 HP	250.00	250.00	
Allowance for timber foundations, wiring, and installation, 15%		375.00	
		2875.00	2875.00
65' 15" galv. ventalation pipe,	1.00	65.00	
310' 12" " " "	.75	227.50	
300' 10" " " "	.50	150.00	
250' 15" canvas vent. tubing	1.00	250.00	
605' 12" " " "	.75	453.75	
250' 10" " " "	.50	125.00	
Allowance for L's, T's, gates, etc, 10%		127.15	
Allowance for installation, 25%		317.80	
		1716.20	1716.20
Estimated cost of ventilation equip~~t~~ment			7494.95

FIRE HAZARDS.

The problem of mine fires is closely related to underground ventilation. The air currents not only supply the necessary oxygen for the fire but carry away the deadly gases from the fire zone. No ventilation scheme is complete that does not provide safety for the crew in case of fire.

That the Belmont Mine presents a grave fire hazard and one worthy of careful attention was brought very forcibly before the management on Feb. 23, 1911. Early that morning a fire was discovered in some timber on the 1166 level. According to reports of the fire in the Engineering and Mining Journal, the general manager and the mine superintendent were notified. They went to the fire, analyzed the situation and directed certain bulkheads to be built to smother the fire, which at that time seemed a small affair. The fire was strong enough, however, to reverse air currents and 17 men were caught in the deadly carbon monoxide gas and killed. The coroner severely criticized the management claiming they lacked the necessary experience to cope with the emergency.

There is just as great a fire hazard at the

Belmont Mine today as existed in 1911 and the lives of all men underground would today be as much at the mercy of the fire as were the crew in 1911.

Natural conditions in the Belmont mine are particularly favorable for a fire. It is a dry mine and a heavily timbered mine.

Electric wires carry electric power at 440 volts to pumps on the 1200 and 1400 levels, to fans on the 900, 1000, 1100 and 1200 levels and to a storage battery charging set on the 1000 level. There is also a lighting circuit of 110 volts. While, in general, the wiring seems to have been carefully done, there are places where the wire rests on timber with no porcelian insulation. Two of the booster fans are located on the sill floor of large stopes and a short circuit at the fan might easily start a fire in the stope.

The timber foundation for the pump on the 1400 level is saturated with oil. Open carbide cans of oil and an uncovered box of greasy waste stand around the pump. All this inflamable material is in the timbered station of the Belmont shaft. The setting is ideal for a fire.

At several of the shaft stations, old carbide cans are used to hold used carbide from the miners' lamps. Invariably carbide is scattered on the timber and ground around these cans. All that is necessary to start a fire is a little water and a carelessly thrown match.

I do not wish to give a false idea of the mine. The company has done much to reduce fire hazards. The drifts and other openings underground are very free from obstructions. Very little old lumber is left underground. All stations are equipped with fire plugs, hose and nozzles. Fire extinguishers are at the stations and most of the fans. But in spite of all these fire precautions, there is plenty of chance for a fire in the Belmont mine.

Possibly the greatest fire hazard of all is due to the fact that the Belmont Mine is connected on all sides with other mining properties. Should a fire start in the Tonopah Mining Co. or the Stone Cabin Mine (the sources of intake air), the deadly gases would sweep thru the Belmont workings. By reversal of air currents, fire gases might enter the Belmont from fires in any of the adjoining mines.

It is true doors have been installed at critical points to be closed in case of fire in adjoining properties and thus prevent the gases from traveling thru the mine. For several reasons it is doubtful if these doors would be effective in case of fire. First, it would take considerable time to get to some of the doors to close them. Second, it would not be save to attempt to close the doors without wearing oxygen breathing apparatus. Third, there is no fire fighting organization and considerable time would be lost getting the rescue and prevention work organized. Fourth, the location and purpose of the various doors are known by only a few officials and employees. There would be so much delay before the proper barriers would be closed, the lives of the crew in the Belmont would be in peril. In fighting a fire, it is the first ten minutes that is the most important.

Should a fire start in any of the stopes of the Belmont or Desert Queen workings, noone could foretell where the gases from the fire would travel. A fire so readily changes the direction of air flow that all portions of the mine would be in jeopardy. Also, there is such a network of underground workings, it would be impossible to isolate the fire from the rest of the mine except by the erection of a large number of barriers, which would take so much time, it would be too late to save the lives of any men.

As long as the Belmont Mine has open connections with other properties, and is dependent on natural ventilation for its air, it will present a very serious fire hazard.

DUST.

Foreword. The removal and prevention of dust is one of the major problems of ventilation in dry mines. No effort was made in the 1926 investigation of the Belmont Mine to study in detail the dust problem because a thorough study of dust had been made by Mr. Gardner in 1921 and his confidential report to the Tonopah-Belmont officials was at our disposal. Dust unless properly prevented and removed from the mine is as great a hazard today as it was in 1921. Any recommendations that may be made to install a better ventilation system must take in account the dust problem.

Because the findings of Mr. Gardner on dust in the Tonopah mines has not, as yet, been published, and because of its direct bearing on the ventilation of the Belmont Mine, I am including in this report most of his report on "Rock Dust, Tonopah-Belmont Mine."

> General. Dust in metal mines probably causes more sickness and ultimately more deaths among metal miners than any other one cause. The continued inhalation of the exceedingly minute, sharp and insoluble particles produces a mechanical injury to the lungs, causing phthisis or miners' consumption.
>
> The fine dust once raised remains suspended

many hours in still mine air; hence in poorly ventilated places the miners continually breathe the fine particles. In still dry air a quartz dust particle one micron in size will fall a little over a foot per hour and a particle two-tenths of a micron in diameter will settle about one inch per day. A micron is one-thousandth of a millimeter, or about 1/25000 of an inch.

The country rock or the vein matter in most metal mines is silicious. The dust in the mines of South Africa and Joplin, which are known to be decidely harmful, contain 85% or over of free silica. The dust in the Butte Mines, which is also harmful, contains about an average of 60% silica. The dust in the Tonopah-Belmont Mine has from 35 to 75% silica.

The prevention of miners' consumption has received considerable study in South Africa and the manner of mining silicious ores is covered by legislation. Several states in America, including Nevada, have passed laws to prevent the raising of dust in mine atmospheres, but the regulations are rarely, if ever, strictly enforced.

Dust Making Processes. Dust in the mine atmosphere is made by blasting, drilling, shoveling, drawing chutes, and by the stirring up of settled dust by air currents, drill exhausts, compressed air blowers and other causes.

As most of the Tonopah-Belmont Mine is dry and the ore contains but little included moisture, considerable dust is made by all mining operations unless water is freely used for sprinkling. Dust enters the air every time dry material is handled and the longer ore stays in the mine the dustier it becomes. Pipes are laid through the mine to supply water for allaying the dust and sprays are installed at the tops of all ore chutes. Dry drilling underground or the handling of broken ore or waste before it is sprinkled is prohibited, but these rules are not always complied with.

Considerable settled dust was noted in various parts of the mine. The concussions from blasting stir up dust and, unless the ventilation is efficient and positive, some of the dust will remain in the air after the men return to work. All haulage ways and incoming air courses were generally dry and should be frequently sprinkled to keep down the dust.

Method of Sampling. The dust content of the air was sampled by means of a sugar filter apparatus developed by the Bureau of Mines, but modeled after South African equipment.

In this work a miner may be considered as inhaling one cubic foot of air per minute while at a maximum effort, and in obtaining the dust samples the air was aspirated through the sugar at the same rate. To compare our work with that done in South Africa, the samples were taken over periods of 15 minutes each. In sampling the air in working places the sugar tubes were held as close as practicable to the work men's heads, so that the samples would indicate the amount and kind of dust that was being breathed. The sugar was treated with formaldehyde to prevent the growth of bacteria, and mailed to the Pittsburg Station of the Bureau of Mines for analysis of the dust content.

In the laboratory the samples in the tubes were removed by dissolving the sugar in a known amount of distilled water. All particles over 90 microns were removed by filtering the sample through a 230 mesh screen. Past experience by other investigators has shown that material above this size in the air is not harmful. A small sample of filtrate was examined under the microscope and a count made of the dust particles with those under ten microms reported separately. By taking advantage of the difference in the speed of settling of different sized particles

Drilling with stoper using
spray and taking dust sample.

in water the dust in the samples after filtering were separated into two component parts with ten microns as the dividing line.

