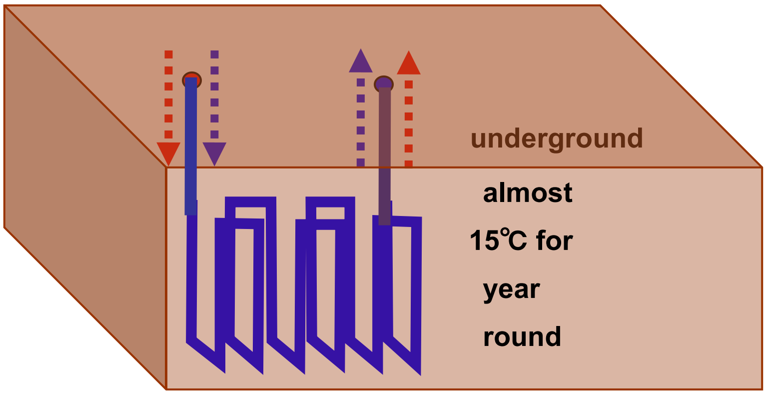
Both Cooling & Heating & by Geothermal

2015/3/24,30.

Cave as natural air conditioner by stable geothermal 15℃ for year round is without most expensive **electrical power charge**.It is cheaper than basement building.Underground pipe line could supply both **Heating & Cooling by Geothermal**.

☞:Note main concern on **non-carbon energy** may be **wind-marine & solar power**, then we should pay concern also for **thermodynamic engineering**.



Ventilation Motor must be with input or output of pipe line.It could be drived by **less than 10W ?**.
Note air conditioner need about **1000W** which is expensive.

[1]:air ventilation through underground long pipe line.

(1)$Q=\int_0^{L_P} dS_P(x)k_v(T(x)-T_G)$....heat amount absorbed or emitted from the surface.

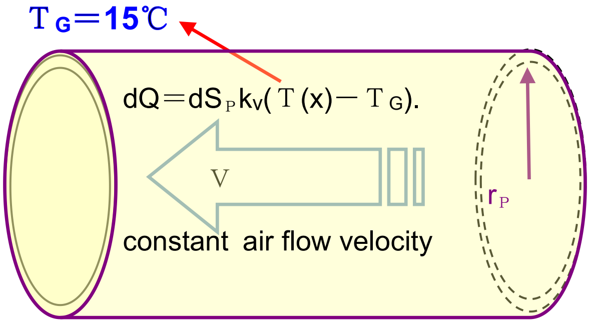
"x" is length variable from input toward output in pipe line.

(2)$k_v=\alpha\times 7W/m^2K$........................ventilation heat coefficient($\alpha(V)=1\sim 3$)by flow V.

(3)$dS_P(x)=dx2\pi r_P$. ....differential ventilation surface in pipe line.

$*S_P=L_P2\pi r_P$. ....total area of pipe line surface of ventilation heat transfer

(4)$T(x)=T_A+x(T_G-T_A)/L_P$......linear distribution assumption??? in pipe line.



Note this is naive technology without heat pump or heat pipe mentioned in below.

Of course demerit is **longer pipe length**,while merit is **almost small energy**.

(heat siphon for heating)without maintenance.

[2]:example estimation.

(1)theorem of average value in integral.

$Q = \int_0^{L_P} dS_P(x) k_V (T(x) - T_G) = S_P k_V (T(x') - T_G)$.. → $< T_A > T(x') > T_G >$.

(2)example calculation.

(a)**heat flow velocity＝V at input and output**：

⁎air specific heat=1.006J/gK ; ⁎air density＝1.2kg/m^3.

⁎air heat capacity/m^3＝C_V＝1.2KJ/m^3.

⁎flow velocity＝V and the input-output air volume/s＝$V 2\pi r_P$.

⁎pipe circular length：$2\pi r_P = 0.3$m

⁎average temperature change in the pipe line length： $\Delta T \equiv T(x') - T_G$).

$P(V) \equiv V 2\pi r_P C_V \Delta T = Q$.

→ $V = Q/2\pi r_P C_V \Delta T$ ＝2.5KW/0.3mx1.2KJ/m^{3}x5℃＝1.2m/s

(b)**ventilation coefficient**＝k_V:

$k_V = \alpha \times 7$W/m^{2}K＝.14(α =2)?? by $V = 1.2$m/s

(c)**total area of inner pipe line**＝S_P,**and pipe length**＝L_P.

