



7 ci fgY[·]Cj Yfj]Yk

`GHJZZ`7cbHJWh`8YHJ]`g`

'7cbj Ybcfg'

B Ua Y	9a U]`	5j U]`UV]`]m	@cWUhjcb	D∖cbY
>c\b`5Hf]X[Y	,	,	FcVYfh KYVghYf	-',)((,(

GWXcc`7cbHJWh=bZcfaUh]cb

Fcca " &&ž`Yj Y`' FcVYfhK YVghYf6i]`X]b[

D\cbY.`f\$&Ł`- ' ,) `(,) *

9a U]`. <u>'gUa 4 i bgk "YXi "Ui</u>

K YVg]hY. <u>http://ttdg.#gUa_"Ufhg"i_bgk_"YXi_"Ui_</u>

: cf`YggYbhJU``ghi XYbh`]bZcfa UhJcb`fY`UhJb[`hc.`fYei Yghg`Zcf`YI hYbg]cb/fYj]Yk `cZa Uf_g/cVWV dUhJcbU``\YU`h UbX`gUZYhm'YI Ua]bUhJcb`dfcVWXi fYg/gdYVJU``Vcbg]XYfUhJcb`]b`h\Y`Yj YbhcZ]``bYgg`cf`a]gUXj Ybhi fY/ ghi XYbhYei]hmUbX`X]gUV]`]hm'UbX`ch\Yf`YggYbhJU``UVUXYa]W]bZcfa UhJcbž gYY`<u>\hhdg.#k k k "Ufhg"i bgk "YXi "Ui #W ffYbhIghi XYbhg#UVUXYa]W]bZcfa UhJcb#dfchcVc`g![i]XY`]bYg#</u>

7ci fgY 8YHJ]g

7 fYX]hDc]bhg *

GiVYWh5fYU.7`Y/jeZ

Gi a a UfmcZh Y 7 ci fqY

H\]g'Wci fgY'WUb'U`gc'VY'gh X]YX']b'h\Y'Zc``ck]b['gdYWJU`]gUh]cb.'8[_ EfgV[We

5hh\YWcbWig]cbcZh\]gWcifgYh\YghiXYbhk]``VYUV`Yhc

&" F Y`UhY'a cXYfb]gh`]hYfUh fY'UbX'Z[`a 'hc'h\Y]f'W `h fU``WcbhYl h '"8fUk WebbYWgebg'VYfkYYb_Yma_cXYfb]ghfYI hg'UbX'Zj`a_g'

%" F YUX'a cXYfb]qh`]hYfUh fY'UbX'Z[`a 'Wf]h]WU``m

("AU_Y'U'dYfqi Uq]jY'Uf[i a Ybh

HYUWX]b[GhfUhY[]Yg

qdYYW UbX dfcqY"

@YWhifYg.

HYUWX]b[ghfUhY[]Yg UbX fUh]cbU`Y.

j]Ykg'UbX'Uf[iaYbhg'cZch\Yfg

H\]gʻWcifgY`]bfcXiW/gʻmci`hc`h\Y`kUjY`cZYIdYf]aYbhUhjcb`]b`h\Y`Ufhg`h\UhikY`\UjY`WcaY`hc`WU```