Results of Dust Sampling. During this inspection dust samples from the atmosphere were taken in practically all working places underground, of the return air, at the surface and other points. Samples of drill cuttings and settled dust were also obtained to determine the chemical composition of the dust. Dr. Insley determined the amount of dust in the samples and the results are shown in Table V. The average results from the table are as follows:

AVERAGE OF DUST SAMPLES IN MINE AIR TONOPAH-BELMONT MINE

PLACE	Number Samples	COUNT Million per cu.meter Plus 10 microns	Minus 10 microns	Total	WEIGHT Milligrams per cu.me Plus 10 microns	Minus 10 microns	Total
Surface	4				1.6	2.8	4.4
Return air	1	77	3110	3187	6.6	9.2	15.8
Intake air from Mizpah	2				3.5	2.1	5.6
Average in drifts	7	68	5620	5688	33.8	19.9	53.7
Average at leyners	3	57	1990	2047	6.0	3.6	9.6
Average at stopers with spray	5	99	4132	4231	16.0	28.7	44.7
Average at stopers, dry	6	176	8942	9118	28.2	38.1	66.3
Average of all samples in stopes	12	137	6422	6559	21.0	31.2	52.2
Average all samples underground	22	110	5811	5921	21.0	23.0	44.0

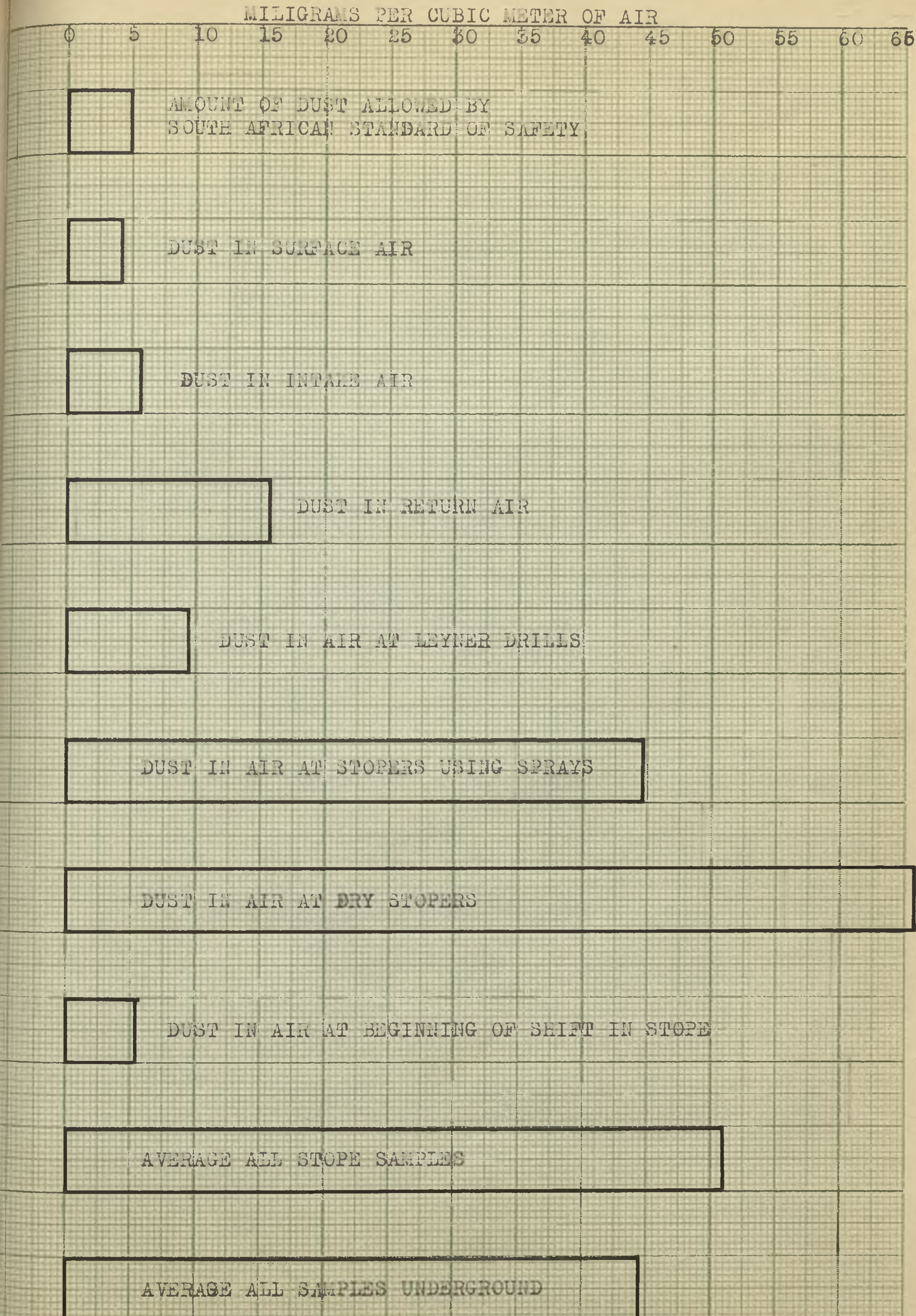


CHART SHOWING AMOUNTS OF DUST IN AIR TONOPAH-BELMONT MINE 1921

SAMPLES DUST IN MINE AIR TONOPAH-BELMONT MINE

Number	Date	Time	Discription and Location	Kind of Material	Number Men	Wet-Bulb	Dry-Bulb	Humidity	Air Motion Feet per Min.	Moisture	Count Million per cubic meter Plus 10 Microns	Minus 10 Microns	Total	Weight Milligrams per cubic meter Plus 10 Microns	Minus 10 Microns	Total
324	1921 11-8	12:00M	Surface air, Main St., Tonopah stiff breeze			49°	65°	34%	200	Dry	5	530	535	3.5	3.1	6.6
276	10-30	12:00M	Surface air, near Victor shaft, light breeze			46	65	24	100	Dry				0.9	2.4	3.3
278	10-30	2:00PM	Surface air, knoll 1/4 mile from Victor shaft, wind blowing fitfully			46	66	20	200	Dry				0.7	1.9	2.6
303	11-7	7:30AM	Surface air, near Desert Queen shaft, light breeze			40	52	37	50	Dry				1.2	3.8	5.0
AVERAGE														1.6	2.8	4.4
322	11-7	8:30AM	In crusher house, dry crushing	Ore	4	44	54	45	10	Dry and Dusty	98	3340	3438	24.0	26.6	50.6
300	11-7	10:30AM	Upcast air, 1100 Level, air from stopes to Belmont shaft.	Ore		78	82	84	100	Dry	77	3110	3187	6.6	9.2	15.8
304	11-8	11:00AM	Intake air, 1000 Level, air from Desert Queen Shaft.			51	61	51	40	Dry	78	2340	2418	0.2	2.8	3.0
313	11-4	8:30AM	Intake air, 900 Level, from Mizpah in 928 cross cut.			57	61	79	50	Dry				3.5	2.1	5.6
AVERAGE														1.8	2.5	4.3
DRIFTS AND CROSSCUTS																
301	11-6	7:40AM	800 Level, Sill stope 814, Dust from blasting should be gone.	Ore	2 shoveling in chute	50	58	58	25	Dry	57	4200	4257	13.1	13.8	26.9
309	11-4	11:40AM	900 W. Drift 9035, leyner machine misty, too much water pressure	Ore	3	74	75	96	0	Damp	26	2690	2716	4.5	3.8	8.3
317	11-6	9:00AM	800 W. Drift 852, leyner, sides dusty	Vein Matter	2	58	61	84	0	Dry	67	1500	1567	10.3	4.7	15.0
311	11-4	12:00M	1000 Level at ore transfer, loading 10 cars from chute, air to Belmont workings	Average Ore	3	51	61	51	40	Drift Sprinkled				4.5	6.1	10.6
305	11-4	8:30AM	1000 Level at ore transfer after loading 9 cars, air to Belmont workings.	Average Ore	3	51	61	51	40	Dry	47	4450	4497	50.8	33.8	84.6
288	11-3	12:30PM	1100 Level at ore transfer, #1 Pocket, transferring ore, air to surface	Ore	1	78	82	84	30	Dry	130	19,100	19,230	113.0	52.8	165.8
286	11-3	11:30AM	1100 Level, 1106 W. Drift, leyner, compressed air blowing	Breccia Trackyte	1	81	83	92	0	Dry	78	1780	1858	3.1	2.3	5.4
AVERAGE											68	5620	5688	28.4	16.8	45.2
STOPES																
280	11-3	9:00AM	1200 Level #7 W. Stope, barring down face, no dust visible	Ore	1	80	86	77	400 c.f.m.	Sprinkled below	130	2750	2880	3.1	2.4	5.5
308	11-4	11:00AM	900 Level, #3 W. Stope, stoper with spray	Ore	2	83	88	81	10	Stope sprinkled	26	2950	2976	9.6	16.2	25.8
312	11-5	8:30AM	900 Level, 992 Stope, stoper with spray, dust visible.	Silicious Ore	1	60	67	68	10	Dry	243	7100	7343	25.4	48.2	73.6
314	11-5	11:00AM	900 Level, 955 stope, top, stoper with spray, slow drilling	Ore	2	80	82	92	0	Dry	5	332	337	4.0	1.6	5.6
315	11-5	11:30AM	900 Level, 45 Raise, 3½×7×30, stoper with spray, part sample spilled	Trackyte	2	80	80	100	10	Dry	67	5200	5267	27.1	63.8	90.9
306	11-4	9:00AM	1100 Middle Vein Stope, stoper with spray, water did not reach hole	Ore	3	67	71	82	10	Dry	119	5080	5199	13.9	14.1	28.0
AVERAGE											99	4132	4231	16.0	28.7	44.7
318	11-6	9:30AM	855 E. Stope, dry stoper, shoveler below, air current 300' - 6' below, sides dusty	Ore		66	69	86	75	Dry	244	26,300	26,544	83.2	97.8	181.0
310	11-4	11:30AM	9035 Stope, dry stoper, 2 timbermen, 2 shovelers.	Ore	6	79	80	96	20	Dry	181	2260	2441	17.6	24.0	41.6
307	11/4	10:30AM	981 Stope, dry stoper, drilled 9 minutes, water shut off for sample	Ore	2	85	88	89	1000 C.F.M. blowing into stope	Sprinkled	57	1840	1897	4.7	8.2	12.9
302	11/6	8:00AM	814 Stope, 9th floor, 1 shoveler, 2 timbermen, dry stoper	Silicious Rhyolite	3	48	56	57	25	Sprinkled, Dust on Timber	119	8760	8879	8.7	9.6	18.3
287	11/3	11:30AM	1188 Drift, dry stoper	Trackyte	1	85	86	96	0	Dry	326	13100	13426	48.6	83.5	132.1
316	11/6	9:00AM	814 Stope, 1st floor, drilling and shoveling, under sample 302	Ore		48	56	57	20	Dry	129	1390	1519	6.3	5.4	11.7
AVERAGE											176	8942	9118	28.2	38.1	66.3