$Q \equiv 2500$W＝S_Px14(α =2)x5℃. .....($T(x') - T_G$)＝5℃.、T_A＝30℃、T_G＝15℃.

→ S_P＝35m^2.

$2\pi r_P = 0.3$m. →L_P＝120m.

$2\pi r_P = 0.15$m.→L_P＝240m.<slim and long are advantageous for cooling,it is evident>

☞:Relation between temperature distribution= $T(x)$ and pipe diameter=r_P,etc are not known to author.

☞:imagine 25 pieces of 100W light bulb in ground located along the line by 5m separation,which could be stationary cooled by ground heat absorbing.

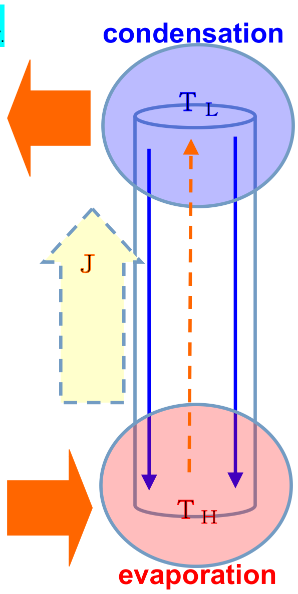
APPENDIX-1:Heat Pipe can realize strong heat transfer without ENERGY.

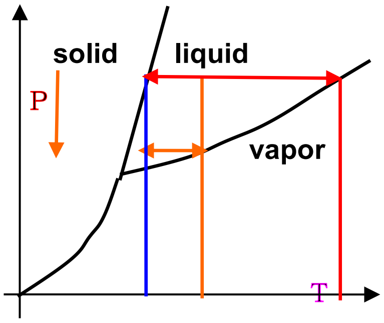
The principle of heat pipe action.

J(heat flow(sink or output) by wattage)＝[Ｔ(high)－Ｔ(low)]/R_T.

A heat pipe realizes **very low** R_T by that large heat sink by evaporation **at higher Ｔ portion** and the light vapor gas is naturally transferred into **lower Ｔportion** to emit heat and be condensed to liquid which turn again naturally(gravity or) into higher temperature portion.This cycle never consume energy by **lower pressure** in closed pipe for realizing easy evaporation and condensation cycle between **lower temperature difference.**.

http://en.wikipedia.org/wiki/Heat_pipe





Left figure is called **phase diagram**,where **lowering pressure**＝Ｐ enables lowering temperature difference between **evaporation & condensation**,which are larger heat transfer(**latent heat**).That is,**small temperature gradient** becomes **larger heat transfer**.

＊Snow melting by heat pipe with geothermal heat source.

http://www.kowa-net.co.jp/index.html

Heavy snow fall is fatal in some snowy regions.

＊Cooler BOX 70L by 80W,while Ordinal 70L refrigerator consumes about 200W.

http://www.peltism.com/lineup/re_70_hpt_black.php

Pelletier effect with **heat pipe technology** is employed.In home, **air cooling** and **refrigerator** are most power consuming.Note **Pelletier effect itself** is not less power consuming.

＊solar water heater by heat pipe

Heat gathering efficiency is higher than that of flat panel type.Also other merits are.

http://www.hwsolar.com/hws_pre_heat_press_solar.html

http://taiyouko.co.jp/compact.html

http://www.ecosurefine.com/solar-water-heaters/pressurized-heat-pipe-solar-water-heater/

APPENDIX-2:*Geothermal Heating and Cooling by Heat Pump.*

https://www.google.co.jp/search?q=geothermal+cooling+system&es_sm=93&tbm=isch&tbo=u&source=univ&sa=X&ei=qokTVbq7FdjX8gX9t4DYCA&ved=0CB0QsAQ&biw=1024&bih=653#imgdii=_

Ten Myths About Geothermal Heating and Cooling

http://energyblog.nationalgeographic.com/2013/09/17/10-myths-about-geothermal-heating-and-cooling/