_ aVWd [e_ "8i f]b['h\Y']fghZcfmcf'gc'mYUfg'cZh\Y'lk YbhJYh\'WYbh fnž'hfUX]hJcbU``UfhZcfa g'i bXYfk YbhUb i bdfYW/XYbhYX'dfcW/gg'cZfYj c`i hjcb'UbX']bbcj UhjcbžUg'Ufnjghg'UbX'k fjhYfg'gci [\hifUX]WU``mbYk 'k Umg'hc YI dfYgg h Y YI dYf]YbW cZa cXYfb]m''K Y k]``Wcbg]XYf h Y k cf_g cZU fUb[Y cZ]bX]j]Xi U`9i fcdYUb UbX Bcfh\5aYf]WbbacXYfb]ghkf]hYfg'UbX'Z]`a!aU_YfgžUg'kY``Ug'YIUa]b]b['gcaYcZh\YaUbmWc``YWj]Y a cj Ya Ybhgž [fci di gW Yg UbX "]ga g" h UhgdfUb[i d Xi f]b[h]g dYf]cX" 5 hci W ghcbY cZci f]bei]fmk]` VY h Y j YI YX fY`Uhcbg\]d`VYh YYb "a cXYfb]m" Ug`U`\]ghcf]WD`WcbX]hcb`UbX "a cXYfb]ga "Ug`U`W`h fU` a cj Ya Ybh''K \UhXcYg']ha YUb'hc'VY'a cXYfb3'K \Uh\UddYbg'hc'Ufhk \Yb'hfUX]h]cbU`'VY`]YZg'UbX'k Umg'cZ `]ZY`YbhYf`U`dYf]cX`cZdYfa UbYbhWf]g]g`—`U``dYf]cXžh\Uh]gžk \Yb`"U```h\Uh]g`gc`]X`a Y`hg`]bhc`U]f"3`5bX`XcYg a cXYfb]ghW h fY hYUW i g k Ung hc ZYY Uh\ca Y]b a cXYfb]mžcf XcYg]hfYa]bX i g cZci f U]YbUh]cb3 i

)": cfa i `UHY`UbX`XYZYbX`Ub`]bXYdYbXYbhdc]bhcZj]Yk `cb`U`gi V^YWžk \]`Y`HU_]b[`]bhc`UWWci bhH\Y

*" 9a d`cmfYgYUfW(`g_]``gž`]bWi X]b[`Z]bX]b[`Uddfcdf]UhY`gYWcbXUfma UhYf]U``UbX`i g]b[`]hWf]hWU``m'

@YWhifYgžhihcf]U`g`UbX`UggYggaYbhi]b`h\]g`WcifgY`g\ci`X`[]jY`mci`h\Y`g_]``g`bYWfggUfmhc`dYfZcfa]bh/``][Ybhž]bXYdYbXYbhfYUX]b[g'cZacXYfb]ghhYI hg'UbX'hc'Wcaaib]WUhY'h\cgY'fYUX]b[g']b'Wc[Ybh

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

Ghi XYbhg UfY YI dYWYX hc di hh\Y]f bUa Yg UbX ghi XYbhbi a VYfg cb Yj YfmdU[Y cZh\Y]f Ugg][ba Ybhg"

Hi fb]h]b Gi Va]gg]cb

Zmci YbWci bhYf'U'dfcV'Ya 'k \Yb'UthYa dhjb['hc'gi Va]hmci f'Ugg][ba Ybht\fci [\'Hi fb]hjbž'd'YUgY hY'Yd\cbY'9I hYfbU''Gi ddcfhicb'-',) '' ' %cf'Ya U]`'h\Ya 'cb'<u>YI hYfbU'hY'hgi ddcfh4 i bgk "YXi "Ui</u>"'Gi ddcfh \ci fg'UfY', .\$\$Ua '-'%\$.\$\$da 'cb'k YY_XUmg'UbX'-.\$\$Ua '-') .\$\$da 'cb'k YY_YbXg'fl *) 'XUmg'U'mYUfŁ'' Zmci UfY'i bUV'Y'hc'gi Va]hmci f'Ugg][ba YbhXi Y'hc'U'ZJi `hk]h\'Hi fb]hjb'mci 'a UmUdd`m'Zcf'Ub'YI hYbg]cbžVi hmci a i ghfYhU]b'mci f'hjW_Yhbi a VYf'Zfca '9I hYfbU''Gi ddcfhfU'cb['k]h\ 'Ubmch\Yf'fY'Yj UbhXcW a YbhgŁ'hc]bWi XY'Ug'Yj]XYbWY hc'gi ddcfhimci f'YI hYbg]cb'Udd`]WUhjcb'' Zmci 'Ya U]`'9I hYfbU''Gi ddcfhimci 'k]`` Ui hca UhjWU'`mfYWY]j Y'U'hjW_Yhbi a VYfž'Vi h]Zmci 'hY'Yd\cbY'mci 'k]``bYYX'hc'gdYWJZWU'`mUg_'Zcf'cbY" Hi fb]hjb'U`gc'dfcj]XYg'i dXUhYg'cb'h\Y]f'gmghYa 'gfUh g'cb'Hk]hYf"