It will be noted that practically all the dust samples taken in the Belmont Mine show more dust than allowed by the South African standard of safety. With the exception of one case, where the spray was shut off to allow a sample to be taken dry, all samples were taken under ordinary conditions and only the normal amount of dust was being made. It will be noted that out of 11 samples taken at stopers six of the drills were being run dry. This dry drilling was done in spite of the fact that the State law of Nevada makes it a misdemeanor for a miner to use a drilling machine dry, and the company has a rule forbidding such practice. A man drilling dry may not only endanger his own health but every one else in the stope or along the return air course. Rules to prevent this practice cannot be too strict. The comparative amount to dust made by this dangerous practice is shown by the accompanying tables and charts.

The next hazardous operation to dry drilling is running the type of stoper in use in this mine. The tables show that the water takes out from a third to one-half of the dust made in drilling, but still enough falls through the spray and enters the air to be exceedingly dangerous. A glance at the chart will show that the average of the samples taken at those stopers is nine times the amount allowed by the South African standard of safety. At one place where the drill was making very slow progress the amount of dust made was practically within the limit of safety.

It is hard to get the miners to use the spray at all times, and some only do it when they think it is time for the boss to come along. When the spary clogs, which happens quite often, the miner is prone to finish the hole without stopping to bother with the water. Some miners, when allowed to use their own discretion, have the spray turned on only while drilling vertical holes and drill inclined holes dry. When drilling a vertical hole dry a cloud of dust can be seen entering the air and, unless carried away by the air currents, the atmosphere of the working places soon becomes filled with the fine particles. The spray reduces the amount of dust made, but enough enters the air to be noted by the eye. This type of stoper is not efficient in flat holes, as the steel sticks and much time is lost in changing. In very hard ground the steel gets hot and hollow steel, through which water is forced to the cutting edge, cuts faster and is more efficient. The water pressure at some of the leyner drills was too high and a dust laden mist was forced out of the holes. In such cases the pressure should be reduced before the water is used in the drills.

It is the writer's opinion that leyner drills should be used in all stopes under 45 degrees dip and wherever practical in all the square set stopes. A stoper which forces water through hollow steel to the cutting edge should be used where leyner drills are not practical. Sample 318, taken at a dry stoper, shows the largest amount of dust. The water connections were broken in this part of the mine and no sprinkling had been done on the shift.

The table shows that shoveling and drawing chutes also make considerable dust. Piles of broken material are sprinkled at the beginning of the shift and chutes are occasionally wet down as they are filled up. However, many shovelers were noted handling dry ore and chutes are occasionally drawn without first using the sprays. Valves to the water connections for sprinkling the ore in chutes should be on the levels so that trammers can turn on the water without climbing up to the stopes or depending on some one else to do it.

As noted by the table a very excessive amount of dust is made while drawing cars from the ore pass on the 1000 level and at the ore transfer at the 1100 station of the Belmont shaft. Apparently neither chute is sprinkled. It is stated that sprinkling in the ore pass to the 1000 causes it to hang up. However, due to the amount of dust made in this place, repairs should be made so that all ore in the chute can be kept dampened until drawn into the cars. The dust at the ore transfer comes mainly from dumping the ore from cars above. This ore should all be damp before handling and a continuous spmay should be used at the top. The 1000 level haulage drift from the ore pass to the Belmont shaft is sprinkled daily. This is a good practice which should be kept up and carried out in other parts of the mine.

The table also shows that about five times the safe amount of dust is made in shoveling. Water should be used freely at the beginning of each shift and as often thereafter as necessary to prevent dust being raised by handling ore in the mine.

The air passing through the mineand before enteringthe upcast shaft has three times the amount of dust allowed by the South African standard. If the more persistent and efficient use of water does not cut down the amount of dust to a safe limit sprays should be installedin air courses between different sections of the mine to act as water curtains and wash the dust from the air. This would cut down the dust in the air before it enters any set of workings and also prevent dust building up in the circulation. The installation of sprays in the air courses would help humidifythe air and prevent it sucking up moisture as it passes through the mine, which would cut down the need of some of the sprinkling.

Compressed air blowers and the exhaust from drills blowing against the sides of the stopes or drifts, or on broken ore, stir up dust. The sides, faces, and backs of all stopes and drifts for 25 feet back should be washed down at the beginning of each shift.

The raising of dust in mines by drilling or handling broken material can be largely prevented by the use of the right kind of drill and by the constant use of water, but there is no way to prevent dust being made by blasting. Ordinarily, after each blast, the air of the working place is completely filled with dust. As this dust cannot be prevented it should be removed from the mine as quickly as possible by efficient ventilation and before men enter the workings. No blasting, of course, should be done during the shifts, and it would be desirable to do all the shooting at the end of the night shift, which would allow a longer time for the dust to clear out before men go underground. The working faces and the immediate vicinities should be sprinkled just before blasting and again when the men enter their places at the beginning of the shift. In unventilated places the extremely fine dust from blasting may hang in the air during all of the next shift and be constantly breathed by the miners.

Air from stopes should be returned to the surface as soon as possible and not allowed to enter other workings or become short circuited, which allows the fine dust to build up in the atmosphere. Ventilation plans should be made with this point in mind.

As shown previously, the humidity of the air in the mine is relatively low, which causes the ore to dry out rapidly after being sprinkled. A more liberal use of water in this mine will increase the humidity and make the working places more uncomfortable in the lower levels, but the gain derived by allaying the dust will more than offset this disadvantage. The use of cool water in the sprays and the cooling due to the evaporation of the water will partly offset the uncomfortable condition caused by increased humidity. In fact the air should be humidified as soon as possible so it will not dry out broken material while being handled.

The amount of dust made at different levels in this mine varied directly with the interest taken by the bosses for its prevention. The 800 level, for instance, was very dusty; little sprinkling was done and the dust conditions on the whole were the worst in the mine. The shift boss on this level was careless and did not take the dust seriously, and an exceedingly dangerous amount was made. The shift boss on the 900 level was concerned about the dust and more efforts were taken for its prevention than elsewhere in the mine.

Sample 322 was taken in the coarse crushing and sorting house. As shown by the table a large amount of dust is made in this building. No dry crushing should be done and sprays should be used at the chutes at the head house and at the coarse ore storage bins. Hoods with exhaust fans could also be used to an advantage.

Physical and Chemical Characteristics of Dust particles. Dr. Insley made photomicrographs and mineralogical determinations of representative samples of the dust and drill cutting samples gathered. His report follows:

"The Dusts in the Mines of the
Tonopah District
by
Herbert Insley.

Geology of the Tonopah District.

According to Spurr, in an article entitled 'Geology and ore deposits at Tonopah, Nevada', in Economic Geology, Vol. 11, pages 713 to 769, 1915; all of the rocks of the Tonopah district are tertiary volcanics. The oldest rock is a flow of trachyte followed by extrusion of the Mizpah trachyte and by the successive intrusions of the Sand-grass andesite, Montana breccia, and the West End rhyolite. These rocks have become largely altered and in places silicified. The West End rhyolite is a characteristic rock of the Mizpah district. It usually has a green color and everywhere contains inclusions of some rock now altered to a white powdery state. These inclusions vary in size from fragments with a diameter of one or two millimeters to large boulders. The inclusions have been sericitized until they retain none of their original characteristics and the rhyolite matrix has been highly altered by quartz, sericite, and kaolin with some calcite, chlorite, adularia, and pyrite.

Younger than the West End rhyolite is the Midway andesite, evidently a flow. This is considered as the 'cap rock' in the district and contains no workable veins.

The veins of the Tonopah district have been divided by Spurr into three main classes according to their period of formation.

The first period veins are the main orebearing veins of the district. Generally these veins are filled with fine granular quartz without large quantities of sulphides and very poor in the baser metals. The primary metallic minerals are silver sulphide principally polybasite, stephanite and argentite with some pyrite, chalcopyrite, galena, and blende. The pyrite is usually more abundant in the adjoining wall rock than in the veins themselves. The first period veins were in many instances reopened by later movements and filled with vein material of one of the following periods.

The second period veins contain large quantities of quartz but their commercial value is insignificant compared to first period veins.