Geothermal Heat Pump: How It Works

http://www.thisoldhouse.com/toh/article/0,,20162296,00.html

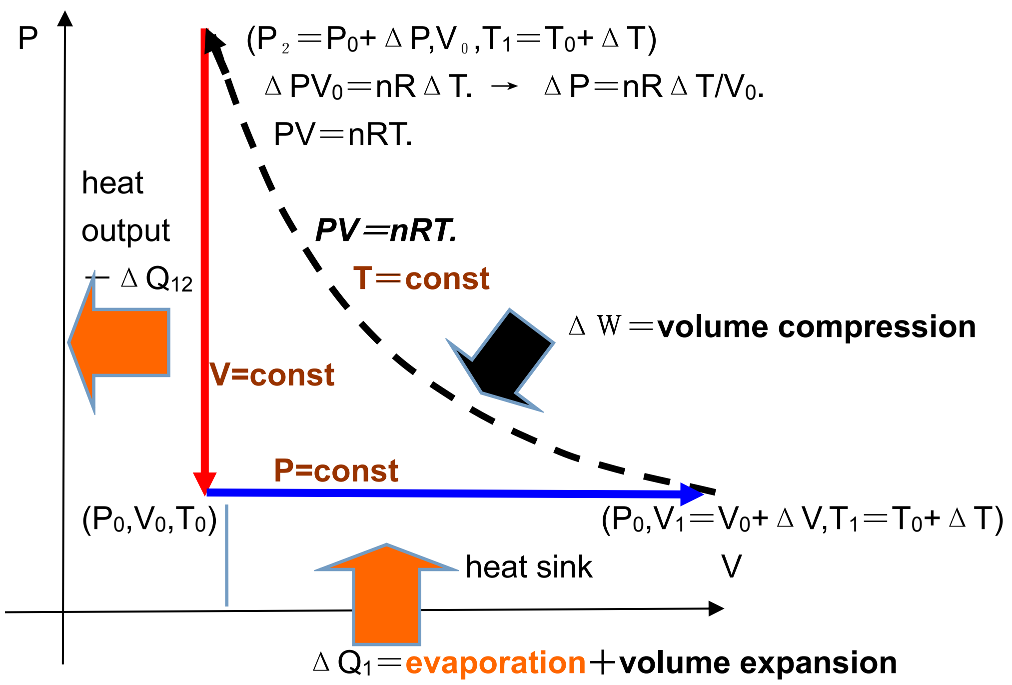
Geothermal Heat Pump Theory

http://www.geothermalmaine.com/theory.html

Heat Pump

http://en.wikipedia.org/wiki/Heat_pump

APPENDIX-3:Heat Pump's COP model calculation<by alternate phase transition cycle>.



(1)$PV=nRT$................ Ideal gas state equation,

(2)$P_0\Delta V=nR\Delta T$..... gas expansion by constant pressure$=P_0$.

(3)$\Delta Q_1=nRT_L+P_0\Delta V=nRT_L+nR\Delta T=nR(T_L+\Delta T)$.

⋆nRT_L≡**latent heat for "n" mol.**

$\Delta W=-\int dVP=-\int dV(nRT/V)=-nRT.\ln<V_0/(V_0+\Delta V,)>$

$=-nRT.\ln<1/(1+\Delta V/V_0,)>=-nRT.\ln<1/(1+\Delta T/T_0)>$

(4)$\Delta W=nRT_1.\ln<1+\Delta T/T_0>=nR(T_0+\Delta T).\ln<1+\Delta T/T_0>$

(5)$-\Delta Q_2=(\Delta Q_1+\Delta W)=nR(T_L+\Delta T)+nRT.\ln<1+\Delta T/T_0>$

$0=\oint(dQ+dW)=\Delta Q_1+\Delta W+\Delta Q_2$.

(6)$\eta_c\equiv\Delta Q_1/\Delta W=(T_L+\Delta T)/(T_0+\Delta T)\ln<1+\Delta T/T_0>$

$\fallingdotseq(T_L+\Delta T)/(T_0+\Delta T)(\Delta T/T_0-(\Delta T/T_0)^2/2)$

$=(T_L/\Delta T+1)/(1+\Delta T/T_0)(1-(\Delta T/T_0)/2)\fallingdotseq(T_L/\Delta T+1)$

⋆$\ln<1+\Delta T/T_0>\fallingdotseq\Delta T/T_0-(\Delta T/T_0)^2/2$.

(7)$\eta_h\equiv-\Delta Q_2/\Delta W=1+\eta_c$.