; YbYfU``mž'UggYgga YbhiHUg_g'a i ghVY'gi Va]HHXXYYWYfcb]WU``mj]U'Y]H\Yf'Hi fb]h]b'cf'U'A ccX`Y Ugg][ba Ybh''=b`]bgHUbWYg'k \YfY'H\]g']g'bchdcgg]V`Yž']hk]``VY'gHUHX'cb'mci f'Wci fgY'g'A ccX`Y'g]HY'k]H\ U`HYfbUh]j Y'gi Va]gg]cb'XYHU]`g''

@UhY 5ggYgga Ybh DYbU h Yg

5b'UggYggYX'HUg_']g'XYYa YX'`UHY']Z]h']g'gi Va]HYX'UZHYF'H\Y'gdYW]ZJYX'Ha Y'UbX'XUHY'Ug'gYhici h']b'H\Y Wci fgY'@YUfb]b['A UbU[Ya YbhGmghYa 'f@A GŁ''

H\Y``UhY`dYbU`hm`]g`h\Y``cgg`cZ)ı `cZh\Y`hchU``dcgg]V`Y`aUf_g`Zcf`h\Y`hUg_`Zcf`YUW\`XUm`cf`dUfhih\YfYcZh\Y kcf_`]g``UhY"`@UhYbYgg`k]```]bWiXY`kYY_YbXg`UbX`diV`]W\c`]XUmg"`H\]g`XcYg`bchUdd`mhc`U`hUg_`h\Uh`]g UggYggYX`Vihbc`aUf_`]g`UkUfXYX"

K cf_'gi Va]httX:Zci fhtYb`f%(EXUmg`UZhYf`h\Y`Xi Y`XUhY`k]``VY`a Uf_YX`UbX`ZYYXVUW_`dfcj]XYX`Vi hbc`a Uf_ k]``VY`fYWcfXYX''`=Zh\Y`k cf_`k ci `X`\Uj Y`fYWY]j YX`U`dUgg`a Uf_`Vi hZcf`h\Y``UhYbYgg`UbX`h\Y`k cf_`]g`U Wca di `gcfmWci fgY`Wca dcbYbhzU`gh XYbhk]``VY`XYYa YX`hc`\Uj Y`a Yhh\UhfYei]fYa Ybh'`H\]g`XcYg`bch Udd`mhc`U`hUg_`h\Uhi]g`UggYggYX`Vi hbc`a Uf_`]g`Uk UfXYX''

K cf_`gi Va]hhYX'hk YbhnicbY'f&&:XUmg'UZhYf'h\Y'Xi Y'XUhY'k]``bch'VY'UWW/dhYX'Zcf'a Uf_]b['cf'ZYYXVUW_ UbX'k]``fYWY]j Y'bc'a Uf_`cf'[fUXY"'=Zh\Y'UggYgga Ybh'hUg_`]g'U'Wca di `gcfm'Wca dcbYbhicZh\Y'Wci fgY'U ghi XYbh'k]``Ui hca Uh]WU``m'ZU]``h\Y'Wci fgY"

GdYWJU``7cbg]XYfUh]cb`5dd`]WUh]cbg

 $\label{eq:milling} \end{tabular} Mci `WUb`Udd`millingYgdYWJU`Wcbg]XYfUh]cb`k \Yb`]``bYgg`cf`ch\Yf`WJfW a ghUbWfg`]bhYfZYfY`k]h\`mci f UggYgga YbhidYfZcfa UbWf"$