The third period veins carry no commercial ore bodies. They are marked by the presence of large amounts of colorless, usually translucent quartz. The sulphides consist of galena, blende, pyrite and chalcopyrite.

<u>Relation of country rock and vein material to dusts:</u> The hardness and shape of dust particles are closely related to the mineralogic composition of the dust. Investigations in mining districts to determine the dustiness of the mines and the amount of pneumoconiosis among the miners have been carried on chiefly in South Africa and the United States, although some work has been done in Australia, New Zealand, England and other countries. In the South African Rand, for instance, both country rock and vein material are quartzose. So prominent was the work on dustiness in South Africa that it became a general opinion that pneumoconiosis among miners was caused almost wholly by the abrading of lung tissue by fine <u>quartz or flint</u> dust. In fact, the data collected was so over-whelming that it may be considered as proved that fine quartz dust is a very effective cause of pneumoconiosis. It is not proved, however, that other dusts besides quartz do not cause pneumoconiosis and that proposition is very probably not true. At present we have no measure of the relative harmfulness of dusts of different mineralogic composition.

Profound alteration is one of the predomoninant characteristics of all the rocks in the Tonopah District. A specimen which shows few signs of alteration is rare. Of the secondary minerals quartz, sericite and pyrite seem to be the most abundant although locally calcite and chlorite are more prominent. Adularia, siderite, kaolin and others are less commonly found. Feldspar phenocrysts in the volcanic rocks usually alter to a mixture of quartz and sericite while the glassy or microlitic groundmass shows extensive silicification which the formation of microscopic quartz grains. Although pyrite is a very common constituent of the vein material it is not unusual to find that it is even more abundant in the adjoining wall-rock as a secondary mineral.

Of the original minerals in the rocks quartz is the most resistant and is usually unchanged. The rocks other than those of rhyolitic andalaskitic composition probably contain small quantities of primary quartz. The feldspars and ferro-magnesian minerals have been very thoroughly altered although it is not uncommon to find remnants of the feldspars still persisting.

The minerals present in large quantities in the Tonopah mines are listed below with the physical characteristics which are supposed to affect them as causes of pneumoconicsis.

1. Quartz - Very hard (hardness of 7). Has no cleavage but breaks with a conchoidal fracture, small particles almost always exhibiting sharp or jagged edges.

2. Feldspar - Hardness of about 6. Very good cleavage in two directions. Microscopic particles sometimes have irregular fracture but more often are cleavage particles with rounded or flat ends.

3. Sericite and chlorite - Both soft with micaceous cleavage. Particles are often long and slender and very minute.

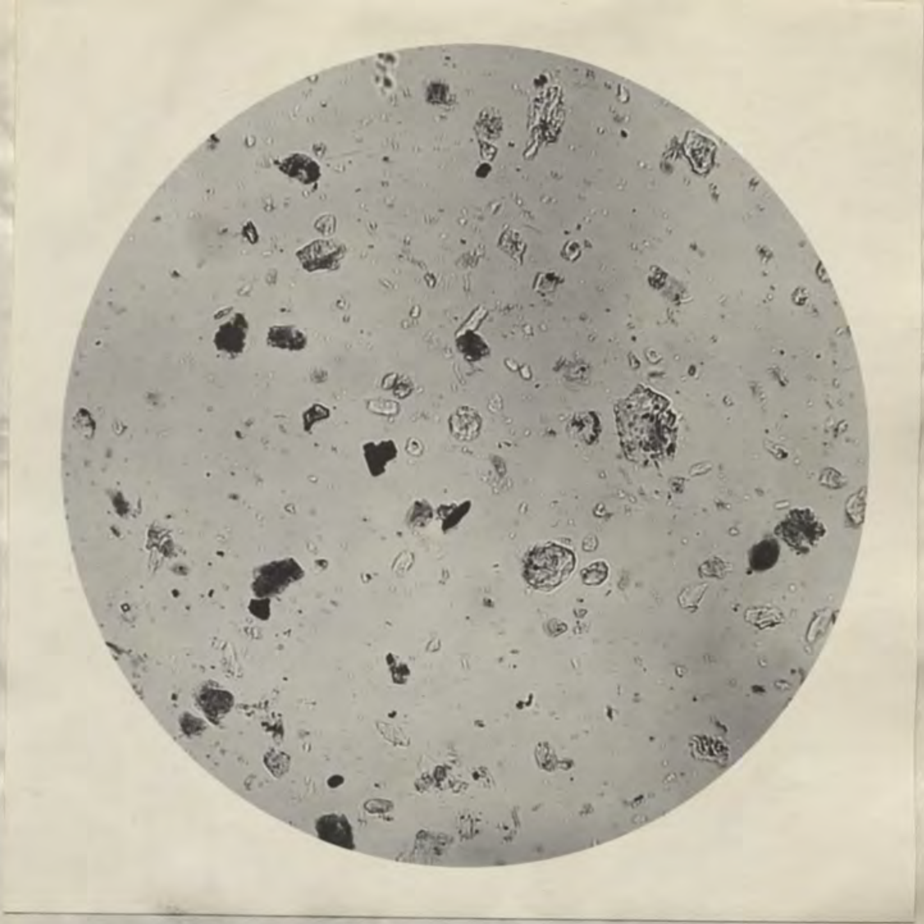
4. Pyrite - Hardness of 6-6.5 and breaks with a conchoidal or uneven fracture. Under the microscope particles of pyrite are opaque and often show rough or jagged edges.

5. Siderite and calcite - Calcite has a hardness of 3 and siderite is slightly harder. Both have perfect rhombohedral cleavage and small particles are almost always cleavage particles rarely having sharp or jagged edges.

6. Ore minerals - The silver sulphides and sulph-antimonides are soft minerals with subconchoidal or uneven fracture. The relative amount of these minerals is so small that they need hardly be considered as a cause of pneumoconicsis.

If the supposition is correct that minerals are harmfull (in relation to pneumoconiosis) if they break up into small hard particles with jagged cutting edges then, of the above minerals, quartz is highest in the scale of harmfulness, feldspar or pyrite next while the place of chlorite, sericite, siderite and calcite is uncertain although probably much lower in the scale than the first three mentioned.

Mineral analyses of dusts and drill cuttings:
The following analyses were made by placing small quantities of the samples on microscopic slides, immersing in liquids of known indices of refraction, and estimating the percentages of the principal minerals present by comparing their indices with the index of refraction of the liquid. Only quartz was determined separately as it is probably the most important mineral in relation to pneumoconiosis. Feldspar, sericite, chlorite and the carbonates were all classed together due to the difficulty of separating feldspar from its alteration products and of distinquishing the alteration products from each other. The opaque minerals were grouped together, but in nearly all the samples pyrite makes up at least 75 percent of the opaque material.



<u>Figure 5</u>, - sample number 289. Sugar tube sample, dust more than 10 microns in diameter, through 280 mesh screen. 1100 Station, dust from 1000 chute pocket. Tonopah-Belmont Development Co. Magnification 200 diameters.

Quartz	35%
Feldspar and secondary minerals	35
Opaque minerals	30

Sharp-edged particles comparatively scarce.

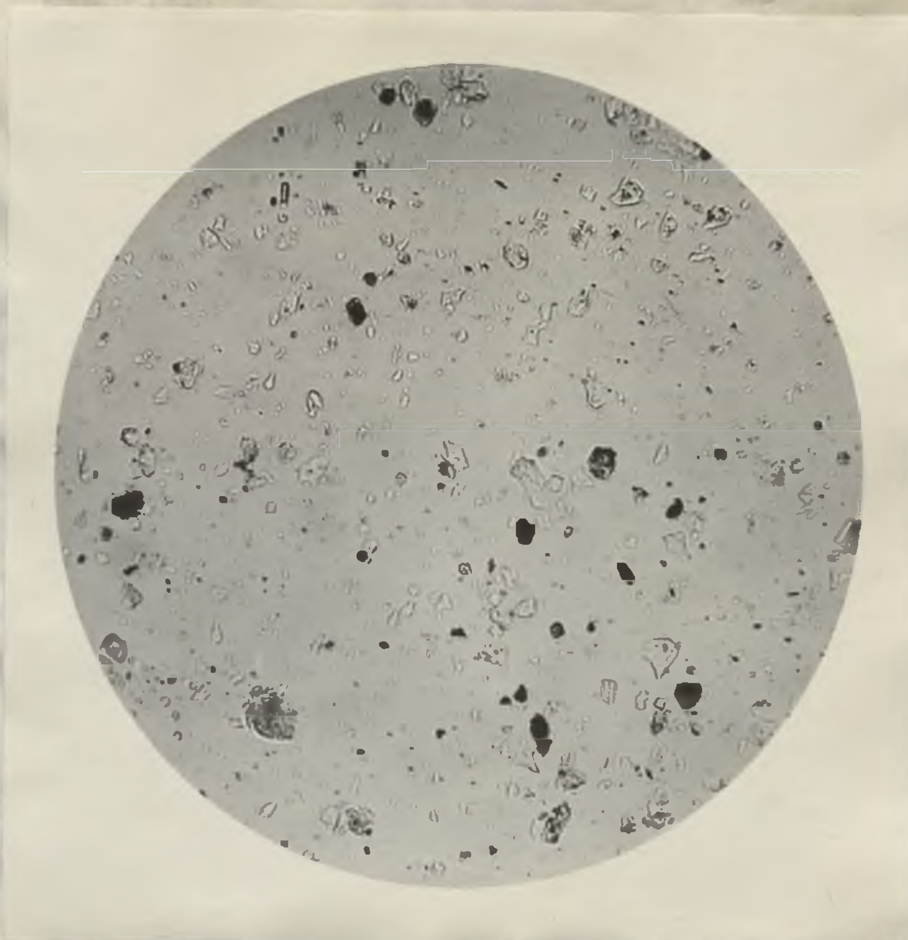


Figure 6. - sample number 319. Sugar tube sample, dust more than 10 microns in diameter, through 280 mesh screen. 855 East stope. One dry stoper working. Tonopah-Belmont Development Company. Magnification 200 diameters.