☞:note this is not **Carnot Cycle** in classical thermodynamics,but should be called **phase transition cycle** between **liquid- gas** by **evaporation & condensation**.

(8)**latent heat for H20,CO2,**

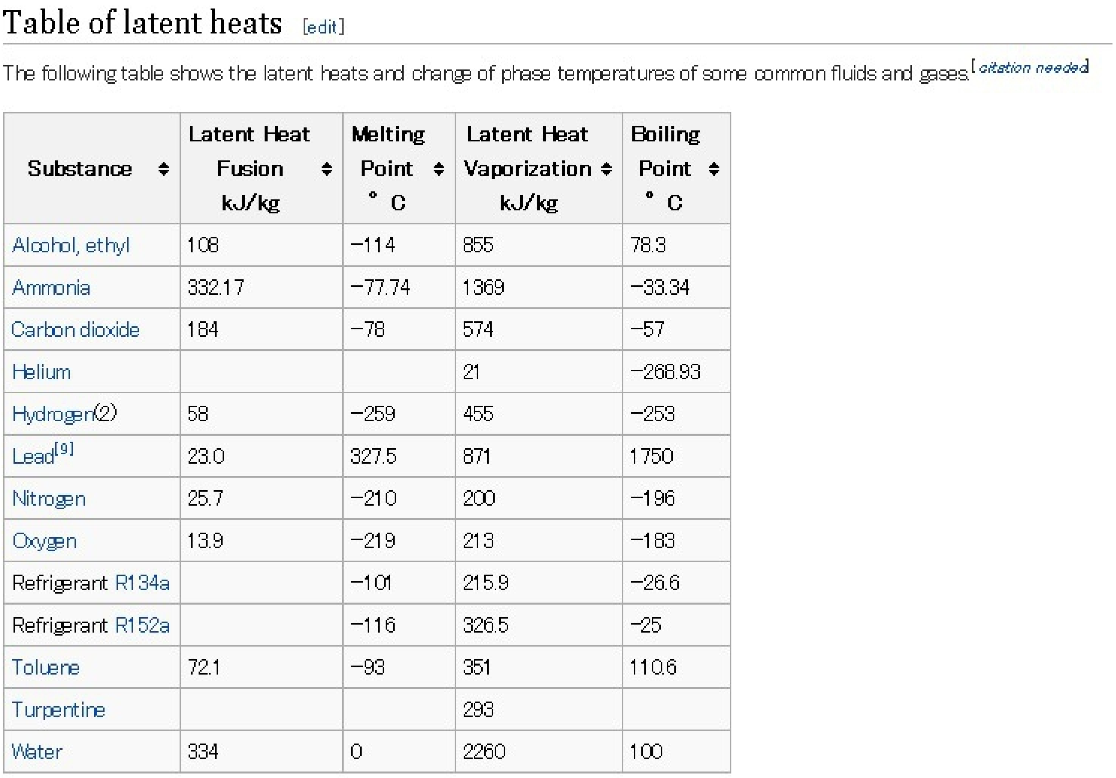


Table of latent heats [edit]

The following table shows the latent heats and change of phase temperatures of some common fluids and gases.[citation needed]

Substance	Latent Heat Fusion kJ/kg	Melting Point °C	Latent Heat Vaporization kJ/kg	Boiling Point °C
Alcohol, ethyl	108	−114	855	78.3
Ammonia	332.17	−77.74	1369	−33.34
Carbon dioxide	184	−78	574	−57
Helium			21	−268.93
Hydrogen(2)	58	−259	455	−253
Lead[9]	23.0	327.5	871	1750
Nitrogen	25.7	−210	200	−196
Oxygen	13.9	−219	213	−183
Refrigerant R134a		−101	215.9	−26.6
Refrigerant R152a		−116	326.5	−25
Toluene	72.1	−93	351	110.6
Turpentine			293	
Water	334	0	2260	100

1mol **water**＝12g

R＝気体定数＝8.31J/K.mol

$H_{Lm}(H_2O)$＝2260KJ/kgx0.012＝27.12J＝RT_L,→T_L＝H_{Lm}/R＝3.3℃. <<1atm>>

$H_{Lm}(CO_2)$＝574KJ/kgx0.012＝6.9J＝RT_L, →T_L＝H_{Lm}/R＝0.83℃. <<1atm>>

Note T_L is dependent on **refrigerant** (working gas material).