G]W_bYggža]gUXjYbhifY`cf`ch\Yf`W]fW a gHubWfg`VYmcbX`mcif`Wcbhfc``aUm

ł DfYj Ybhmci Zfca Wcad Yhjb[UWci fgY fYei]fYa Ybhž

ł?YYdimci Zfca UHYbX]b[UbUggYggUVYUW]j]mž

ł Ghod moi i gi Va]hh]b[iUggYggUV Y k cf_ Zcf U Wci fgYž

ł `G][b]Z]WUbhmUZYWimci f`dYfZcfa UbWi`]b`UggYggUV`Y`k cf_ž`VY`]hU`Zcfa U``YbX!cZigYa YghYf`YI Ua]bUh]cbž`U WUgg`hYghž`U``UVcfUhcfmhYghž`U`gYa]bUf`dfYgYbhUh]cb`cf`Ubmich\Yf`Zcfa `cZUggYgga Ybh'

: cf'Z fh\Yf'XYHJ]`g`]b`fY`UH]cb`rc`GdYW]U``7 cbg]XYfUH]cb`]bWi X]b[`''K \Yb`rc`5dd`mf'Z''<ck`rc`5dd`mf'UbX "Gi ddcfh]b[`8cW a YbHJh]cb"'d`YUgY`fYZYf'rc'h\Y`GdYW]U``7 cbg]XYfUH]cb`rk YVgh]Y.` \hhdg.##gh XYbH'i bgk "YXi "Ui #gdYW]U`!Wcbg]XYfUH]cb

5WUXYa]W<cbYghmUbX^D`U[]Uf]ga

D`U[]Uf]ga `]g`i g]b[`h\Y`k cfXg`cf`]XYUg`cZch\Yfg`UbX`dfYgYbh]b[`h\Ya `Ug`mci f`ck b"`=hWUb`hU_Y`a Ubm Zcfa gžZca `XY`]VYfUhY`W\YUh]b[`hc`UWW]XYbhU``mWcdm]b[`Zca `U`gci fWY`k]h\ci hUW_bck `YX[Ya Ybh'

I BGK '[fci dg'd`U[]Uf]ga ']bhc 'h\Y'Zc``ck]b['WUhY[cf]Yg.

7 cdm]b[..i g]b[.ih,Y`gUa Y`cf`j Yfmig]a]`Uf`k cfXg`hc`h,Y`cf][.]bU``hYI h`cf`]XYU`k]h\ci hUW_bck `YX[.]b[.ih,Y gci fWY`cf`i g]b[`ei chUh]cb`a Uf_g"`H\]g`U`gc`Udd`]Yg`hc`]a U[.Ygž`Ufh`UbX`XYg][b`dfc`YWfgž`Ug`k Y```Ug dfYgYbhUh]cbg`k \YfY`gca YcbY`dfYgYbhg`Ubch\Yf`g`]XYUg`cf`k cfXg`k]h\ci hWfYX]h"

=bUddfcdf]UhY'dUfUd\fUg]b[.'W\Ub[]b['U'ZYk 'k cfXg'UbX'd\fUgYg'k \]Y'a cghmfYhU]b]b['h\Y'cf][]bU' ghfi Whi fY'UbX']bZcfa Uh]cb'k]h\ci hUW_bck `YX[Ya Ybh''H\]g'U`gc'Udd`]Yg']b'dfYgYbHUh]cbg'k \YfY'gca YcbY dUfUd\fUgYg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci hWfYX]h''=hU`gc'Udd`]Yg'hc'd]YW]b['hc[Yh\Yf'ei chYg'UbX dUfUd\fUgYg']bhc'U'bYk 'k \c`Yž'k]h\ci hfYZYfYbW]b['UbX'U'gh XYbhg'ck b'UbU`mg]g'hc'Vf]b['h\Y'a UhYf]U` hc[Yh\Yf''