Quartz............................50%
Feldspar and secondary minerals....20%
Opaque minerals....................30%

Sharp-edged particles fairly numerous.

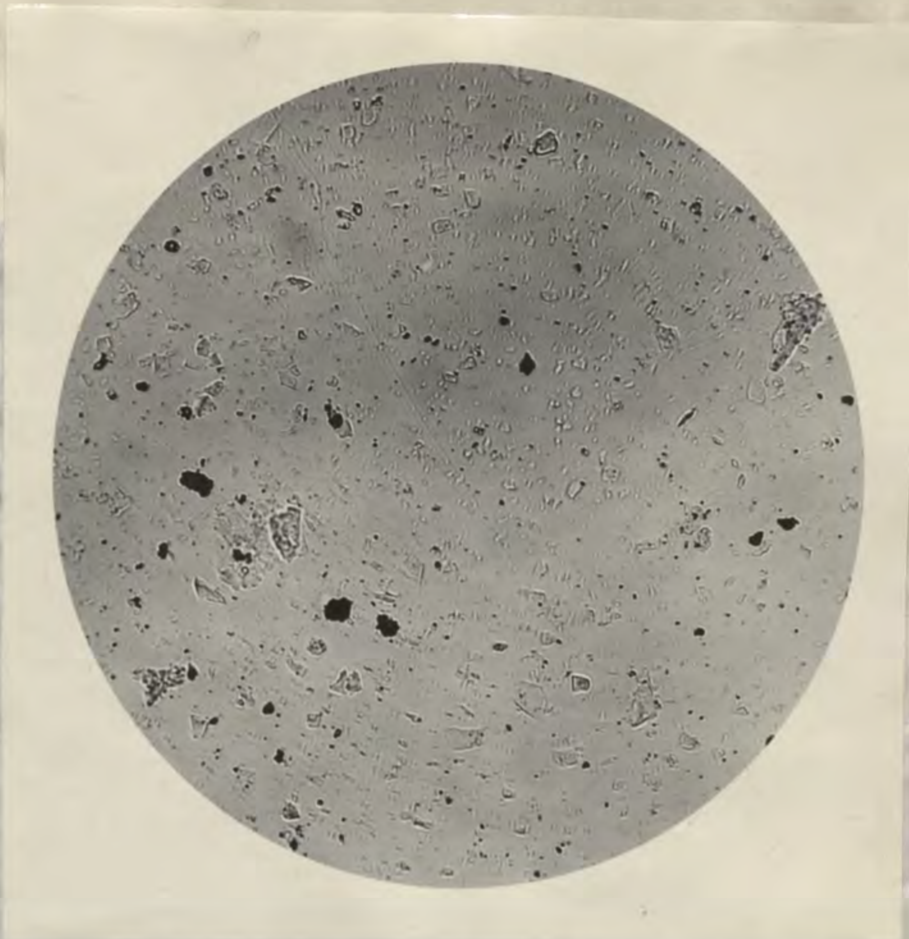


Figure 7, - Drill cuttings (through 200 mesh) in 981 stope - silicious ore. Tonopah-Belmont Development Company. Magnification 200 diameters.

Quartz	75%
Feldspar and secondary minerals	5
Opaque minerals	20

Quartz high; secondary minerals and feldspar low. Large numbers of fine, sharp-edged particles.

9625

Shale dust from Illinois Coal Mine. Note
the rounded character of the dust particles.

Drill cuttings (through 280 mesh), stope 314 - low silica vein. One dry stoper working. Tonopah-Belmont Development Company.

Quartz	55%
Feldspar and secondary minerals	30
Opaque minerals	15

Compare sugar tube sample number 302. Comparatively few fine, sharp-edged particles. See chemical analysis.

Dust from silicious vein (through 280 mesh screen. Tonopah-Belmont Development Company.

Quartz	70%
Feldspar and secondary minerals	20
Opaque minerals	10

Fine sharp-edged particles numerous.

Average vein matter, 956 stope (through 280 mesh). Tonopah-Belmont Development Company.

Quartz	60%
Fledspar and secondary minerals	25
Opaque minerals	15

Fine sharp-edged particles fairly numerous. See chemical analysis."[7]

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7. This ends Dr. Insley's report. Mr. Gardner's report continues.

Table No. VI gives the chemical analyses of settled dust and drill cutting samples taken in the mine. Sample 35309 is settled dust collected on timber at the 1100 station and is probably an average of ore from above the 1000 level. The analysis shows that the dust contains 45.4 percent silica and undecomposable silicates. Dr. Insley found under the microscope that the sample contained 35 percent quartz, which corresponds approximately to that shown by the chemical analysis. Sample 35307 is of drill cuttings corresponding approximately to an average of the vein matter in the mine. The sample contained 63.6 percent quartz and undecomposable silicates thriugh 280 mesh, of which 94.5 percent was silica, Allowing for enough silica to combine with the bases in the sample it would contain about 56 percent quartz, Dr. INsley's mineralogical determination showed it to contain 60 percent quartz, Sample 35303 is of low silica ore and contained 60.2 percent quartz and undecomposable silicates through 280 mesh, of which 93 percent was silica. This would correspond to about 51 percent quartz in this part of the sample. Dr. Insley's determination indicates 55 percent quartz. Sample 35305 was taken to represent the high silicious ore in the mine. By allowing for enough silica to combine with the bases in the undecomposable silicates, this portion of the sample would contain 69 pereent quartz. Dr. Insley, under the microscope, found it to contain 70 percent quartz. The following is a tabulation of Dr. Insley's results:

TABLE VI DRILL CUTTINGS AND SETTLED DUST TONOPAH-BELMONT MINE

	Sugar Tube No. 307 Laboratory No.35305 Drill cuttings 981 stope. High silica ore.	Sugar Tube No. 302 Laboratory No.35303 Drill cuttings 814 stope. Low silica vein	Sugar Tube No. 314 Laboratory No.35307 Drill cuttings 955 stope. Average vein matter in mine.	Laboratory No. 35309 Settled dust at ore pass 1100 station. Average of ore above 1000 level.
Moisture at 105 C as received	0.5%	0.5%	0.2%	1.1%
Silica, SiO_2 (Dry sample)	81.4	69.1	79.1	74.7
Aluminum Oxide, Al_2O_3	11.1	15.6	8.5	17.0
Ferric Oxide, Fe_2O_3	2.8	5.4	5.4	4.7
Manganese Oxide, MnO	0.0	0.0	1.6	0.0
Calcium Oxide, CaO	0.2	0.2	0.3	0.7
Magnesium Oxide, MgO	0.6	0.5	0.8	0.7
Carbon Dioxide, CO_2	0.1	0.1	3.0	0.6
Undetermined	3.8	9.1	1.3	1.6
Loss on ignition	1.6	5.2	0.3	4.5
Amount through 280 mesh	30.2	28.3	34.1	88.1
Quartz and undecomposed silicates (Through 280 mesh)	73.4	60.2	63.6	45.4
Silica (SiO_2) in quartz and undecomposable silicates.	98.5	93.0	94.5	94.5

Figure	Table Number	Sugar Tube Number	Place	Quartz	Feldspar and Secondary Minerals	Opaque Minerals
5	35309	289	Plus 10 microns, 1100 station at ore transfer,	35	35	30
6		319	Plus 10 microns, 855 E. Stope. Dry stoper working.	50	20	30
7			Drill cuttings, silicious ore.	75	5	20
	35303	302	Drill cuttings, 814 Stope. Low silica vein.	55	30	15
	35305		Drill cuttings, 981 Stope. Silicious ore.	70	20	10
	35307	314	Drill cuttings, 955 Stope. Average vein matter.	60	25	15

Assuming, as Haldane suggests, that certain clay dust or shale surround the sharp quartz particles and act as carriers and remove them from the lungs, it can be noted from the above table that the proportion of such alleviating minerals in the Tonopah ores is so very small they would probably have no beneficial effect.

Following the underground work physical examinations were made of a number of miners working in the Tonopah-Belmont Mine, and it was found that a large percentage of them had contracted miners' consumption from breathing rock dust in the mine air, which was frequently hot, humid and stagnant. These results are shown in Part II of this report.

Summary:

(1) The sampling indicates that an excessive amount of finely divided dust occurs in the air of this mine. (2) The photomicrographs show that a large proportion of dust particles have sharp jagged edges, which make it extremely dangerous to breath. (3) The chemical and mineralogical analyses show that the proportion of soft secondary minerals in the samples is too low to be of any material advantage in alleviating the harmful qualities of quartz dust, providing, of course, that they have any such properties. (4) The physical examinations indicate that underground workers are affected by breathing the dust in the mine air.