(9)$P_0\Delta V = nR\Delta T$.

In **phase transition** from **liquid to vapor**, $\Delta V/\Delta T$ is discontinous change.

so ΔT may be order of 1℃ or less ??. Now author don't know.

example) $\eta_c \equiv \Delta Q_1/\Delta W = (T_L+\Delta T)/(T_0+\Delta T)\ln<1+\Delta T/T_0> \fallingdotseq (T_L/\Delta T+1)$

T_L＝H_{Lm}/R＝3.3℃. And if $\Delta T = 1$, $\eta_c \fallingdotseq 3.3/1+1 = 4.4$.

T_L＝H_{Lm}/R＝0.83℃. And if $\Delta T = 1$, $\eta_c \fallingdotseq 0.83/1+1 = 1.83$.

APPENDIX-4:Evaporation Heat≡L in changing pressure≡P by THERMO DYNAMICS.

In **heat pipe** or **heat pump** design,evaporation heat≡L(P,T(P))in various pressure≡P Is important for larger heat transfer.It could be derived from so call phase diagram of various working gas(**refrigerant**=CO2,H20,....).A concern may be getting **evaporation temperature by various pressure** in order to realize pragmatical utility.

(1)Reaction Direction in Thermo-Dynamics SUMMARY.

(a)The 1st law.

$dU = dQ - dW' + \mu dN = dQ - PdV + \mu dN$.

internal energy increment＝heat－work for exterior＋chemical component t increment.

＊chemical component t increment＝internal energy increment－heat＋work for exterior

(b)The 2nd law.

$\int_i^f dQ/T = S(f) - S(i)$. 0r $dQ = TdS$.〈**reversible process only !!!**〉

$\int_i^f dQ/T < S(f) - S(i)$. 0r $dQ < TdS$.

Actual thermodynamical process is **irreversible**,therefore above relation is established.

→ $dQ = dU + PdV$.

→ $dU + PdV - TdS < 0$.

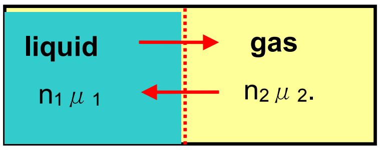
(2)Change in equi-temperature($dT = 0$),and equi-pressure($dP = 0$).

$G \equiv U - TS + PV = \mu N$. 〈**Gibbs chemical potential**〉

chemical component t increment＝internal energy increment－heat＋work for exterior

$dG \equiv dU - TdS - PdV < 0$. ***Reaction goes toward "G" decreasing to the bottom.***

(3)Equilibrium Condition in two phase-co-existence by Gibbs's bottom.



Constant amount＝$N_1 + N_2$

Total Gibbs energy $G = n_1\mu_1 + n_2\mu_2$.

equilibrium →$0 = \delta G$.→ $\mu_1 = \mu_2$.

Each chemical<Gibbs/unit mol>potential is equal

⑷**Clapeyron-Clausius equation on Equilibrium Phase Boundary**.

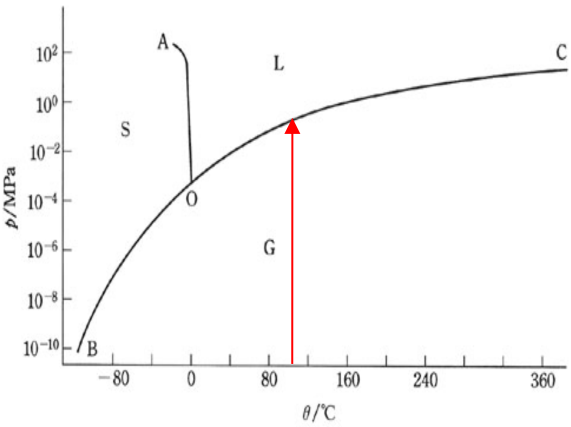


図 6-6　水の状態図（圧力のスケールは対数目盛）

$\mu_1(P, T) = \mu_2(P, T)$、

$\mu_1(P+dP, T+dT) = \mu_2(P+dP, T+dT)$.