7 c``i g]cb. 'k cf_]b['k]h 'ch Yfg'Vi hdUgg]b['cZh Y'k cf_'Ug'U'dYfgcb'g']bX]j]Xi U``k cf_''7 c``i g]cb'U`gc]bWi XYg'dfcj]X]b['mci f`k cf_'hc'Ubch Yf'gh XYbhVYZcfY'h Y'Xi Y'XUhYzcf'Zcf'h Y'di fdcgY'cZh Ya d`U[]Uf]g]b['UhUbmh]a Yž'dUm]b['Ubch Yf'dYfgcb'hc'dYfZcfa 'Ub'UWUXYa]WhUg_ž'ghYU`]b['cf'UWei]f]b[Ubch Yf'dYfgcb'g'UWUXYa]Wk cf_'UbX'Wcdm]b[']hz'cZYf]b['hc'Wca d`YhY'Ubch Yf'dYfgcb'g'k cf_'cf'gYY_]b[dUma YbhZcf'Wca d`Yh]b['UWUXYa]Wk cf_''

=ÐUddfcdf]UhY`W]hUh]cb. 7]h]b[`gci fWYg`k∖]WX`\Uj Y`bchVYYb`fYUXžk]h\ci hUW_bck`YX[]b[`h\Y`″gYWcbXUfm´ gci fWY`Zfca`k∖]W\`_bck`YX[Y`cZh\Ya`\Ug`VYYb`cVhU]bYX"

8id`]\WUh]cb`fl`gY`ZId`U[]Uf]ga "Ł`gi Va]hhjb[`mcif`ckb`kcf_ž`]b`k\c`Y`cf`]b`dUfhž`k\YfY`]h\Ug`dfYj]cig`m VYYb`dfYdUfYX`cf`gi Va]hhYX`Zcf`Ubch\Yf`UggYggaYbhcf`\\circf`Ucil BGK `cf`Ubch\Yf`ib]jYfg]hm"

7 cffYWhfYZYfYbW]b[dfUWf]WYg.

• VYHYfa UbU[Y'mcifh]a Y

7 ci fgY GWX YXi `Y

<u>J]Yk WUgg'hja YHJV`Y</u>

H]a YHJV`Y'

8 UHY	Hmd Y	7 c bhYbh
K_YY_`%`&*`: YVfi_Ufmi!`(@YWhifY	DUfh'%
a ufvx		
		=ðhfcXi Wnjcb.`a cXYfb]ga ža cXYfb]hmžUj Ubh![UfXY`
		DUfh'&
		G`UZ[W`S`VS?aggWfYYb]b['Ž`YWfifY#X]gW`gg]cb
K YY_`&.`) `A UfWX '!`%% A UfWX	@YWMifY Hihcf]U`	AUf]UbbY'AccfYžgY`YWYX'dcYag
		=bhfcXiWhjcb"`6UiXY`U]fYž″≕\UjY`acfY`aYacf]Yg h\Ub`]Z≕kYfY`cbY`h\cigUbX`mYUfg`c`X″`fgYY`AccX`YŁ
I		ļ]

	Hihcf]U`	JYfhcjž?S`i[fZS?ah[W5S_W65f%&+Ł	
K YY_``' \$`5df]`'!`*`A Un	n @YWhifY	K cc`Z:Fa fZW>[YZfZageW	
	Hihcf]U`	7 cbfUXž ~H\Y GYWfYhG\UfYf ~	
K_YY_`%\$.`+`A_Um!`% A_Um	GWFYYb]b[: [daeZ[_S_a`3_agdfgWfYYb]b[Ł	
	Hihcf]U`	K cc`ZiFa fZW>[YZfZageW	
K_YY_`%%`%(`A_Um!`&\$ A_Um	@YWhi fY	: [daeZ[_Sł?a`3_agdźX]f"`FYgbU]g`fIYWhifYŁ	
	Hi hcf]U`	: [daeZ[_S_a`3_agdf%)-Ł	
K_YY_`%&.`&%`A_Um'!`&+ A_Um	@YWhi fY	@JhY`a_cXYfb]ghdcYhfm`>c\b`5g\VYfmŽ`>cf]Y ;_fU\Ua	
	Hi hcf]U`	>c\b`5g\VYfmžgY`YWYX`dcYag	
K YY_`% .`&, `A Um!'' >i bY	Hi hcf]U`	>cf]Y`; fU\Ua žgY`YWYX`dcYa g`Ž`Wci fgY`cj Yfj]Yk	