The remarkable results obtained in South African mines and elsewhere indicate that by installing adequate ventilation and by persistent efforts and unceasing vigilance to prevent the formation of dust on the part of the management and the men alike, the amount of dust made in ordinary mining operations can be reduced to such an extent that breathing it will not endanger the health of the miner. By following out the suggestions made in this report for preventing and removing dust, and by applying remedies that might occur to the management, conditions in the Tonopah-Belmont Mine should be materially improved and a man's health should not be in jeopardy by working in the mine.

1926 Conditions. In 1926 dust was very bad on the 1200 level due to drawing dry ore thru an ore pass from the 1100 level. Dust was also noted in several stopes,. The return air courses all showed fine dust that had settled out from the air currents, In general, conditions were better than in 1921 due, primarily, to the mine operating on a much lower tonnage basis and , therefore, making less dust. The shift-bosses are negligent in enforcing some of the regulations.

TIMBER DECAY.

The principal factors that influence timber decay are:

1. The kind of wood used for timber.
2. The seasoning of the wood.
3. Hot and damp air.
4. Impure air containing timber decay spores and germs.

While timber decay is not excessive in the Belmont Mine because of the low relative humidity, it is great enough to have some marked effects. It was noted in the discussion of temperatures and humidities that the 900 level is hotter than the neighboring levels due to heat generated by timber decaying in the large square-set stopes. Also the depletion of oxygen in the return air over that necessary for the increase of the carbon dioxide content is due to oxygen removed from the air by the decaying timber.

The most important case of timber decay is that of the Belmont shaft,,which takes the hottest air in the mine and upcasts it to the surface. Mr. Gardner found that this air becomes saturated with moisture before it reaches the collar because of the lowering of the dry-bulb temperature by the cooler rocks near the surface. This combination of hot air, damp air, and impure return air is most favorable for timber decay. The company found it necessary to retimber the Belmont shaft its entire length, completing the work in 1925.

RECOMMENDATIONS.

In confidential reports to mine operators, Mr. Pickard has outlined the major points to be considered in developing any ventilation scheme as follows:

1. The size and life of the mine and status as a profitable commercial enterprise.

2. Places at present and in future which must be ventilated; that is, supplied with fresh moving air.

3. Type of ventilation system - pressure or exhaust or both.

4. Intake air courses.
   a. Cross section of openings.
   b. Shortest route; that is, distances.
   c. Prevention of contamination by heat, spores, dust, and by powder, rock and timber gases.
   d. Relation of rock and surface temperatures.
   e. Course and direction of natural air currents.
   f. Interferences with tramming and hoisting.
   g. Elimination of interventilation between mines under separate managements.

5. Return air courses.
   a. Cross section of openings.
   b. Condition of old workings.
   c. New openings required.
   d. Best routing to secure minimum of timber decay.

6. Proper location of main fan and the distribution of air through proper location of doors, splits, and auxiliary fans.

7. Size of main fan.
   a. The amount of air (c.f.m.).
   b. Mine resistance (pressure of water gauge).
   c. Size of motor.

8. Fire and dust hazards.

9. Cost.

10. Organization for installation, operation and maintenance.

This investigation of ventilation problems in the Tonopah-Belmont Mine did not in any way include a study of the financial condition and policy of the company, of ore values and ore reserves, or of future plans for exploration and development. All recommendations in this report are made on the assumptions that the mine has sufficient ore reserves to guarantee its life as a paying business proposition for several years to come, that the present low tonnage output of the mine is temporary due to the low price of silver, and that the company is financially able and willing to carry out the recommendations.

It has been shown in the preceding analysis and discussion of results that the present ventilation scheme for the Belmont Mine is not satisfactory because:

1. The mine is dependent on adjoining properties for most of its intake air.

2. Natural ventilation pressure is not sufficient to force air thru all air courses.

3. The temperature and humidity in several stopes

are too high for miners to work at maximum capacity.

4. Most of the working places are not receiving enough air to comply with the minimum standard of air movement recommended bu the U. S. Bureau of Mines engineers.
5. The intake air for many of the working places is diluted with hot used air which has become contaminated with dust, decay spores, and timber and powder gases.
6. Much of the air circulating in the mine is not used at any working face.
7. A dangerous amount of silicious dust is formed in the mine and is not removed promptly from the working faces.
8. The mine presents a serious fire hazard because of uncontrolled air currents.

In order to secure direct control of air currents in the mine and thereby be able to correct the faults of the existing ventilation scheme, my first recommendation is to place the mine under mechanical ventilation.

The next question to be decided is the location of the fan. Shall the fan be underground or on the surface?

The main advantage to the underground location is that it does not interfere with hoisting. Both the Belmont shaft and the Desert Queen shaft could be used for hoisting. Also in cases of leaks between the two shafts, the recirculated air passes thru working places increasing the cooling effect. This is a doubtful advantage, however, because dust and smoke may be recirculated at the same time.

An objection to the underground location is that the greatest pressure on the ventilation doors would be on those in the levels nearest the fan. These levels are the main working levels and contain the most used doors. In case of 3 inches pressure and a 4 ft. by 6 ft. door, this pressure amounts to 374 pounds.

The most serious objection to a fan underground is that it may become useless in case of a fire. Should a fire start in the portion of the mine under negative pressure, the fan would soon be enveloped in dangerous CO gas. Before a crew could be organized and equipped with oxygen breathing apparatus and reach the fan to reverse the direction of air currents, the CO laden air would have been forced by the fan thru all that portion of the mine under positive pressure with probably many fatalities.

A fan on the surface would be accessable at all times and would eliminate the high pressure on doors in the lower levels, but would necessitate the use of one shaft for ventilation purposes exclusively. The Desert Queen shaft is only used occasionally to lower supplies which could be handled almost as cheaply thru the Belmont shaft. The logical location for the fan is on the surface at the Desert Queen shaft.

Positive or Negative Pressure. Another point to be decided is whether the mine shall be under positive or negative pressure. In the first case, the fan will run as a blower, all pressures underground will be greater than atmospheric pressure, the Desert Queen shaft will be the down cast and the Belmont shaft the upcast. In the case of negative pressure, the fan will exhaust air from the mine, all pressures underground will beless than atmospheric pressure, the Belmont shaft will be the down cast and the Desert Queen shaft the upcast.

There are several objections to the Belmont being the upcast shaft. First, as it is the main working shaft, the crew goes on and off shift in the return air from the mine. This practice is particularly objectionable when going off shift as the air is then laden with dust, powder smoke and gases from blasting. Second, most of the working places, as pointed out earlier, are nearer the Belmont Shaft than the Desert Queen and could, consequently, receive air by a quicker and shorter route were the Belmont the downcast instead of the upcast shaft. Third, the fact that the Belmont shaft had to recently be retimbered from top to bottom because of timber decay caused primarily by the hot damp return air shows it is a poor practice to use the main working shaft for an upcast.

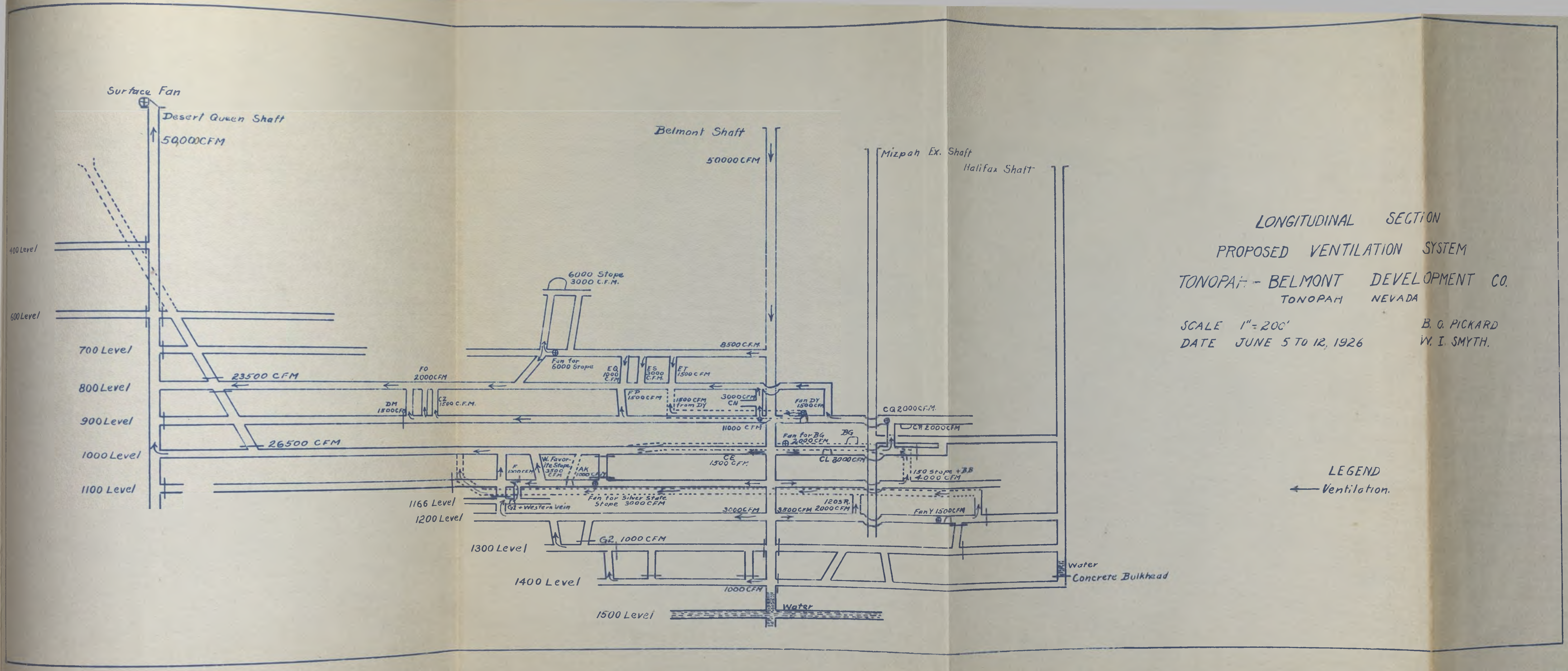
In order to supply fresh air to the crew when changing shifts, to furnish fresher air in the working places, and to reduce timber decay in the main working shaft to a minimum, I recommend that the mine be placed under negative pressure and, thereby, make the Belmont the downcast shaft.