On the curve line of evaporation,both equations are established,then the total differentiation yields.

$$(\partial \mu_1/\partial P)dP + (\partial \mu_1/\partial T)dT$$
$$= (\partial \mu_2/\partial P)dP + (\partial \mu_2/\partial T)dT.$$
$$V_1 dP + S_1 dT = V_2 dP + S_2 dT.$$
$$dP/dT = (S_2 - S_1)/(V_2 - V_1)$$
$$\rightarrow dP/dT = L/T(V_2 - V_1)$$

http://www.campus.ouj.ac.jp/~hamada/TextLib/rm/chap6/Text/Cr990603.html

⑸**evaporation heat**：$L\ (=\langle S_2 - S_1\rangle/T) = (dP/dT)/T(V_2 - V_1)$.

V_2=gas volume, V_1=liquid volume, T =evaporation temperature at pressure P.

example) water evaporation heat at 100℃,1atm.

T	P (Hg)	dP/dT	V_2	V_1
372℃	733.7mm	(733.7-788.0)/2 x980x13.6 dyn/cm^2℃		
373℃			1673.0cm^3/g	1.04cm^3/g
374℃	788.0mm			

$L = (dP/dT)T(V_2 - V_1) = 2.261\times10^{10}$erg/g

*citation：原島鮮, 熱力学統計力学(p96, 97), 培風館, 1966.

⑸More simplified equation for calculation.

$V_2 \gg V_1 \fallingdotseq 0$.

$PV_2 \fallingdotseq RT$.　. . . . . 1 **mol ideal gas state equation,**　R =8.31434J/K.mol.

$L = (dP/dT)RT^2/P$. . . . . . . this is physical quantity for the matter.

Thus we could evaluate evaporation heat in various pressure by so called **phase diagram of refrigerant gas.**

APPENDIX-5:REVERSED CARNOT CYCLE NEVER BE !!.

REVERSED CARNOT CYCLE .

http://thermodynamics-engineer.com/429-2/

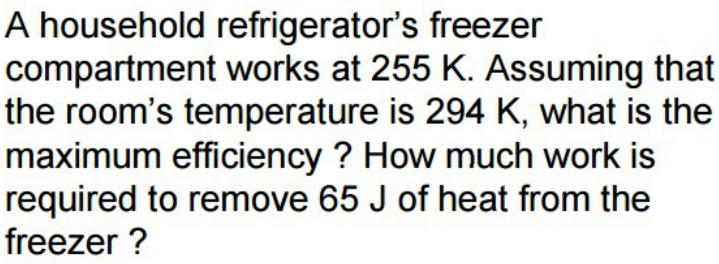
Refrigeration Cycle The Reversed Carnot Cycle

http://www.sfu.ca/~mbahrami/ENSC%20461/Notes/Refrigeration%20Cycle.pdf

Carnot cycle.pdf

http://www.usask.ca/chemistry/groups/burgess/242/Carnot%20cycle.pdf

$$\boxed{\eta_{\text{carn.fri.}} = \frac{T_c}{T_h - T_c}}$$



A household refrigerator's freezer compartment works at 255 K. Assuming that the room's temperature is 294 K, what is the maximum efficiency ? How much work is required to remove 65 J of heat from the freezer ?

answer by author)$\eta_{\text{carn.fri}}$＝$T_C/(T_h - T_C)$＝255/(294-255)＝6.54??.

APPENDIX-6:COP≡*heat exhausted/compressor energy* in air conditioners

For an example,COP＝3 cooler with compressor power consuming＝800Ｗ could exhaust 2400W heat.

表８　実使用時平均ＣＯＰとカタログＣＯＰ

	運転状態	測定日	実使用時平均COP	カタログCOP
住宅A	冷房	8/1～9/30	6.61	5.00
	暖房	10/1～3/4	3.00	4.94
住宅B	冷房	9/11～9/15	10.90	5.79
	暖房	12/20～12/24	6.70	5.77
住宅C	冷房	9/2～9/5	5.53	5.83
	暖房	12/5～12/8	1.82	5.97
住宅D	冷房	8/26～8/31	2.89	3.06
住宅E	暖房	11/14～11/17	4.00	5.88

- 5 -

http://tkkankyo.eng.niigata-u.ac.jp/HP/HP/sympo3/akabayashi.pdf

Note efficiency of electrical power may be about 1/3, so COP＝3 is canceled.

By anyhow,heating by electricity is larger,so it is not CO2 reduction merit.