FYgci fWg

DfYgWf]VYX F Ygci fWYg

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>c\b`5g\VYfmžgY`YWhYX`dcYag`fdcYag`gYhZcf`X]gWigg]cb`UfY`]bX]WUhYX`cb`AccX`YŁ

H"G"`9`]chž'FZWI SefW>S`V

>cf]Y'; fU\Ua ž'gY`YWYX'dcYa g`fdcYa g`gYhZcf`X]gW gg]cb'UfY`]bX]WUHYX'cb'A ccX`YŁ

A Uf]UbbY'A ccfYžgY'YWYX'dcYa g'fdcYa g'gYhZcf'X]gW gg]cb'UfY']bX]WUHYX'cb'A ccX'YŁ

BcjY`g`fdifW\UgY`Zfca 'h\Y`IBGK 'Vcc_g\cdŁ

: cfX'AUXcl : cfXžFZW9aaVEaV[Wdf%-%)Ł

J]f[]b]U`K cc`ZzFafZW>[YZfZageWf% &+Ł

:]`a g`fgWfYYbYX`]b``YWfi fYg`UbX`Uj U]`UV`Y`]b`f\Y``]VfUfmŁ

G`UZ[W S`VS′agʻfbiĺiY``UbX'8U`É'f%-&-Ł

FZWBSee[a` aX<aS` aX3dJ fB fYmYfŁ'f%- &, Ł

? S` i [fZ S ? ah[W5 S_ WdS fJ Yfhcj Łf1% &+Ł

: [daeZ[_S_a`3_agdfFYgbU]gŁf%-)-Ł

FYWca a YbXYX⁻FYgci fWYg

GYY'A ccX`Y'Zcf'UXX]h]cbU``fYgci fWfg"

7 ci fgY 9j U`i Uh]cb UbX 8Yj Y`cda Ybh

A cghWca a YbhgʻhYbX'hcʻVYʻUVci hh\YʻgmʻUVi g"ʻH\YfYfgʻVYYbʻgca YʻfYg]ghUbWYʻhcʻUʻbcj Y`ʻh\Uhk Yʻi gYX'hc ghi Xmcbʻh\]gʻWci fgYžʻ9`]nUVYh\ʻ6ck YbfgʻFZW: WSfaXfZW6Skł gcʻ=fa'ʻYUj]b[ʻ]hci hh\]gʻmYUf"ʻGca Y ghi XYbhgʻ\Uj YʻYI dfYggYXʻUʻXYg]fYʻhcʻghi Xma cfYʻ″WUgg]Wʻcfʻ″WUbcb]WU`″a cXYfb]ghik f]hYfgžgcʻk YʻUfY Xc]b[ʻH"G"ʻ9`]chih\]gʻmYUfʻ]bghYUXʻcZK "< "ʻ5i XYb"

gYa YghYfž']bWi X]b[`dfYdUfUh]cbžUggYgga Ybhg`UbX`WcbhUWi\ci fg"`A Ubmighi XYbhg`Xc`a cfY`h\Ub`h\]g a]b]a i a "`=i bXYfgHUbX`h\Uhih\YfY`a][\hVY`cbY`k YY_`]b`h\Y`gYa YghYf`k \Yb`mci `WUb'h`]b]g\`h\Y`fYUX]b[" 6i hd`YUgY`fYa Ya VYf`h\Uhimci `g\ci `X`VY`gdYbX]b[`Sf MSef`%\$`\ci fg`U`k YY_`cb`h\]g`Wci fgYž'UbX`=YI dYWh mci `hc`gdYbX`U``chicZh\Uhih]a Y`fYUX]b["

-a U[Y[·]7fYX]h

<aS` aX3dJ fX]f"'7 Uf`H\YcXcf'8 fYmYfŁ

7F =7CG

7F =7CG Dfcj]XYf 7cXY. \$\$\$-,;