An objection that is sometimes made to having the main working shaft the downcast is that in winter it will freeze and ice must be chopped out. The Belmont shaft, however, is dry for most of its length and no great difficulty should arise from ice in winter.

<u>Intake Air Courses</u>. In order that the total air supply will downcast thru the Belmont Shaft, all connections to adjoining properties must be bulkheaded with permenant concrete bulkheads. A small gunnited wooden door or an iron door should be built in each bulkhead.

Every lateral from the Belmont shaft must be equipped with regulators to adjust the amount of air taken from the shaft for that split. The regulator may be an opening in a door or a permenant stopping so designed that the size of the opening may be varied by a sliding gate. The openings should be as large as possible in order that the mine resistance shall not be too great.

The amount of air to be removed at each level will vary according to the number and requirements of working places dependent on that split for air. The following volumes of air for each split and the routing of the air are recommended for conditions as existed in June, 1926. These factors will contin-


LONGITUDINAL SECTION
PROPOSED VENTILATION SYSTEM
TONOPAH - BELMONT DEVELOPMENT CO.
TONOPAH NEVADA
SCALE 1" = 200'
DATE JUNE 5 TO 12, 1926
B. O. PICKARD
W. I. SMYTH.
LEGEND
Ventilation.
Surface Fan
Desert Queen Shaft
50,000 CFM
Belmont Shaft
50000 CFM
Mizpah Ex. Shaft
Halifax Shaft
400 Level
600 Level
700 Level
800 Level
900 Level
1000 Level
1100 Level
1166 Level
1200 Level
1300 Level
1400 Level
1500 Level
6000 Stope
3000 C.F.M.
Fan for 6000 Stope
8500 C.F.M.
23500 CFM
26500 CFM
FO 2000 CFM
11000 CFM
CQ 2000 C.F.M.
CL 3000 CFM
G2 1000 CFM
1000 CFM
Water
Concrete Bulkhead

ually change as old stopes are worked out and new ones opened up.

The 700 level split is allowed 8500 c.f.m. of air which will pass EI and go to a stoped area, northwest of the shaft; 3000 c.f.m. to be forced by a booster fan up raise EO to the 6000 stope and the balance to pass thru stopes EQ, ES and ET to the 800 level. The amounts of air for the last three stopes are 1000 c.f.m., 3000 c.f.m. and 1500 c.f.m. respectively. The air from the 6000 stope will go down raises EO and EW and join the return air on the 800 level.

The 900 level split is allowed 11,000 c.f.m. of air. 1500 c.f.m. will take a course northeast from the shaft passing ED and EB to a fan to be installed at junction HA, which will force the air to working place DY. The balance of the air will follow an air course opposite the direction of the arrows first to fan CN, then west to raise CV and fan CZ, then northwest to raise DF and stope DM. Fan CN is allowed 3000 c.f.m. of air for the stope in the intermediate level above, raise CV 1500 c.f.m. for stope FP, fan CZ 1500 c.f.m. for stope at the discharge end of fan, raise DF 2000 c.f.m. for stope FO on the 800 level, and stope DM 1500 c.f.m. All the air from the 900 level split will join the return air course on the 800 level. Connections with the 800 level must be made for the air from fans CN and CZ. To get to the 800 level, air from DY will travel west on the 900 level to the raise near DS.

The 1000 level split north from the Belmont shaft is allowed 2000 c.f.m. of air. A fan at BF will force this air to stope BG. Until BG connects with the 900 level, the return air from the stope will pass BF, FS, FR and BM and then follow the main haulage way opposite the arrows to the Desert Queen shaft.

The 1000 level split south from the Belmont shaft is allowed 8500 c.f.m. of air; fan CK 3000 c.f.m for stope CL, raise CH 4000 c.f.m for stopes CQ and CR on the 900 level, and stope CE 1500 c.f.m. the used air from CL will follow the crosscut east of the Belmont shaft to BF where it will join the return air from BG. The return air from CQ and CR will pass CP and CO and then go up raise EB to the 800 level return air course. The used air from CE will pass CD joining the 1000 level return air course at BM.

The 1100 level split north from the Belmont shaft is allowed 12,000 c.f.m. of air. The course will follow the route indicated on the map passing AZ, AH, HC, HD, AJ, HG, HI and HJ; at AZ 4000 c.f.m. of air to be taken out for stopes 150 and BB (these two stopes will soon be connected into one stope), at HD 3000 c.f.m. to be taken out by fan for the Silver State stope, at HG 1000 c.f.m. for drift AK, and at HI 3500 c.f.m. for the West Favorite stope and 1000 c.f.m. for stope F. The used air from the working places on the 1100 level will all go the 1000 level return air course; used air from the West Favorite and 150 stopes rising up the respective stopes to the 1000 level, air from the Silver State stope following route HE, HF and raise AM , air from 1153 drift going up 1132 stope and air from stope F going up the 1156 winze.

The 1200 level split north from the Belmont shaft is allowed 3000 c.f.m. of air which will follow the air course opposite the arrows to the bottom of the 1166 winze and then up the winze to the 1166 level where it is used to ventilate prospect drill station G1 and the Western Vein stope. The used air will return to the 1000 level return air course thru a raise to be made from the Western Vein stope to the 1100 level and then up the 1056 winze to the 1000 level.

The 1200 level split south from the Belmont shaft is allowed 3500 c.f.m. of air which will follow the arrows to 1203 raise and fan Y; 2000 c.f.m. and 1500 c.f.m. being the amounts of air for these places, respectively. The used air from Y will go to the 1100 level thru a raise south of curtain Z and rejoin the used air from 1203 raise at the top of the 1203 raise. The air will then pass south of the Belmont station and join the return air from the Silver State stope.

The 1400 level split west from the Belmont shaft is allowed 1000 c.f.m. of air which will travel opposite the arrows to raise Q, then up this raise to prospect drill station G2. Until stoping operations are begun in this part of the mine, the air from G2 opposite the present ventilation scheme up raise D and the 1166 winze diluting the air for G1 and the Western Vein stope because the amount of air is small and no dust is raised or blasting done at G2. A new return air course to the 1000 level must be made when mining operations begin at G2.

The volumes of air recommended for the various working places are sufficient to give a velocity of 25 feet per minute or more at all working faces with the exception of the stopes of large cross section. By lagging a manway up one side of the latter stopes and allowing the air to sweep from the top of the manway across the working face, the velocity may be increased to the 25 feet per minute recommended by the Bureau of Mines as a minimum.

The table on page 144 shows that the amount of air required to ventilate the mine according to the scheme outlined above is 50,000 c.f.m. This amount of air should be sufficient when the output of the mine is raised again to 500 tons daily because the mine is now only working one shift, several of the stopes idle and practically none of them producing a maximum amount of ore.

Return Air Courses. The return air courses have been indicated in the above description of intake air courses to the various working places. All the air from the 700 and 900 level splits and the 4000 c.f.m. of air from the 1000 level split for stopes CQ and CR

PROPOSED DISTRIBUTION OF AIR.

Intake Air Course	Working Place	Level	Amount of Air	Return Air Course.	
700 Level Split	6000 Stope	600	3000 c.f.m.	800 Level	
" " "	Stope RQ	800	1000 c.f.m.	" "	
" " "	Stope ES	800	3000 c.f.m.	" "	
" " "	Stope ET	800	1500 c.f.m.	" "	
900 Level Split	Stope DY	900	1500 c.f.m.	" "	
" " "	Stope CN	900	3000 c.f.m.	" "	
" " "	Stope FP	800	1500 c.f.m.	" "	
" " "	Stope CZ	900	1500 c.f.m.	" "	
" " "	Stope FO	800	2000 c.f.m.	" "	
" " "	Stope DM	900	1500 c.f.m.	" "	
1000 Level S Split	Stope CR	900	2000 c.f.m.	" "	
" " " "	Stope CQ	900	2000 c.f.m.	" "	Total air returning on 800 level, 23500 c.f.m.
" " " "	Stope CL	1000	3000 c.f.m.	1000 Level	
" " " "	Stope CF	1000	1000 c.f.m.	" "	
1000					
1000 Level N Split	Stope BG	1000	2000 c.f.m.	" "	
1100 Level Split	Stopes BB & 150	1000	4000 c.f.m.	" "	
" " "	Silver State Stope	1100	3000 c.f.m.	" "	
" " "	1153 Drift	1100	1000 c.f.m.	" "	
" " "	West Favorite Stope	1100	3500 c.f.m.	" "	
" " "	Stope F	1100	1000 c.f.m.	" "	
1200 Level N Split	G1 and Western Vein	1166	3000 c.f.m.	" "	
1200 Level S Split	1203 Stope	1200	2000 c.f.m.	" "	
	Fan Y	1200	1500 c.f.m.	" "	
1400 Level Split	G2	1300	1000 c.f.m.	" "	Total air returning on 1000 level, 26500 c.f.m.
Total			50000 c.f.m.		

will return to the Desert Queen shaft by way of the 800 level return air course. The balance of the air will return to the upcast shaft thru the 1000 level return air course. Not allowing for expansion and compressed air, the volumes of air in the two return air courses are 23,500 c.f.m. and 26,500 c.f.m., respectively.

Stoppages. Air courses similar to those already in the Belmont Mine will have to be made to route the intake and return air. The type of stoppage to be installed will depend on the length of time the respective air courses will be used. Concrete bulkheads are best but most expensive and are only recommended along main courses where large abandoned areas may be isolated. Bulkheads built of wooden sheathing and gunnited will be almost as tight as concrete, cost considerable less and at the same time be fairly fire resistant. Gunnited wooden stoppages are superior to the brattice cloth stoppages now used because they will have a lower leakage loss, will last longer, will be less damaged by mining operations and harder to destroy in case of fire. They are recommended for stoppages along all air courses except those of very temporary nature where brattice cloth because of its lower cost should be used.

In order to cut resistance, stoppages should be built as near the sides of an air course as possible. If a stoppage is built in a crosscut some distance from the drift used for an aircourse, eddy currents will form in the space between the stoppage and air course which adds to the resistance which must be overcome by the fan.

The standard ventilation door already adopted by the company is satisfactory but the two improvements suggested in the discussion; namely, a positive latch and closing against the frame instead of against a jamb within the frame, should be made in all new doors.

The Desert Queen shaft should be sheathed and gunited its entire length to lower the resistance factor of the shaft, to lessen fire hazard and to lessen timber decay.

Booster Fans. Auxiliary fans will be need to supply air to the following dead ends and stopes; 6000 stope, DY, CN, CZ, CR, CQ, CL, BG, Silver State stope and 1153 drift. CN, CZ, and BG will only need fans until connections are made with the levels above. The fans should be so installed that no used air can dilute the intake air. See discussion of set-up of booster fans, pages 94 to 98. Flexible canvas ventilation tubing should be used instead of galvanized iron tubing for discharge lines from the fans because it costs less and can be used very close to the working face and a section removed before blasting.

Abandoned Workings. All thru the mine are worked out areas which, unless isolated, heat and contaminate the circulating air and present a fire hazard. Most of the Desert Queen workings, particularly those south-east of the shaft, are abandoned and should be bulk-headed from the rest of the mine. All stopes when worked out should be isolated from live workings. Either concrete bulkheads or wooden bulkheads well gunited will be satisfactory for this work.

Size of Fan. The best method of determining the size of fan needed for the Belmont Mine is to determine the mine resistance after all underground ventilation control measures have been installed. A small fan, temporarily installed at the top of the Desert Queen shaft, may be used to determine the negative pressure,

P_1, in inches water gauge at the fan for the volume of air, V_1, circulated by this fan. As the fan is exhausting against natural ventilation pressure, P_n, the mine resistance, R_1, equals $P_1 - P_n$.

Mine resistance varies as the square of the volume of air circulating. Let R_2 equal the mine resistance for 50,000 c.f.m. of air.

Then R_2 equals $\frac{R_1 \times (50000)^2}{(V_1)^2}$

The negative pressure to be produced by the fan, P_2, will equal $R_2 + P_n$.

$$P_2 \text{ equals } \frac{R_1 \times (50000)^2}{(V_1)^2} + P_n.$$

Substituting the value of R_1,

$$P_2 \text{ equals } \frac{(P_1 - P_n) \times (50000)^2}{(V_1)^2} + P_n.$$

The value of P_n can best be determined by temporarily bulkheading one of the shafts and measuring the difference in pressure on each side of the bulkhead.

After P_2 has been determined, a fan whose characteristic shows a volume of 50,000 c.f.m. against a pressure of P_2 inches should be ordered.

Cost of Fan. The size and cost of the fan needed at the Belmont will approximately be the same as an excellent fireproof surface fan recently installed by the Tonopah Extension Mining Co. The following is taken from a ventilation report on the Tonopah Extension Mining Co. by B. O. Pickard.

> It is a double inlet primarily blowing reversible Jeffrey's Stepped, multiblade fan, 5 feet by 2 feet. At 420 revolutions it has a computed capacity of 50,000 c.f.m. (elevation is 6000 feet above sea level) at 3.75 inches water gauge and 42 B.H.P. This fan is manufactured by the Jeffrey's Manufacturing Co. of Columbus, Ohio, and described in their catalogue No. 280. The installation including the cost of fan with material and laborfor lining the shaft to the 1646 ft. level is $12,250.00

Fan Cost	$1068.00	F.O.B. Columbus
Steel	1100.00	
House	875.00	
Pulley	28.00	
Total	3091.00	No motor included.
Freight and Installation	5000.00	
Lining shaft as above noted ..	4158.00	
	12249.00	

Allowing for the Belmont Mine $5000.00 additional to construct the necessary bulkheads, regulators, etc., to maintain air courses underground, the investment to charge to mechanical ventilation will be about

$17,250.00. Interest at 6% on the investment would amount to about $1000.00 annually and power at $100 per H.P. year to run the fan $4000.00 or a total of $5000.00 anually.

The pay roll of the Tonopah-Belmont Development is $200,000.00 per year. Assuming 5% increased efficiency from the men by the improved working conditions due to mechanical ventilation, the pay roll could be cut $10,000.00 a year. In less than four years, the increase in efficiency of labor will not only pay for the running of the fan but also its first cost and installation.

Dust Hazards. Mr. Gardner gave very definite directions for reducing dust to a minimum and the shift bosses should be required to enforce these dust rules more carefully. No dry ore should be trammed or dropped thru ore passes as is now being done on the 1200 level. More sprinkling should be done in the stopes and air courses. To impress upon the men the danger of dust, it might be well to adopt the system used in the Tonopah Extension of posting signs throughout the mine, such as, "Fight dust - don't eat it!!" and "Raise Hell with the man who raises dust!!"

Fire Hazards. With mechanical ventilation and the bulkheading of abandoned workings and connections to adjoining properties, fire hazards will be greatly reduced. All loose inflamable material should be removed from the mine, particularly greasy waste and old oil around the pumps and fans. Loose carbide around the station timber should be cleaned up and means taken to stop the men from dumping carbide at the stations except in proper containers. Electric wiring throughout the mine should be carefully inspected for possible short circuits and to make sure all wires are properly insulated from timber. A fire survey should be made of the mine, fire fighting units organized and workmen instructed what to do in case of fire.

Ventilation Organization. A full-time engineer should be assigned to ventilation work with sufficient help to make necessary installations and inspections. His duties will be to keep up a ventilation map of the mine, study the ventilation requirements of all working places, distribute the air as needed thru the mine, take steps to reduce dust and fire hazards and have charge of safety first, mine rescue and fire fighting organizations. He must make regular inspections to make sure there are no obstructions in the air courses, that all doors and regulators are properly set and that there are no short cutting of air.

In order for the ventilation engineer's efforts to be effective, he must have the co-operation of the mine formman and shift bosses. All workmen should be instructed to observe the safety and ventilation rules he will make.

Summary of Recommendations. In conclusion, I will summarize my recommendations as follows:

1. The Tonopah-Belmont Mine should be placed under mechanical ventilation with a reversible fire-proof fan, capacity 50,000 c.f.m., installed on the surface at the Desert Queen shaft.
2. The mine should be placed under negative pressure.
3. The main working shaft should be the downcast shaft.
4. Air courses should be established to furnish each working place with a supply of fresh air by the quickest and shortest route possible.
5. This air should not be diluted with used air

from other working places.

6. The minimum velocity of air at the working faces should be 25 feet per minute.

7. Booster fans should be used to supply air to dead ends and poorly ventilated stopes.

8. Return air courses to the upcast shaft should be established to remove used air from the mine as quickly as possible.

9. Stoppages should be built in all connections with adjoining properties.

10. All abandoned workings should be isolated from the live workings of the mine.

11. Water should be used more freely to prevent the formation of dust and any dust that is raised should be removed from the mine as quickly as possible.

12. Measures to prevent fire should be adopted and fire fighting units organized.

13. A full-time engineer should be in charge of the ventilation work.